IEEE P802.11
Wireless LANs

Proposed TGah Draft Amendment

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Abstract

This document contains a proposal for the TGah draft amendment. It captures the feature requirements outlined in the TGah specification framework document (11-11/1137) in detailed draft text.

IEEE P802.11ah™/D0.1

Draft Standard for Information technology— Telecommunications and information exchange between systems Local and metropolitan area networks— Specific requirements

Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

Amendment 6: Sub 1 GHz License Exempt Operation

Prepared by the 802.11 Working Group of the

LAN/MAN Standards Committee
of the
IEEE Computer Society

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Abstract: This amendment defines modifications to both the IEEE 802.11 physical layer (PHY) and the medium access control (MAC) sublayer to enable operation of license-exempt 802.11 wireless networks in frequency bands below 1 GHz excluding the TV White Space bands, with a transmission range up to 1 km and a minimum data rate of at least 100 Kb/s.

Keywords: sub 1 GHz, narrower bandwidth, long transmission range, low power consumption, PHY, physical layer, MAC, medium access control, OFDM, orthogonal frequency division multiplexing, wireless local area network, WLAN

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Introduction

This introduction is not part of IEEE P802.11ah/D0.1, May 2013, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area network—Specific requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications—Amendment 6: Sub 1 GHz License-Exempt Operation.

This amendment defines modifications to both the IEEE 802.11 physical layer (PHY) and the medium access control (MAC) sublayer to enable operation of license-exempt 802.11 wireless networks in frequency bands below 1 GHz excluding the TV White Space bands, with a transmission range up to 1 km and a minimum data rate of at least 100 Kb/s.

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<name>

IEEE Standards Program Manager, Document Development

<name>

IEEE Standards Program Managers, Technical Program Development

Contents

3. Definitions, acronyms, and abbreviations

3.1 Definitions

Change the following definitions (maintaining alphabetical order):

paged AID: The paged AIDs refer to those AIDs with their corresponding bits being set to ‘1’ if encoded by partial virtual bitmap.

traffic classification (TCLAS): The specification of certain parameter values to identify the medium access control (MAC)~~ service~~ protocol data units (M~~S~~PDUs)~~ belonging to a particular traffic stream (TS)~~. The classification process, performed ~~above the MAC service access point (MAC_SAP) ~~at a quality-of-service (QoS) access point (AP), uses the parameter values ~~for a given TS~~ to examine each ~~incoming~~outgoing M~~S~~PDU and determine whether this M~~S~~PDU ~~belongs to that TS~~ matches a classification specification. TCLAS might also occur at non-access-point (non-AP) QoS station (STA) ~~with multiple streams~~.

NOTE-However, such classification is beyond the scope of this standard.

3.2 Definitions specific to IEEE 802.11

3.3 Abbreviations and acronyms

Insert the following acronym definitions (maintaining alphabetical order):

BAT	Block Acknowledgement TWT
TWT	Target Wake Time
TACK	TWT Acknowledgement
STACK	Short TWT Acknowledgement
SF	Speed Frame

4. General description

Add a new subclause 4.11a after subclause 4.11 as follows:

4.11a Relay

A Relay AP is defined as an AP that has Relay capability, for example 4 address frame support, with dot11RelayAPEnabled set to true; Relay AP shall include the Relay element in its Beacon and Probe Responses.

A Relay STA is defined as a STA with dot11RelaySTACapable set to true which successfully completes association and authentication, and receives a Relay element in the association response.

A Relay is an entity that logically consists of an Relay AP and a STA, as illustrated in Figure 4-23a (Relay1 and Relay2 are Relays whose Relay STAs are associated with an AP that is a Root AP. STA1, STA2, STA3, and STA4 are STAs that are associated with the Relay AP inside Relay1 and Relay2, respectively). An AP that sends a Relay element with the Control field set to 0 is referred to as a Root AP. Relayed frames between a Relay AP and a Relay STA use either the 4-address frame format or the A-MSDU format, so that information about the receiver, transmitter, source address and destination address can be conveyed.

A Relay AP shall include the Relay element in its Beacon and Probe responses only if its Relay STA has an association with an AP.

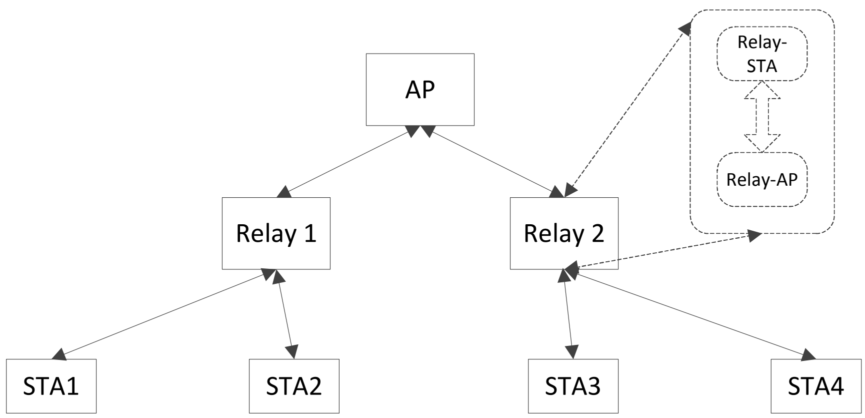

Figure 4-23a—Relay1 and Relay2 are Relays whose Relay STAs are associated with an AP that is a Root AP. STA1, STA2, STA3, and STA4 are STAs that are associated with the Relay AP inside Relay1 and Relay2, respectively

4.11a.1 Two-hop relay function

The relay function allows an AP and non-AP STAs to exchange frames with one another by the way of a relay. The introduction of a relay allows non-AP STAs to use higher MCSs and reduce the time non-AP STAs will stay in Active mode. This improves battery life on non-AP STAs. Relay STAs may also provide connectivity for non-AP STAs located outside the coverage of the AP.

There is an overhead cost on overall network efficiency and increased complexity with the use of relay STAs. To limit this overhead, the relaying function shall be bi-directional and limited to two hops only.

4.11a.2 TXOP sharing operation

One source of additional overhead when relays are used is due to a frame being transmitted over two hops through a relay STA requiring two separate channel accesses. The additional channel access delay increases the number of the contention-based channel accesses in the network. This increases the collision probability between multiple STAs trying to access the medium.

TXOP sharing by relays reduces channel access delay and the number of contention-based channel accesses by allowing the frame transmission exchanged over the first hop and second hop to share a single TXOP. Frames transmitted over the first hop and second hop are separated by SIFS.

4.11b Grouping of non-AP STAs

Grouping allows partitioning of the non-AP STAs within a BSS into groups and restricting channel access only to STAs belonging to a given group at any given time period. This time period is enabled by allocating a slot duration and a number of slots in a RAW. Grouping can help to reduce contention by restricting access to the medium to a subset of the STAs associated with the AP. Grouping can also reduce the signaling overhead.

The assignment of non-AP STAs into different groups is based on the RAW slot assignment procedure. An AP may also assign a STA supporting TWT to one of the predefined TWT groups. The AID assignment criteria can depend on STA location, for example, when non-AP STAs sharing common location information are placed inside of the same group. Such assignment is a form of sectorization. Group assignment criteria can be based on the sleeping or traffic requirements of non-AP STAs as well as other criteria that are beyond the scope of the standard.

Grouping of non-AP STAs can improve network energy consumption, as STAs that are not in the group assigned to the current slot can enter a doze state until their slot time or assigned TWT arrives. Doze state is allowed for no-AP STAs assigned in the current slot when they do not have traffic to transmit.

4.11c Target Wake Time

Target Wake Time (TWT) is a function that permits an AP to define a specific time or set of times (i.e. TWT values) for individual STAs to access the medium. The AP conveys the TWT value(s) to each participating STA within specific frames. Some of the frames containing TWT values are response frames, the use of which allows for minimal wake activity between successive STA accesses of the medium. TWT values can be periodic or aperiodic. The use of periodic TWT values further reduces the amount of wake time for a STA by eliminating the need to send a TWT value at each wake interaction. The STA and the AP exchange information that includes an expected activity duration to allow the AP to control the amount of contention and overlap among competing STA. The AP can protect the expected duration of activity with various protection mechanisms. The use of TWT is negotiated between an AP and a STA.

4.11d Speed Frame Exchange

Speed frame exchange provides the functionality that enables an AP and non-AP STA to exchange a sequence of uplink and downlink PPDUs in a TXOP. This continuous frame exchange sequence may exchange both uplink and downlink data frames between the pair of STAs. This operation mode is intended to reduce the number of contention-based channel accesses, improve channel efficiency by minimizing the number of frame exchanges required for uplink and downlink data frames, and enable STAs to extend battery lifetime by keeping Awake times short.

4.11e Sectorization

The partition of the coverage area of a BSS into sectors, each containing a subset of stations, is called sectorization. This partitioning is generally achieved by the AP transmitting or receiving through a set of antennas or a set of synthesized antenna beams to cover different sectors of the BSS. The goal of the sectorization is to reduce medium contention or interference by the reduced number of stations within a sector and/or to allow spatial sharing among OBSS APs or STAs. Two types of sectorization scheme: Type 0 Sectorization and Type 1 Sectorization, are described in this specification.

Type 0 Sectorization is a beacon interval-based operation which allows STA transmissions in different sectors in a time division multiplexing scheme. In a Type 0 Sectorization BSS, AP assigns Type 0 Sectorization capable STAs belongs to a sector into group(s) identified by the group ID(s). By transmitting a sectorized beacon carrying the Sectorized Operation element, AP initiates a sectorized beacon interval in which a Type 0 sectorization capable STA in the BSS is either allowed to transmit during this beacon interval if the STA is in a group belonging to the sector or not allowed to transmit during this beacon interval if the STA is in a group not belonging to the sector. A STA which does not support Type 0 Sectorization capable is allowed to transmit on both sectorized and non-sectorized beacon interval. The hidden node problems are mitigated since the number of active STAs is reduced in Type 0 Sectorized BSS during the sectorized beacon intervals.

Type 1 Sectorization, on the other hand, is a TXOP-based operation. Type 1 Sectorization AP starts a TXOP with omni-beam transmission which reaches both STAs supporting Type 1 Sectorization capable and STAs not supporting Type 1 Sectorization capable in order to set up the NAV protection for the duration of the sectorized beam transmission. Then, the AP switches to the sectorized beam transmission and the reception for the remainder of the protection duration. Furthermore, during the protection duration, Type 1 Sectorization capable OBSS APs or STAs are allowed to start simultaneous spatial orthogonal frame exchanges if a certain condition is detected. With the sectorized beam transmission and reception, the hidden node problems are mitigated in Type 1 Sectorization BSS operation. The spatial re-use of the wireless medium is accomplished through the Spatial Orthogonal frame exchange and significant increase of the overall network capacity can be achieved in any level of OBSS interferences without requiring any AP to AP coordination.

In both types of sectorization scheme, the Sectorization capable AP can learn about STA's best sector in various ways which is beyond the scope of this specification. However, the specification defines the procedure for sector capability exchange, request and scheduling of either the periodic or the non-periodic sector training and to allow Sector ID feedback capable STAs to report sector ID information back to the AP.

6. Layer management

6.1 Overview of management model

6.2 Generic management primitives

6.3 MLME SAP interface

6.3.3 Scan

6.3.3.2 MLME-SCAN.request

6.3.3.2.2 Semantics of the service primitive

Modify the primitive parameters by inserting the following text :

The primitive parameters are as follows:

```
MLME-SCAN.request(
                BSSType,
                BSSID,
                SSID,
                ScanType,
                ProbeDelay,
                ChannelList,
                MinChannelTime,
                MaxChannelTime,
                RequestInformation,
                SSID List,
                ChannelUsage,
                AccessNetworkType,
                HESSID,
                MeshID,
                ProbeResponseOption,
                VendorSpecificInfo
                )
```

Name	Type	Valid range	Description
ProbeResponseOption	As defined in 8.4.2.170v (Probe Response Option element)	As defined in 8.4.2.170v (Probe Response Option element)	Indicates which optional information is requested to be included in the Short Probe Response frame. This element is optionally present if dot11S1GOptionImplemented is true.

Modify the valid range of the ScanType row as following:

Name	Type	Valid range	Description
ScanType	Enumeration	ACTIVE, PASSIVE, NDP PROBING	Indicates ~~either~~ active or passive scanning, NDP probing.

6.3.3.3 MLME-SCAN.confirm

6.3.3.3.2 Semantics of the service primitive

Other optional fields and IEs of short probe response frame are TBD.

Modify the Timestamp element of BSSDescriptionSet as follows:

Name	Type	Valid range	Description	IBSS adoption
Timestamp	Integer	N/A	The timestamp of the received frame (probe response/beacon, or short probe response/short beacon) from the found BSS. When a short probe response or a short beacon is received, the timestamp is the 4 least significant bytes of the TSF timer value of the transmitting STA.	Adopt

Add the following elements after the last element of the BSSDescriptionSet as follows:

Name	Type	Valid range	Description	IBSS adoption
Compressed SSID	Integer	N/A	32-bit CRC calculated as defined in 8.2.4.8 FCS field, wherein the calculation fields is the SSID field in the Probe Response frame or Beacon frame. This parameter is optionally present if dot11S1GOptionImplemented is true.	TBD
Next TBTT	Integer	N/A	Highest 3 bytes of the 4 least significant bytes of the next TBTT. This parameter is optionally present if dot11S1GOptionImplemented is true.	TBD

Modify Table on the various elements of BSSDescriptionSet by inserting the following rows after MCCAOP Advertisement element:

Name	Type	Valid Range	Description	IBSS adoption
RPS	RPS element	As defined in 8.4.2.170b (RPS element)	The parameter set for group-based restricted medium access, if such element was present in the Beacon or Probe Response, else null. The support of a feature is described on RAW-based medium access (9.19.4a (Restricted Access Window (RAW) Operation))	Do not adopt
Segment Count	Segment Count element	As defined in 8.4.2.170c (Segment Count element)	The set of TIM and page segments present in DTIM interval, if such element was present in the Beacon or Probe Response, else null. The support of a feature is described on TIM and page segmentation (see 9.32j (TIM and Page segmentation))	Do not adopt
S1G Capabilities	As defined in frame format	As defined in 8.4.2.170k (S1G Capabilities element)	The values from the S1G Capabilities element. The parameter is present if dot11S1GOptionImplemented is true and a S1G Capabilities element was present in the Probe Response or Beacon frame from which the BSSDescription was determined, and not present otherwise.	Adopt

6.3.4 Synchronization

6.3.5 Authenticate

6.3.5.1 Introduction

6.3.5.2 MLME-AUTHENTICATE.request

6.3.5.2.1 Function

6.3.5.2.2 Semantics of the service primitive

6.3.5.2.3 When generated

Add a sentence at the end of section 6.3.5.2.3 as follows :

When dot11S1GOptionImplemented is true, a STA for which dot11S1GAuthenticationPause is true shall not generate this primitive.

6.3.7 Associate

6.3.7.2 MLME-ASSOCIATE.request

6.3.7.2.2 Semantics of the service primitive

Modify the primitive parameters by inserting the following text :

The primitive parameters are as follows:

```
MLME-ASSOCIATE.request(
                PeerSTAAddress,
                AssociateFailureTimeout,
                CapabilityInformation,
                ListenInterval,
                Supported Channels,
                RSN,
                QoSCapability,
                Content of FT Authentication elements,
                SupportedOperatingClasses,
                HT Capabilities,
                Extended Capabilities,
                20/40 BSS Coexistence,
                QoSTrafficCapability,
                TIMBroadcastRequest,
                EmergencyServices,
                Sector Capabilities,
                AID Request,
                S1G Capabilities,
                VendorSpecificInfo
                )
```

Name	Type	Valid range	Description
Sector Capabilities	Sector Capabilities element	As defined in 8.4.2.170l (Sector Capabilities element)	Specifies the sectorization scheme, period, subperiod sector intervals. Sector training
AID Request	AID Request element	As defined in 8.4.2.170d (AID Request element)	Indicate the device characteristic of the non-AP STA requesting AID assignment.
S1G Capabilities	As defined in frame format	As defined in 8.4.2.170k (S1G Capabilities element)	Specifies the parameters in the S1G Capabilities element that are supported by the STA. The parameter is present if dot11S1GOptionImplemented is true and not present otherwise.

6.3.7.3 MLME-ASSOCIATE.confirm

6.3.7.3.2 Semantics of the service primitive

Modify the primitive parameters by inserting the following text :

The primitive parameters are as follows:

MLME-ASSOCIATE.confirm(
ResultCode,
CapabilityInformation,
AssociationID,
ListenInterval,
SupportedRates,
EDCAParameterSet,
RCPI.request,
RSNI.request,
RCPI.response,
RSNI.response,
RMEnabledCapabilities,
Content of FT Authentication elements,
SupportedOperatingClasses,
HT Capabilities,
Extended Capabilities,
20/40 BSS Coexistence,
TimeoutInterval,
BSSMaxIdlePeriod,
TIMBroadcastResponse,
QosMapSet,
QMFPolicy,
Sector Operation,
Sector Capabilities,
S1G Capabilities,
AID Response,

VendorSpecificInfo
)

Name	Type	Valid range	Description
Listen Interval	Integer	≥ 0	Specifies the value of listen interval different from that in Association Request frame based on AP's buffer management consideration.
Sector Operation	Sector Operation element	As defined in 8.4.2.170f (Sector Operation element)	Specifies the sectorization sheme, period, subperiod sector intervals, and sector training.
Sector Capabilities	Sector Capabilities element	As defined in 8.4.2.170l (Sector Capabilities element)	Specifies the parameters in the Sector Capabilities element that are supported by the AP. The parameter is present if dot11S1GSectorImplemented is true and the Sector Capabilities element is present in the Association Response frame received from the AP. and not present otherwise.
S1G Capabilities	As defined in frame format	As defined in 8.4.2.170k (S1G Capabilities element)	Specifies the parameters in the S1G Capabilities element that are supported by the AP. The parameter is present if dot11S1GOptionImplemented is true and the S1G Capabilities element is present in the Association Response frame received from the AP, and not present otherwise.
AID Response	AID Response element	As defined in 8.4.2.170e (AID Response element)	Indicate the information about the AID assignment.

6.3.7.4 MLME-ASSOCIATE.indication

6.3.7.4.2 Semantics of the service primitive

Modify the primitive parameters by inserting the following text :

The primitive parameters are as follows:

MLME-ASSOCIATE.indication(
PeerSTAAddress,
CapabilityInformation,
ListenInterval,
SSID,
SupportedRates,

RSN,
QoSCapability,
RCPI,
RSNI,
RMEnabledCapabilities,
Content of FT Authentication elements,
SupportedOperatingClasses,
DSERegisteredLocation,
HT Capabilities,
Extended Capabilities,
20/40 BSS Coexistence,
QoSTrafficCapability,
TIMBroadcastRequest,
EmergencyServices,
Sector Capabilities,
AID Request,
S1G Capabilities,
VendorSpecificInfo
)

Name	Type	Valid range	Description
Sector Capabilities	Sector Capabilities element	As defined in 8.4.2.170l (Sector Capabilities element)	Specifies the parameters in the Sector Capabilities element that are supported by the AP. The parameter is present if dot11S1GSectorImplemented is true and the Sector Capabilities element is present in the Association Response frame received from the AP. and not present otherwise.
AID Request	AID Request element	As defined in 8.4.2.170d (AID Request element)	Indicate the device characteristic of the non-AP STA requesting AID assignment.
S1G Capabilities	As defined in frame format	As defined in 8.4.2.170k (S1G Capabilities element)	Specifies the parameters in the S1G Capabilities element that are supported by the STA. The parameter is present if dot11S1GOptionImplemented is true and the S1G Capabilities element is present in the Association Request frame received from the STA, and not present otherwise.

6.3.7.5 MLME-ASSOCIATE.response

6.3.7.5.2 Semantics of the service primitive

Modify the primitive parameters by inserting the following text :

The primitive parameters are as follows:

MLME-ASSOCIATE.response(
PeerSTAAddress,
ResultCode,
CapabilityInformation,
AssociationID,
ListenInterval,
EDCAParameterSet,
RCPI,
RSNI,
RMEnabledCapabilities,
Content of FT Authentication elements,
SupportedOperatingClasses,
DSERegisteredLocation,
HTCapabilities,
Extended Capabilities,
20/40 BSS Coexistence,
TimeoutInterval,
BSSMaxIdlePeriod,
TIMBroadcastResponse,
QoSMapSet,
QMFPolicy,
Sector Operation,
Sector Capabilites,
S1G Capabilities,
AID Response,
VendorSpecificInfo
)

Name	Type	Valid range	Description
Listen Interval	Integer	≥ 0	Specifies the value of listen interval different from that in Association Request frame based on AP's buffer management consideration.
Sector Operation	Sector Operation element	As defined in 8.4.2.170f (Sector Operation element)	Specifies the sectorization scheme, period, subperiod sector intervals, sector training.
Sector Capabilities	Sector Capabilities element	As defined in 8.4.2.170l (Sector Capabilities element)	Specifies the parameters in the Sector Capabilities element that are supported by the STA. The parameter is present if dot11S1GSectorImplemented is true and not present otherwise.
S1G Capabilities	As defined in frame format	As defined in 8.4.2.170k (S1G Capabilities element)	Specifies the parameters in the S1G Capabilities element that are supported by the STA. The parameter is present if dot11S1GOptionImplemented is true and not present otherwise.
AID Response	AID Response element	As defined in 8.4.2.170e (AID Response element)	Indicate the information about the AID assignment.

6.3.8 Reassociate

6.3.8.2 MLME-REASSOCIATE.request

6.3.8.2.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-REASSOCIATE.request(
NewAPAddress,
ReassociateFailureTimeout,
CapabilityInformation,
ListenInterval,
Supported Channels
RSN,
QoSCapability,
Content of FT Authentication elements,
SupportedOperatingClasses,
HT Capabilities,
Extended Capabilities,
20/40 BSS Coexistence,
QoSTrafficCapability,

TIMBroadcastRequest,
FMSRequest,
DMSRequest,
EmergencyServices,
Sector Capabilities,
AID Request,
S1G Capabilities,
VendorSpecificInfo
)

Name	Type	Valid range	Description
Sector Capabilities	Sector Capabilities element	As defined in 8.4.2.170l (Sector Capabilities element)	Specifies the parameters in the Sector Capabilities element that are supported by the STA. The parameter is present if dot11S1GSectorImplemented is true and not present otherwise.
AID Request	AID Request element	As defined in 8.4.2.170d (AID Request element)	Indicate the device characteristic of the non-AP STA requesting AID assignment.
S1G Capabilities	As defined in frame format	As defined in 8.4.2.170k (S1G Capabilities element)	Specifies the parameters in the S1G Capabilities element that are supported by the STA. The parameter is present if dot11S1GOptionImplemented is true and not present otherwise.

6.3.8.3 MLME-REASSOCIATE.confirm

6.3.8.3.2 Semantics of the service primitive

Modify the primitive parameters by inserting the following text :

The primitive parameters are as follows:
MLME-REASSOCIATE.confirm(
ResultCode,
CapabilityInformation,
AssociationID,
ListenInterval,
SupportedRates,
EDCAParameterSet,
RCPI.request,
RSNI.request,

RCPI.response,
RSNI.response,
RMEnabledCapabilities,
Content of FT Authentication elements,
SupportedOperatingClasses,
HT Capabilities,
Extended Capabilities,
20/40 BSS Coexistence,
TimeoutInterval,
BSSMaxIdlePeriod,
TIMBroadcastResponse,
FMSRespone,
DMSResponse,
QoSMapSet,
QMFPolicy,
Sector Operation,
Sector Capabilities,
S1G Capabilities,
AID Response,
VendorSpecificInfo
)

Name	Type	Valid range	Description
Listen Interval	Integer	≥ 0	Specifies the value of listen interval different from that in Association Request frame based on AP's buffer management consideration.
Sector Operation	Sector Operation element	As defined in 8.4.2.170f (Sector Operation element)	Specifies the sectorization scheme, period, subperiod sector intervals, sector training.
Sector Capabilities	Sector Capabilities element	As defined in 8.4.2.170l (Sector Capabilities element)	Specifies the parameters in the Sector Capabilities element that are supported by the STA. The parameter is present if dot11S1GSectorImplemented is true and the Sector Capabilities element is present in the Reassociation Response frame received from the AP, and not present otherwise.
S1G Capabilities	As defined in frame format	As defined in 8.4.2.170k (S1G Capabilities element)	Specifies the parameters in the S1G Capabilities element that are supported by the AP. The parameter is present if dot11S1GOptionImplemented is true and the S1G Capabilities element is present in the Reassociation Response frame received from the AP, and not present otherwise.
AID Response	AID Response element	As defined in 8.4.2.170e (AID Response element)	Indicate the information about the AID assignment.

6.3.8.4 MLME-REASSOCIATE.indication

6.3.8.4.2 Semantics of the service primitive

Modify the primitive parameters by inserting the following text :

The primitive parameters are as follows:

MLME-REASSOCIATE.indication(
PeerSTAAddress,
CurrentAPAddress,
CapabilityInformation,
ListenInterval,
SSID,
SupportedRates,

RSN,
QoSCapability,
RCPI,
RSNI,
RMEnabledCapabilities,
Content of FT Authentication elements,
SupportedOperatingClasses,
DSERegisteredLocation,
HT Capabilities,
Extended Capabilities,
20/40 BSS Coexistence,
QoSTrafficCapability,
TIMBroadcastRequest,
FMSRequest,
DMSRequest,
EmergencyServices,
Sector Capabilities,
AID Request,
S1G Capabilities,
VendorSpecificInfo
)

Name	Type	Valid range	Description
Sector Capabilities	Sector Capabilities element	As defined in 8.4.2.170l (Sector Capabilities element)	Specifies the parameters in the Sector Capabilities element that are supported by the STA. The parameter is present if dot11S1GSectorImplemented is true and the Sector Capabilities element is present in the Association Request frame received from the STA, and not present otherwise.
AID Request	AID Request element	As defined in 8.4.2.170d (AID Request element)	Indicate the device characteristic of the non-AP STA requesting AID assignment.
S1G Capabilities	As defined in frame format	As defined in 8.4.2.170k (S1G Capabilities element)	Specifies the parameters in the S1G Capabilities element that are supported by the STA. The parameter is present if dot11S1GOptionImplemented is true and the S1G Capabilities element is present in the Reassociation Request frame received from the STA, and not present otherwise.

6.3.8.5 MLME-REASSOCIATE.response

6.3.8.5.2 Semantics of the service primitive

Modify the primitive parameters by inserting the following text :

The primitive parameters are as follows:

MLME-REASSOCIATE.response(
PeerSTAAddress,
ResultCode,
CapabilityInformation,
AssociationID,
<u>ListenInterval,</u>
EDCAParameterSet,
RCPI,
RSNI,
RMEnabledCapabilities,
Content of FT Authentication elements,
SupportedOperatingClasses,
DSERegisteredLocation,
HT Capabilities,
Extended Capabilities,
20/40 BSS Coexistence,
TimeoutInterval,
BSSMaxIdlePeriod,
TIMBroadcastResponse,
FMSResponse,
DMSResponse,
QoSMapSet,
<u>Sector Operation,</u>
<u>Sector Capabilities,,</u>
<u>S1G Capabilities,</u>
<u>AID Response,</u>
VendorSpecificInfo
)

Name	Type	Valid range	Description
Listen Interval	Integer	≥ 0	Specifies the value of listen interval different from that in Association Request frame based on AP's buffer management consideration.
Sector Operation	Sector Operation element	As defined in 8.4.2.170f (Sector Operation element)	Specifies the sectorization scheme, period, subperiod sector intervals, and sector training.
Sector Capabilities	Sector Capabilities element	As defined in 8.4.2.170l (Sector Capabilities element)	Specifies the parameters in the Sector Capabilities element that are supported by the STA. The parameter is present if dot11S1GSectorImplemented is true and not present otherwise.
S1G Capabilities	As defined in frame format	As defined in 8.4.2.170k (S1G Capabilities element)	Specifies the parameters in the S1G Capabilities element that are supported by the STA. The parameter is present if dot11S1GOptionImplemented is true and not present otherwise.
AID Response	AID Response element	As defined in 8.4.2.170e (AID Response element)	Indicate the information about the AID assignment.

6.3.11 Start

6.3.11.2 MLME-START.request

6.3.11.2.2 Semantics of the service primitive

Modify the primitive parameters by inserting the following text :

MLME-START.request(

...
Mesh Configuration,
S1G Capabilities,
VendorSpecificInfo
)

Name	Type	Valid range	Description
S1G Capabilities	As defined in frame format	As defined in 8.4.2.170k (S1G Capabilities element)	Specifies the parameters in the S1G Capabilities element that are supported by the STA. The parameter is present if dot11S1GOptionImplemented is true, not present otherwise.

Insert the following new subclauses 6.3.96a and 6.3.96b as shown below:

6.3.96a RAW Parameter Set distribution

6.3.96a.1 MLME-RPS.request

6.3.96a.1.1 Function

This primitive requests the distribution of information describing a period or periods of group-based restricted medium access.

6.3.96a.1.2 Semantics of the service primitive

```
MLME-RPS.start(
                RPS
                )
```

Name	Type	Valid range	Description
RPS	RPS element	As defined in 8.4.2.170b (RPS element)	The parameter set for group-based restricted medium access, if such element was present in the Beacon or Probe Response, else null. The support of a feature is described on RAW-based medium access (see 9.19.4a (Restricted Access Window (RAW) Operation))

6.3.96a.1.3 When generated

This primitive is generated by the SME for a STA to distribute information describing a period or periods of group-based restricted medium access within the BSS.

6.3.96a.1.4 Effect of receipt

On receipt of this primitive, the MLME schedules the group-based restricted medium access event and announces this event to STAs in the BSS using the RPS element.

6.3.96b Segment Count distribution

6.3.96b.1 MLME-SegmentCountDistribution.request

6.3.96b.1.1 Function

This primitive requests the distribution of Segment Count information.

6.3.96b.1.2 Semantics of the service primitive

```
MLME-SEGMENTCOUNTDISTRIBUTION.request(
                                  SegmentCount
                                  )
```

Name	Type	Valid range	Description
Segment Count	Segment Count element	As defined in 8.4.2.170c (Segment Count element)	The set of TIM and page segments present in DTIM interval, if such element was present in the Beacon or Probe Response, else null. The support of a feature is described on TIM and page segmentation (see 9.32j (TIM and Page segmentation))

6.3.96b.1.3 When generated

This primitive is generated by the SME for a STA to distribute segment count information within the BSS.

6.3.96b.1.4 Effect of receipt

On receipt of this primitive, the MLME announces segment count information to STAs in the BSS using the Segment Count element.

8. Frame formats

Modify the title of sub-clause 8.2 as follows:

8.2 MAC frame formats for regular frames

8.2.4 Frame fields

8.2.4.1 Frame Control field

8.2.4.1.1 General

Editor's Note: The changes are based on 802.11REVmc D1.1.

Modify the first paragraph of subclause 8.2.4.1.1 as follows:

The first three subfields of the Frame Control field are Protocol Version, Type, and Subtype. The Control frames transmitted by S1G STAs are called S1G Control frames. The remaining subfields of the Frame Control field in S1G Control frame are different from the other frames. The remaining subfields of the Frame Control field also depend on the setting of the Type and Subtype subfields.

When the value of the Type subfield is not equal to 1 or the value of the Subtype subfield is not equal to 6, the remaining subfields within the Frame Control field of frames except S1G control frames consists of the following subfields: Protocol Version, Type, Subtype, To DS, From DS, More Fragments, Retry, Power Management, More Data, Protected Frame, and Order. In this case, the format of the Frame Control field of frames except S1G control frames is illustrated in .Figure 8-2 (Frame Control field in frames except S1G control frames when Type is not equal to 1 or Subtype is not equal to 6)

Modify the title of Figure 8-2 as follows:

	B0 B1	B2 B3	B4 B7	B8	B9	B10	B11	B12	B13	B14	B15
	Protocol Version	Type	Subtype	To DS	From DS	More Frag-ments	Re-try	Power Manage-ment	More Data	Protect-ed Frame	Or-der
Bits:	2	2	4	1	1	1	1	1	1	1	1

Figure 8-2—Frame Control field in frames except S1G control frames when Type is not equal to 1 or Subtype is not equal to 6

Modify the third paragraph of subclause 8.2.4.1.1 as follows:

When the value of the Type subfield is equal to 1 and the value of the Subtype subfield is equal to 6, the remaining subfields within the Frame Control field of frames except S1G control frames are the following: Control Frame Extension, Power Management, More Data, Protected Frame, and Order. In this case, the format of the Frame Control field of frames except S1G control frames is illustrated in Figure 8-3 (Frame Control field in frames except S1G control frames when Type is equal to 1 and Subtype is equal to 6).

Modify the title of Figure 8-3 as follows:

Figure 8-3—Frame Control field in frames except S1G control frames when Type is equal to 1 and Subtype is equal to 6

Add the following paragraphs and Figure 8-3a and Figure 8-3b after Figure 8-3 (Frame Control field when Type is equal to 1 and Subtype is equal to 6). The changes are based on 802.11 REVmc D1.1::

When the value of the Type subfield is equal to 1 and the value of the Subtype subfield is not equal to <ANA> and not equal to 10, the Frame Control field of S1G control frames consists of the following subfields: Protocol Version, Type, Subtype, Bandwidth Indication, Dynamic Indication, Power Management, More Data, Protected Frame, and Order. The format of the Frame Control field of S1G control frames is illustrated in Figure 8-3a (Frame Control field in S1G control frames when Type is equal to 1 and Subtype is not equal to <ANA> and not equal to 10).

	B0 B1	B2 B3	B4 B7	B8 B10	B11	B12	B13	B14	B15
	Protocol Version	Type	Subtype	Bandwidth Indication	Dynamic Indication	Power Manage-ment	More Data	Protect-ed Frame	Or-der
Bits:	2	2	4	3	1	1	1	1	1

Figure 8-3a—Frame Control field in S1G control frames when Type is equal to 1 and Subtype is not equal to <ANA> and not equal to 10

When the value of the Type subfield is equal to 1 and the value of the Subtype subfield is equal to <ANA>, the remaining subfields within the Frame Control field of S1G control frames are the following: Bandwidth Indication, Dynamic Indication, Next TWT Present, More Data, S1G Control Extension. In this case, the format of the Frame Control field is illustrated in Figure 8-3b (Frame Control field in S1G control frames when Type is equal to 1 and Subtype is equal to <ANA>).

	B0 B1	B2 B3	B4 B7	B8 B10	B11	B12	B13	B14 B15
	Protocol Version	Type	Subtype	Bandwidth Indication	Dynamic Indication	Next TWT Present	More Data	S1G Control Extension
Bits:	2	2	4	3	1	1	1	2

Figure 8-3b—Frame Control field in S1G control frames when Type is equal to 1 and Subtype is equal to <ANA>

When the value of the Type subfield is equal to 1 and the value of the Subtype subfield is equal to 10, the remaining subfields within the Frame Control field of S1G control frames are the following: Bandwidth Indication, Dynamic Indication, Power Management, More Data, Poll Type. In this case, the format of the Frame Control field is illustrated in Figure 8-3c (Frame Control field in S1G control frames when Type is equal to 1 and Subtype is equal to 10).

B0 B1	B2 B3	B4 B7	B8 B10	B11	B12	B13	B14 B15
Protocol Version	Type	Subtype	Bandwidth Indication	Dynamic Indication	Power Management	More Data	Poll Type

Figure 8-3c—Frame Control field in S1G control frames when Type is equal to 1 and Subtype is equal to 10

Bits: 2 2 4 3 1 1 1 2

Figure 8-3c—Frame Control field in S1G control frames when Type is equal to 1 and Subtype is equal to 10

8.2.4.1.2 Protocol Version field

Modify the first paragraph of sub-clause 8.2.4.1.2:

The Protocol Version field is 2 bits in length and is invariant in size and placement across all revisions of this standard. For this standard, the value of the protocol version is 0 for regular MAC frames per 8.2 (MAC frame formats for regular frames) or 1 for short MAC frames per 8.7 (MAC frame format for short frames). All other values are reserved. The revision level will be incremented only when a fundamental incompatibility exists between a new revision and the prior edition of the standard. See 9.24.2 (Revision level field processing).

8.2.4.1.3 Type and Subtype fields

Modify the following Table 8-2 by adding a row for S1G Control Frame Extension and modify the last value of Subtype for Reserved as follows. The changes are based on 802.11 REVmc D1.1 and 802.11ac D5.0:

Table 8-2—Valid type and subtype combinations

Type value b3 b2	Type description	Subtype value b7 b6 b5 b4	Subtype description
01	Control	0000–~~0011~~<ANA>	Reserved
01	Control	<ANA>	S1G Control Frame Extension
01	Control	0100	Beamforming Report Poll

Modify the following Table 8-2 by adding a row for Short Beacon, Short Probe Response, and Resource Allocation frames and modify the last value of Subtype for Reserved as follows. The changes are based on 802.11 REVmc D1.1 and 802.11ac D5.0:

Table 8-2—Valid type and subtype combinations

Type value b3 b2	Type description	Subtype value b7 b6 b5 b4	Subtype description
01	Control	0000–0110	Reserved
11	Extension	0000	DMG Beacon
11	Extension	<ANA>	Short Beacon
11	Extension	<ANA>	Short Probe Response

Table 8-2—Valid type and subtype combinations *(continued)*

Type value b3 b2	Type description	Subtype value b7 b6 b5 b4	Subtype description
11	Extension	<ANA>	Resource Allocation
11	Extension	<ANA>–1111	Reserved

Add the following two paragraphs and Table 8-3a (S1G Control Frame Extension) after Table 8-3(Control Frame Extension). The changes are based on 802.11 REVmc D1.1:

The Next TWT Present field is 1 bit in length and is set to 1 if the Next TWT field is present in Control frames of subtype S1G Control Frame Extension. Otherwise, it is set to 0.

The S1G Control Extension field is 2 bits in length and is used to increase the subtype space for S1G STAs by reusing b14-b15. These additional Control frames are defined in Table 8-3a (S1G Control Frame Extension).

Table 8-3a—S1G Control Frame Extension

Type value b3 b2	Subtype value b7 b6 b5 b4	S1G Control Frame Extension value b14 b15	Description
01	<ANA>	00	TACK
01	<ANA>	01	STACK
01	<ANA>	10	BAT
01	<ANA>	11	Reserved

The Poll Type field is 2 bits in length. The Poll Type bit 0 is bit 14 and Poll Type bit 1 is bit 15. The following indication is only valid when Power Management field is set to 1. Otherwise, when Power Management field is set to 0, the Poll Type bits are reserved.

Table 8-3b—Poll Type

Poll Type value b14 b15	Description
00	Requesting a buffered frame without rescheduling awake/doze cycle
01	Requesting Change Sequence/Timestamp
10	Requesting for a duration to a TBTT or Next TWT to reschedule awake/doze cycle
11	Requesting for a duration to a service period to reschedule awake/doze cycle

8.2.4.1.4 To DS and From DS fields

Modify the 4th row of Table 8-4—To/From DS combinations in Data frames as shown below:

Table 8-4—To/From DS combinations in data frames

To DS and From DS values	Meaning
To DS = 0 From DS = 0	A data frame direct from one STA to another STA within the same IBSS, a data frame direct from one non-AP STA to another non-AP STA within the same BSS, or a data frame outside the context of a BSS.
To DS = 1 From DS = 0	A data frame destined for the DS or being sent by a STA associated with an AP to the Port Access Entity in that AP.
To DS = 0 From DS = 1	A data frame exiting the DS or being sent by the Port Access Entity in an AP, or a group addressed Mesh Data frame with Mesh Control field present using the three-address MAC header format.
To DS = 1 From DS = 1	A data frame using the four-address MAC header format. This standard defines procedures for using this combination of field values only in a mesh BSS, or a BSS with Relay.

Add a new subclause 8.2.4.1.11 after subclause 8.2.4.1.10 as follows:

8.2.4.1.11 Bandwidth Indication and Dynamic Indication fields

The Bandwidth Indication field is 3 bits in length, and the dynamic Indication field is 1 bit in length. The Bandwidth Indication field identifies the bandwidth of the PPDU. The Bandwidth Indication and Dynamic Indication fields together identify the bandwidth negotiation of the TXOP. Table 8-4a (Bandwidth Indication encoding) defines the valid bandwidth indication. Table 8-4b (Dynamic Indication encoding) defines the dynamic/static indication. When the dynamic indication is set to 1, the TXOP initiator wants to negotiate TXOP bandwidth with the TXOP responder.

Table 8-4a—Bandwidth Indication encoding

Bandwidth Indication encoding	Meaning
000	1MHz
001	2MHz
010	4MHz
011	8MHz
100	16MHz
101 -- 111	Reserved

Table 8-4b—Dynamic Indication encoding

Dynamic Indication encoding	Meaning
0	Static
1	Dynamic

8.2.4.2 Duration/ID field

Modify the item a) in the first paragraph as follows:

a) In Control frames of subtype PS-Poll except the initial frame of a Speed Frame (SF) exchange in S1G, the Duration/ID field carries the association identifier (AID) of the STA that transmitted the frame in the 14 least significant bits (LSB), and the 2 most significant bits (MSB) both set to 1. The value of the AID is in the range 1-2007.

Modify Table 8-6 as follows:

.

Table 8-6—Duration/ID field encoding

Bits 0–13	Bit 14	Bit 15	Usage
0–32 767		0	Duration value (in microseconds) within all frames other than PS-Poll frames transmitted during the CP, and PS-Poll frames transmitted during the CP that are initial frames of speed frame exchange in S1G, and under HCF for frames transmitted during the CFP
0	0	1	Fixed value under point coordination function (PCF) within frames transmitted during the CFP
1–16 383	0	1	Reserved
0	1	1	~~Reserved~~AID for broadcasting in S1G, reserved if not S1G
1–2007	1	1	AID in PS-Poll frames
2008–8191	1	1	Additional AIDs in S1G PS-Poll frames, reserved if not S1G
~~2008~~8192–16 383	1	1	Reserved

8.2.5 Duration/ID field (QoS STA)

8.2.5.1 General

8.2.5.2 Setting for single and multiple protection under enhanced distributed channel access (EDCA)

Modify the following paragraph by inserting the paragraph 7) after the paragraph 6) of the paragraph a) in the sub-clause 8.2.5.2:

The Duration/ID field is determined as follows:

b) Single protection settings.

7) For PS-Poll frames as the initial frame of SF exchange from S1G STAs, the Duration/ID field is set to the estimated time required for the transmission of one ACK frame, plus the estimated time required for the transmission of the following MPDU and its response if required, plus applicable IFS durations.

8.3 Format of individual frame types

8.3.1 Control frames

8.3.1.1 Format of control frames

Change the second paragraph in subclause 8.3.1.1:

The subfields within the Frame Control field of Control frames except S1G control frames are set as illustrated in Figure 8-14 (Frame Control field subfield values within control frames except S1G control frames).

	B0 B1	B2 B3	B4 B7	B8	B9	B10	B11	B12	B13	B13	B15
	Protocol Version	Type (Control)	Subtype	To DS (0)	From DS (0)	More Frag (0)	Retry (0)	Power Man-age-ment	More Data (0)	Protected Frame (0)	Order (0)
Bits:	2	2	4	1	1	1	1	1	1	1	1

Figure 8-14—Frame Control field subfield values within control frames except S1G control frames

Add the following paragraph and Figure 8-14a after Figure 8-14:

The subfields within the Frame Control field of Control frames with bandwidth indication in MAC are set as illustrated in Figure 8-14a (Frame Control field subfield values within S1G control frames when Type is equal to 1 and Subtype is not equal to <ANA> and not equal to 10).

	B0 B1	B2 B3	B4 B7	B8 B10	B11	B12	B13	B14	B15
	Protocol Version	Type	Subtype	Bandwidth Indication	Dynamic Indication	Power Manage-ment	More Data (0)	Protect-ed Frame (0)	Or-der (0)
Bits:	2	2	4	3	1	1	1	1	1

Figure 8-14a—Frame Control field subfield values within S1G control frames when Type is equal to 1 and Subtype is not equal to <ANA> and not equal to 10

8.3.1.5 PS-Poll frame format

Modify the sub-clause as follows:

Octets:	2	2	6	6	4
	Frame Control	Duration/AID	BSSID (RA)	TA	FCS

Figure 8-18—PS-Poll frame

The BSSID is the address of the STA contained in the AP. The TA field is the address of the STA transmitting the frame. The Duration/ID field contains Duration if the PS-Poll is sent as the initial frame of a Speed Frame exchange by S1G STAs; otherwise, the Duration/ID field contains AID.

When the Duration/ID field contains a duration, the value for the field is determined according to 8.2.5 (Duration/ID field (QoS STA)).

The AID is the value assigned to the STA transmitting the frame by the AP in the association response frame that established that STA's current association.

8.3.1.6 CF-End frame format

Modify the last sentence of the sub-clause 8.3.1.6 as the following:

The Duration field is set to a value greater or equal to 0 as described in 9.19.2.7 (Truncation of TXOP).

8.3.1.19 VHT NDP Announcement frame format

Insert the following paragraph and Figure 8-29k1 at the end:

For S1G band, the same NDP announcement frame is used for sounding exchange, with "VHT" replaced by "S1G", and with the following exception:

— In Table 8-18a(STA Info subfields), Nc index field shall not indicate a value that is more than 4

	B0 B12	B13	B14 B15
	AID13	Feedback Type	Nc Index
Bits:	13	1	2

Figure 8-29k1—STA Info field when used in S1G band

8.3.1.20a BAT frame format

The frame format of the BAT frame is defined in Figure 8-29m (BAT frame format):

Octets:	2	2	2	6	1	5	0 or 6	2	2	4
	FC	Duration	RA (AID)	TA	Beacon Sequence	Partial Timestamp	Next TWT (Optional)	Starting Sequence Number	BAT Information	FCS

Figure 8-29m—BAT frame format

The RA field contains the AID of the intended recipient of the frame.

The TA field contains the address of the transmitter sending the frame.

The Beacon Sequence field contains the value of the Change Sequence Field from the most recently transmitted Beacon.

The Partial Timestamp field contains the least significant five octets of the value of the transmitting STA's TSF timer at the time that the data symbol containing the first bit of the Partial Timestamp is transmitted to the PHY plus the transmitting STA's delays through its local PHY from the MAC-PHY interface to its interface with the WM [e.g. antenna, light emitting diode (LED) emission surface].

The Next TWT field is optionally present if the Next TWT Present field is set to 1 in the FC field. Otherwise, it is not present in the BAT frame. The Next TWT field contains the next TWT value for the intended recipient of the frame given as the lowest six bytes of the TSF time for the next TWT. A value of 0 in this field means that the frame does not carry a Next TWT value.

The Starting Sequence Number field contains the sequence number of the first MSDU for which this BAT frame is sent.

The BAT Information subfield is defined in Figure 8-29n (BAT Information field):

	B0 B3	B4 B15
	BAT TID	BAT Bitmap
Bits:	4	12

Figure 8-29n—BAT Information field

The BAT TID subfield contains the TID for which this BAT frame is sent.

The BAT Bitmap subfield is 12 bits in length and is used to indicate the received status of up to 12 MSDUs and A-MSDUs. Each bit that is equal to 1 in the BAT Bitmap acknowledges the successful reception of a single MSDU or AMSDU in sequentially increasing sequence number order, with the first bit of the BAT Bitmap corresponding to the MSDU or A-MSDU with the sequence number that matches the value of the Starting Sequence Number subfield of the BAT frame.

8.3.1.20b TACK frame format

The frame format of the TACK frame is defined in Figure 8-29o (TACK frame format):

Octets:	2	2	6	6	1	5	0 or 6	4
	FC	Duration	RA (A1)	TA (A2)	Beacon Sequence	Partial Timestamp	Next TWT (Optional)	FCS

Figure 8-29o—TACK frame format

The RA field contains the address of the intended recipient of the frame.

The TA field contains the address of the transmitter sending the frame.

The Beacon Sequence field is defined in 8.3.1.20a.

The Partial Timestamp field is defined in 8.3.1.20a.

The Next TWT field is optionally present if the Next TWT Present field is set to 1 in the FC field. Otherwise, it is not present in the TACK frame. The Next TWT field is defined in 8.3.1.20a.

8.3.1.20c STACK frame format

The frame format of the STACK frame is defined in Figure 8-29p (STACK frame format):

Octets:	2	2	2	4	4
	FC	AID (RA)	TA	Partial Timestamp	FCS

Figure 8-29p—STACK frame format

The RA field contains the AID of the intended recipient of the frame.

The TA field contains the concatenation of one octet of the Service field and the least significant octet of the FCS field of the eliciting frame.

The Partial Timestamp field is defined in 8.3.1.20a.

8.3.2 Data frames

8.3.2.1 Data frame format

Modify Table 8-23 and add the notes below the Table as the following:

Table 8-23—Address field contents

To DS	From DS	Address 1	Address 2	Address 3		Address 4	
				MSDU case	A-MSDU case	MSDU case	A-MSDU case
0	0	RA = DA	TA = SA	BSSID	BSSID	N/A	N/A
0	1	RA ~~= DA~~	TA = BSSID	SA	BSSID	N/A	N/A
1	0	RA = BSSID	TA ~~= SA~~	DA	BSSID	N/A	N/A
1	1	RA	TA	DA	BSSID	SA	BSSID

Note- Address 1 field of a frame with To DS set to 0 and From DS set to 1 is equal to the DA, except when an individually addressed A-MSDU frame is used in DMS and Relay, in which case, the destination address of the frame is included in DA field of the A-MSDU subframe (see 10.23.15 and 9.32n (Relay operation)).

Note- Address 2 field of a frame with To DS set to 1 and From DS set to 0 is equal to the SA, except when an individually addressed A-MSDU frame is used in Relay, in which case, the source address of the frame is included in SA field of the A-MSDU subframe (see 9.32n (Relay operation)).

8.3.3 Management frames

8.3.3.1 Format of management frames

8.3.3.2 Beacon frame format

Modify Table 8-24 in Clause 8.3.3.2 by inserting the following rows :

Table 8-24—Beacon frame body

Order	Information	Notes
TBD	RPS	The RPS element is present in Beacon frames generated by APs for medium access of a group of STAs. This element is present if dot11RAWOptionActivated is true.
TBD	Segment Count	The Segment Count element is used for indication of TIM and page segments served in DTIM intervals. This element is present if dot11TIMSegmentSupported is true.
TBD	Sector Operation	The AP provides via this element the information related to the sector duration and sector periodicity or Sector Training when dot11S1GSectorizationActivated is true and dot11S1GSectorizationBeaconElement is true.

Table 8-24—Beacon frame body

TBD	Subchannel Selective Trans-mission	The Subchannel Selective Transmission element is optionally present if dot11SubchannelSelectiveTransmissionActivated is true.
TBD	Authentication Control	The Authentication Control element is present when dot11S1GAuthenticationControlActivated is true.
TBD	TSF Timer Accuracy	The TSF Timer Accuracy element is optionally present when the dot11TSFTimerAccuracyImpemented is true.
TBD	Relay	The Relay element is optionally present if dot11RelayCapable is true.
TBD	Change Sequence	The Change Sequence is optionally present if dot11ShortBeaconOptionImplemented is true.
TBD	S1G Capabilities	S1G Capabilities element is optionally present if dot11S1GOptionImplemented is true.

8.3.3.5 Association Request frame format

Editor's Note: Changes based on 802.11REVmc D1.1

Modify Table 8-26 in Clause 8.3.3.5 by inserting the following rows:

Table 8-26—Association Request frame body

Order	Information	Notes
TBD	TWT	The Target Wake Time element is optionally present if dot11TargetWakeTimeOptionImplemented is true.
TBD	Sector Capabili-ties	The Sector Capabilities element is present when the dot11S1GSectorImplemented is true.
TBD	AID Request	The AID Request element is optionally present if dot11S1GOptionImplemented is true.
TBD	S1G Capabilities	S1G Capabilities element is optionally present if dot11S1GOptionImplemented is true.

8.3.3.6 Association Response frame format

Editor's Note: Changes based on 802.11REVmc D1.1

Change the row of Order 3 and Order 13 in Table 8-27 Association Response frame body as the following:

Order	Information	Notes
3	AID	This field is not present when the dot11S1GOptionImpemented is true.

13	Timeout Interval (Association Comeback time)	A Timeout Interval element (TIE) containing the Association Comeback time is present when dot11RSNAActivated is true, dot11RSNAProtectedManagementFramesActivated is true, and either the association request is rejected with a status code 30 or the association request is accepted with a status code 0.

Modify Table 8-27 in Clause 8.3.3.6 by inserting the following rows:

Table 8-27—Association Response frame body

Order	Information	Notes
TBD	Sector Operation	The AP provides via this element the information related to the sector duration and sector periodicity or Sector Training when dot11S1GSectorizationActivated is true.
TBD	TWT	The Target Wake Time element is present if dot11TargetWakeTimeOptionImplemented is true and the Target Wake Time element is present in the Association Request frame that elicited this Association Response frame.
TBD	Sector Capabili-ties	The Sector Capabilities element is present when the dot11S1GSectorImplemented is true.
TBD	TSF Timer Accuracy	The TSF Timer Accuracy element is optionally present when the dot11TSFTimerAccuracyImpemented is true.
TBD	S1G Capabilities	S1G Capabilities element is optionally present if dot11S1GOptionImplemented is true.
TBD	AID Response	The AID Response element is present when the dot11S1GOptionImpemented is true.
TBD	Group ID List	A Group ID List is added when the dot11S1GSectorizationActivated is true and indicates new membership groups for a receiving STA

8.3.3.7 Reassociation Request frame format

Editor's Note: Changes based on 802.11REVmc D1.1

Change the row of Order 15 in Table 8-28 Association Response frame body as the following:

Order	Information	Notes
15	Timeout Interval (Associa-tion Comeback time)	A TIE containing the Association Comeback time is present when dot11RSNAActivated is true, dot11RSNAProtectedManagementFramesActivated is true, and either the reassociation is rejected with status code 30 or the reassociation request is accepted with a status code 0.

Modify Table 8-28 in Clause 8.3.3.7 by inserting the following rows:

Table 8-28—Reassociation Request frame body

Order	Information	Notes
TBD	TWT	The Target Wake Time element is optionally present if dot11TargetWakeTimeOptionImplemented is true.
TBD	Sector Capabili-ties	The Sector Capabilities element is present when the dot11S1GSectorImplemented is true.
TBD	AID Request	The AID Request element is present when the dot11S1GOptionImpemented is true.
TBD	S1G Capabilities	S1G Capabilities element is optionally present if dot11S1GOptionImplemented is true.

8.3.3.8 Reassociation Response frame format

Editor's Note: Changes based on 802.11REVmc D1.1

Change the row of Order 3 in Table 8-29 Reassociation Response frame body as the following:

Order	Information	Notes
3	AID	This field is not present when the dot11S1GOptionImpemented is true.

Modify Table 8-29 in Clause 8.3.3.8 by inserting the following rows:

Table 8-29—Reassociation Response frame body

Order	Information	Notes
TBD	Sector Operation	The AP provides via this element the information related to the sector duration and sector periodicity or sector Training when dot11S1GSectorizationActivated is true.
TBD	TWT	The Target Wake Time element is present if dot11TargetWakeTimeOptionImplemented is true and the Target Wake Time element is present in the Reassociation Request frame that elicited this Reassociation Response frame.
TBD	Sector Capabili-ties	The Sector Capabilities element is present when the dot11S1GSectorImplemented is true.
TBD	TSF Timer Accuracy	The TSF Timer Accuracy element is optionally present when the dot11TSFTimerAccuracyImpemented is true.
TBD	S1G Capabilities	The S1G Capabilities element is optionally present if dot11S1GOptionImplemented is true.

Table 8-29—Reassociation Response frame body

TBD	AID Response	The AID Response element is present when the dot11S1GOptionImpemented is true.

8.3.3.9 Probe Request frame format

Modify Table 8-30 in Clause 8.3.3.9 by inserting the following rows:

Table 8-30—Probe Request frame body

Order	Information	Notes
TBD	Change Sequence	The Change Sequence is optionally present if dot11ShortBeaconOptionImplemented is true.
TBD	Relay Discovery	The Relay Discovery is optionally present if TBD is true.
TBD	ProbeResponse-Option	The ProbeResponseOption is optionally present if dot11S1GOptionImplemented is true.
TBD	S1G Capabilities	S1G Capabilities element is optionally present if dot11S1GOptionImplemented is true.

8.3.3.10 Probe Response frame format

Modify Table 8-31 in Clause 8.3.3.10 by inserting the following rows:

Table 8-31—Probe Response frame body

Order	Information	Notes
TBD	RPS	The RPS element is present only within Probe Response frames generated by APs for medium access of STAs.
TBD	Segment Count	The Segment Count element is used for indication of TIM and page segments present in DTIM intervals.
TBD	ProbeResponseOption	The ProbeResponseOption element is optionally present if dot11S1GOptionImplemented is true.
TBD	Change Sequence	The Change Sequence is optionally present if dot11ShortBeaconOptionImplemente d is true.

Table 8-31—Probe Response frame body

TBD	TSF Timer Accuracy	The TSF Timer Accuracy element is optionally present when the dot11TSFTimerAccuracyImpemented is true.
TBD	Relay Discovery	The Relay Discovery is optionally present if TBD is true.
TBD	Relay	The Relay element is optionally present if dot11RelayCapable is true.
TBD	S1G Capabilities	S1G Capabilities element is optionally present if dot11S1GOptionImplemented is true.

8.3.4 Extension frames

Insert the following new sub-clauses after 8.3.4 as the following:

8.3.4.1a Short Beacon frame format

The format of the Short Beacon is shown in Figure 8-34e (Short Beacon frame format).

	FC	SA	Timestamp	Change Sequence	Next TBTT	Compressed SSID	Access Network Options	Optional elements	FCS
Octets:	2	6	4	1	3	4	1	variable	4

Figure 8-34e—Short Beacon frame format

The SA field is the address of the STA transmitting the Short Beacon.

The Timestamp field is the 4 least significant bytes of the TSF of the transmitting STA.

The Change Sequence field is defined as an unsigned integer initialized to 0, that increments when a critical update to the Beacon frame has occurred (see 10.43c.1 (System information update procedure)).

The Next TBTT field is optionally present and indicates the most significant 3 bytes of the 4 least significant bytes of the next TBTT.

The Compressed SSID field is optionally present and indicates a 32-bit CRC calculated as defined in 8.2.4.8 FCS field, wherein the *calculation fields* is the SSID field in the Beacon frame.

The Access Network Options field is defined in 8.4.2.94 Interworking element (see Figure 8-352—Access Network Options field format).

Optional elements can be present, as described in TBD.

The format of the FC field of the Short Beacon is shown in Figure 8-34f (FC field format).

	Protocol Version	Type	Subtype	Next TBTT Present	SSID Present	Interworking Present	BSS BW	Security	Reserved
Bits:	2	2	4	1	1	1	3	1	1

Figure 8-34f—FC field format

The Next TBTT Present field is set to 1 if the Next TBTT field is present; otherwise it is set to 0.

The SSID Present field is set to 1 if the Compressed SSID field is present; otherwise it is set to 0.
The Internetworking Present field is set to 1 if the Access Network Options field is present; otherwise it is set to 0.

The BSS BW field indicates the current operating bandwidth of the BSS.

Table 8-33b—FC field BSS BW setting

BSS BW	BW [MHz]
0	1
1	2
2	4
3	8
4	16
5-7	Reserved

The Security field is set to 1 if the AP is an RSNA AP.

8.3.4.15b Resource Allocation frame format

The Resource Allocation frame is transmitted to all STAs within a RAW Group (see 8.4.2.170b) to indicate presence of downlink buffered data for paged STAs and their assigned time slots for both uplink and downlink service periods. The Resource Allocation frame contains Frame Control, Duration, TA, BSSID, RAW Group, RAW Duration, Group Indicator, Slot Assignment, and FCS fields. The Resource Allocation frame format is illustrated in Figure 8-37g (Resource Allocation frame format).

Octets:	2	2	2	6	3	TBD		TBD		TBD	4
	FC	Duration	TA	BSSID	RAW Group	RAW Duration	Group Indicator	Slot Assignment 1	...	Slot Assignment N	FCS
Bits:							1				

Figure 8-37g—Resource Allocation frame format

Bits:	1	6	TBD
	EOM	Group ID	Slot Start Offset

Figure 8-37h—Slot Assignment field when the Group Indicator field is set to 1

Bits:	1	TBD	TBD
	UL/DL	Partial AID	Slot Start Offset

Figure 8-37i—Slot Assignment field when the Group Indicator field is set to 0

The Frame Control field is as defined in 8.2.4.1 (Frame Control field) and illustrated in 8-2 (Frame Control field in frames except S1G control frames when Type is not equal to 1 or Subtype is not equal to 6).

The Duration field is as defined in 8.2.5 (Duration/ID field (QoS STA))

The TA field indicates the partial MAC address of the AP transmitting the resource allocation frame.

The BSSID is an identifier that uniquely identifies the BSS and is defined in 8.2.4.3.4.

The RAW Group indicates the STA AIDs that are assigned the RAW as defined in 8.4.2.170b (RPS element).

The RAW Duration field indicates the duration of the current RAW where the Resource Allocation frame is transmitted. The format of the RAW Duration field is defined in 8.4.2.170b (RPS element).

Group Indicator of length 1bit indicates whether any subfield of MU group is included or no subfield of MU group exists in the Slot Assignment field.

The Slot Assignment field indicates to each of the STA / MU group of STAs' addresses and their corresponding slot(s) of medium access within the current RAW. This field is of length 2 octets for each MU Group and TBD octets for each STA. The Slot Assignment field contains EOM Indicator, Group ID, and Slot Start Offset for each MU group of STAs or UL / DL Indicator, Partial AID, and Slot Start Offset for each STA. The subfield for MU group of STAs is located first at the beginning of the Slot Assignment field, if exists.

Within the Slot Assignment field, the UL /DL Indicator subfield indicates whether the first data transmitted in the assigned RAW slot shall be used for UL or DL direction. This subfield is of length 1 bit and when the bit is set to 0, it indicates DL traffic and UL traffic when the bit is set to 1. Since MU MIMO can only be used for DL traffic, the first bit, as called EOM Indicator, for the MU group block indicates whether its following subfields are used for the last MU group when the bit is set to 1 or more MU groups exist after subfields for this MU group when the bit is set to 0. The next subfield indicates either a Partial AID for an assigned STA or a MU Group ID for MU group. The Slot Start Offset subfield indicates the start time slot of STA's medium access, relative to the end of the RA frame transmission, in TBD units.

8.3.4.15c Short Probe Response frame format

The Short Probe Response frame is a shortened version of Probe Response frame and it can be used instead of Probe Response frame as described in 10.1.4.1, 10.1.4.3.1, and 10.1.4.3.2. The Short Probe Response frame is shown in Figure 8-37j (Short Probe Response frame format).

	FC	DA	SA	Timestamp	Chance Sequence	Next TBTT (Optional)	Compressed SSID	Access Network Options (optional)	Optional IEs	FCS
Octets:	2	6	6	4	1	3	4	1	variable	4

Figure 8-37j—Short Probe Response frame format

The Short Probe Response frame contains Timestamp, Change Sequence, and either Compressed SSID or full SSID. It optionally contains Next TBTT, Access Network Options, and Optional IEs.

The Timestamp field is the 4 least significant bytes of the TSF timer value of the transmitting STA.

Change Sequence field is defined as an unsigned integer initialized to 0, that increments when a critical update to the Beacon frame has occurred.

The Compressed SSID field indicates a 32-bit CRC calculated as defined in 8.2.4.8 FCS field, wherein the calculation fields is the SSID field in the Probe Response frame or Beacon frame.

When a Full SSID is requested to be included in the Short Probe Response frame, then SSID element as defined in 8.4.2.2 is included in the Optional IEs part of the Short Probe Response frame.

The Next TBTT field is optionally present and indicates the most significant 3 bytes of the 4 least significant bytes of the next TBTT.

The Access Network Options field is optionally present and is defined in 8.4.2.94 (Interworking element).

The Short Beacon Compatibility element as defined in 8.4.2.170g (Short Beacon Compatibility element) can be included in the Optional IEs part of the Short Probe Response frame.

Other optional elements can be included in the Optional IEs part of the Short Probe Response frame.

The Frame Control field of the Short Probe Response frame is shown in Figure 8-37k (Frame Control field of Short Probe Response frame format).

	Protocol Version	Type	Subtype	Next TBTT Present	Full SSID Present	Interworking Present	BSS BW	Security	Reserved
Bits:	2	2	4	1	1	1	3	1	1

Figure 8-37k—Frame Control field of Short Probe Response frame format

The Frame Control field of the Short Probe Response frame contains Next TBTT present field, Full SSID Present field, Internetworking Present field, BSS Bandwidth field and Security field.

The Next TBTT present field is set to 1 if the Next TBTT field is included in the Short Probe Response frame and otherwise set to 0.

The Full SSID Present field indicates whether a Full SSID or a Compressed SSID is included in the Short Probe Response frame. If it is set to 1, it indicates that a Full SSID is included in the Short Probe Response frame. If it is set to 0, it indicates that a Compressed SSID is included in the Short Probe Response frame.

The Interworking Present field is set to 1 if the Access Network Options field is present; otherwise it is set to 0.

The BSS Bandwidth field indicates the current operating bandwidth of the BSS and is defined in Table 8-33b (FC field BSS BW setting).

Security field is set to 1 if the AP is an RSNA AP.

Insert the following new sub-clauses after 8.3.4 as the following:

8.3.4a NDP MAC frames

Several NDP MAC frame formats are defined to decrease MAC protocol overhead in S1G BSS. An NDP MAC frame is indicated by setting the value of the NDP Indication subfield to 1 in the SIG field. Subclause 8.3.4a describes the NDP MAC frame body content in each of NDP MAC frame types defined in Table 8-33c (NDP MAC frame type field values).

Table 8-33c—NDP MAC frame type field values

Value	Meaning	See subclause
0	NDP CTS (control frame)	8.3.4a.1.1
1	NDP PS-Poll (control frame)	8.3.4a.1.2

Table 8-33c—NDP MAC frame type field values

2	NDP ACK (control frame)	8.3.4a.1.3
3	NDP Modified ACK (control frame)	8.3.4a.1.4
4	NDP Block ACK (control frame)	8.3.4a.1.5
5	NDP Beamforming Report Poll (control frame)	8.3.4a.1.6
6	NDP Paging (control frame)	8.3.4a.1.7
7	NDP Probe Request (management frame)	8.3.4a.2.1

8.3.4a.1 NDP control frame details

8.3.4a.1.1 NDP CTS

The NDP MAC frame body of the NDP CTS frame contains NDP MAC Frame Type, Address Indicator, RA Address or Partial BSSID, Duration, Early Sector Indicator, Reserved subfields. The SIG field frame format is illustrated in Table 8-33d (NDP MAC frame body of NDP CTS (1 MHz)) and Table 8-33e (NDP MAC frame body of NDP CTS (≥ 2MHz)).

Table 8-33d—NDP MAC frame body of NDP CTS (1 MHz)

Field	Size (bits)	Description
NDP MAC Frame Type	3	NDP MAC Frame Type field is set to 0.
Address Indicator	1	Indicates whether the following subfield is an RA or a Partial BSSID. This field is of length 1 bit and when set to 0 indicates that the following field represents a unicast STA address. In the case that NDP CTS is used in the sector training, the field is set to the Partial BSSID. The Address Indicator bit set to 1 indicates that the following field represents a Partial BSSID.
RA Address / Partial BSSID	9	Indicates whether the value is an RA or a Partial BSSID. If the value indicates an RA address, then the NDP CTS frame is intended AID for a unicast STA. If the value indicates a Partial BSSID, then it indicates a broadcast address.
Duration	10	As defined for the Duration field in 8.3.1.3 CTS frame format and is expressed in OFDM symbol time (40 µs). In the case that NDP CTS is used in the sector training, the relative value of the Duration field in the NDP CTS to the value of the Duration field in the frame which carries the NDP Announcement in the HT Control field for initiating the sector training is used to deduct the Sector ID the current NDP CTS is transmitted to.
Early Sector Indicator	1	The Early Sector Indicator facilitates the detection of Spatially Orthogonal conditions by the stations receiving the short CTS frame. If the Early Sector Indicator is set to 1, it indicates that the short CTS frame is followed by the sectorized beam frame exchange. If the Early Sector Indicator is set to 0, it indicates that the NDP CTS frame is not followed by the sectorized beam frame exchange.

Table 8-33d—NDP MAC frame body of NDP CTS (1 MHz)

Reserved	1	Reserved for future use

Table 8-33e—NDP MAC frame body of NDP CTS (≥ 2MHz)

Field	Size (bits)	Description
NDP MAC Frame Type	3	NDP MAC Frame Type field is set to 0.
Address Indicator	1	Indicates whether the following subfield is an RA or a Partial BSSID. This field is of length 1 bit and when set to 0 indicates that the following field represents a unicast STA address. In the case that NDP CTS is used in the sector training, the field is set to the Partial BSSID. The Address Indicator bit set to 1 indicates that the following field represents a Partial BSSID.
RA Address / Partial BSSID	9	Indicates whether the value is an RA or a Partial BSSID. If the value indicates an RA, then the NDP CTS frame is intended AID for a unicast STA. If the value indicates a Partial BSSID, then it indicates a broadcast address.
Duration	15	As defined for the Duration field in 8.3.1.3 CTS frame format and is expressed in μs. In the case that NDP CTS is used in the sector training, the relative value of the Duration field in the NDP CTS to the value of the Duration field in the frame which carries the NDP Announcement in the HT Control field for initiating the sector training is used to deduct the Sector ID the current NDP CTS is transmitted to.
Early Sector Indicator	1	The Early Sector Indicator facilitates the detection of Spatially Orthogonal conditions by the stations receiving the short CTS frame. If the Early Sector Indicator is set to 1, it indicates that the short CTS frame is followed by the sectorized beam frame exchange. If the Early Sector Indicator is set to 0, it indicates that the NDP CTS frame is not followed by the sectorized beam frame exchange.
Reserved	8	Reserved for future use

8.3.4a.1.2 NDP PS-Poll

NDP MAC frame body of NDP PS-Poll frame contains the information listed in Table 8-33f (NDP MAC frame body of NDP PS-Poll (1MHz)) and Table 8-33g (NDP MAC frame body of NDP PS-Poll (≥ 2MHz)).

The NDP MAC frame body of NDP PS-Poll for 1MHz has the structure defined in Table 8-33f (NDP MAC frame body of NDP PS-Poll (1MHz)).

Table 8-33f—NDP MAC frame body of NDP PS-Poll (1MHz)

Field	Size (bits)	Description
NDP MAC Frame Type	3	NDP MAC Frame Type field is set to 1
RA	9	PARTIAL_AID addressed to AP as described in 9.17b

Table 8-33f—NDP MAC frame body of NDP PS-Poll (1MHz)

TA	9	PARTIAL_AID addressed to a STA as described in 9.17b
Preferred MCS	TBD	TBD
UDI	1	Se to 0: no uplink data Set to 1: uplink data present
Reserved	TBD	

The NDP MAC frame body of NDP PS-Poll for >=2MHz has the structure defined in Table 8-33g (NDP MAC frame body of NDP PS-Poll (≥ 2MHz)).

Table 8-33g—NDP MAC frame body of NDP PS-Poll (≥ 2MHz)

Field	Size (bits)	Description
NDP MAC Frame Type	3	NDP MAC Frame Type field is set to 1
RA	9	PARTIAL_AID addressed to AP as described in 9.17b
TA	9	PARTIAL_AID addressed to a STA as described in 9.17b
Preferred MCS	4	Preferred MCS field indicates the preferred MCS level of the STA for downlink transmission, and its value represents MCS index.
UDI	12	Set to 0: No uplink data Set to Non-zero: Duration of uplink data in unit of TU.

8.3.4a.1.3 NDP ACK

NDP MAC frame body of NDP ACK frame contains the information listed in Table 8-33h (NDP MAC frame body of NDP ACK(1MHz)) and Table 8-33i (NDP MAC frame body of NDP ACK (≥ 2MHz)). The NDP ACK frame used to respond to all frames other than a NDP PS-Poll frame is responded by a NDP ACK frame described in this sub-clause.

The NDP MAC frame body of NDP ACK for 1MHz has the structure defined in Table 8-33h (NDP MAC frame body of NDP ACK(1MHz)).

Table 8-33h—NDP MAC frame body of NDP ACK(1MHz)

Field	Size (bits)	Description
NDP MAC Frame Type	3	NDP MAC Frame Type field is set to 2

Table 8-33h—NDP MAC frame body of NDP ACK(1MHz)

ACK ID	TBD	The ACK ID field is TBD bits in length and computed based on the partial FCS and the information from the scrambling seed in the SERVICE field of the frame being acknowledged for the computation of the ACK ID for the NDP ACK frame. The computation method is TBD.
More Data	1	The More Data field is described in 8.2.4.1.8.
Duration Indication	1	The Duration Indication field is 1 bit in length. It is used to indicate whether the duration is the time of no data transmission (i.e., wakeup timer) for the STA (Duration Indication = 1) or the channel access reservation time following current NDP ACK (Duration Indication = 0).
Duration	TBD	The Duration field is TBD bits in length for 1 MHz. It is used to indicate either the period of time that there will be no data transmission for the STA being acknowledged if Duration Indication is set to 1, or the duration for all frames transmitted during CP, and under HCF for frames transmitted during the CFP, if Duration Indication is set to 0. The time unit is TBD.
Relayed Frame	1	The Relayed Frame field when set to 1 indicates the current TXOP is shared with the Relay STA using Explicit ACK procedure as described in 9.32n.3.1 (Explicit ACK procedure). The Relayed Frame field may be set to 1 only if the More Data field was set to 0 in the frame most recently received from the non-AP STA.
Reserved	TBD	

The NDP MAC frame body of NDP ACK for >=2MHz has the structure defined in Table 8-33i (NDP MAC frame body of NDP ACK (≥ 2MHz)).

Table 8-33i—NDP MAC frame body of NDP ACK (≥ 2MHz)

Field	Size (bits)	Description
NDP MAC Frame Type	3	NDP MAC Frame Type field is set to 2
ACK ID	TBD	The ACK ID field is TBD bits in length and computed based on the partial FCS and the information from the scrambling seed in the SERVICE field of the frame being acknowledged for the computation of the ACK ID for the NDP ACK frame. The computation method is TBD.
More Data	1	The More Data field is described in 8.2.4.1.8.
Duration Indication	1	The Duration Indication field is 1 bit in length. It is used to indicate whether the duration is the time of no data transmission (i.e., wakeup timer) for the STA (Duration Indication = 1) or the channel access reservation time following current NDP ACK (Duration Indication = 0).
Duration	TBD	The Duration field is TBD bits in length for the bandwidth equal or larger than 2 MHz. It is used to either indicate the period of time that there will be no data transmission for the STA being acknowledged if Duration Indication is set to 1, or the duration for all frames transmitted during CP, and under HCF for frames transmitted during the CFP, if Duration Indication is set to 0. The time unit is TBD.

Table 8-33i—NDP MAC frame body of NDP ACK (≥ 2MHz)

Relayed Frame	1	The Relayed Frame field when set to 1 indicates the current TXOP is shared with the Relay STA using the Explicit ACK procedure as described in 9.32n.3.1 (Explicit ACK procedure). The Relayed Frame field may be set to 1 only if the More Data field was set to 0 in the frame most recently received from the non-AP STA.
Reserved	TBD	

8.3.4a.1.4 NDP Modified ACK

NDP MAC frame body of NDP Modified ACK frame contains the information listed in Table 8-33j (NDP MAC frame body of NDP Modified ACK (1MHz)) and Table 8-33k (NDP MAC frame body of NDP Modified ACK (≥ 2MHz)). The NDP Modified ACK frame used to respond to a NDP PS-Poll frame is described in this sub-clause.

The NDP MAC frame body of NDP Modified ACK for 1MHz has the structure defined in Table 8-33j (NDP MAC frame body of NDP Modified ACK (1MHz)).

Table 8-33j—NDP MAC frame body of NDP Modified ACK (1MHz)

Field	Size (bits)	Description
NDP MAC Frame Type	3	NDP MAC Frame Type field is set to 3
ACK ID	18-21	The ACK ID field is 18-21 bits in length and computed based on RA, TA and CRC fields of received NDP PS-Poll frame. The computation method is TBD.
More Data	1	The More Data field is described in 8.2.4.1.8.
Reserved	TBD	

The NDP MAC frame body of NDP Modified ACK for >=2MHz has the structure defined in Table 8-33k (NDP MAC frame body of NDP Modified ACK (≥ 2MHz)).

Table 8-33k—NDP MAC frame body of NDP Modified ACK (≥ 2MHz)

Field	Size (bits)	Description
NDP MAC Frame Type	3	NDP MAC Frame Type field is set to 3
ACK ID	18-21	The ACK ID field is 18-21 bits in length and computed based on RA, TA and CRC fields of received NDP PS-Poll frame. The computation method is TBD.

Table 8-33k—NDP MAC frame body of NDP Modified ACK (≥ 2MHz)

More Data	1	The More Data field is described in 8.2.4.1.8.
Duration Indication	1	The Duration Indicate field is described in 8.3.4a.1.3.
Duration	TBD	The Duration field is described in 8.3.4a.1.3.
Reserved	TBD	

8.3.4a.1.5 NDP Block ACK

NDP MAC frame body of NDP Block ACK frame contains the information listed in Table 8-33l (NDP MAC frame body of NDP Block ACK (1MHz)) and Table 8-33m (NDP MAC frame body of NDP Block ACK (≥ 2MHz)).

Table 8-33l—NDP MAC frame body of NDP Block ACK (1MHz)

Field	Size (bits)	Description
NDP MAC Frame Type	3	NDP MAC Frame Type field is set to 4.
BlockAck ID	TBD	The BlockAck ID field is TBD bits in length and contains the identifier of the NDP BlockAck frame. It is set to the TBD LSBs of the Scrambler (as defined in 20.3.11.3 (Scrambler)) of the PSDU that carries the soliciting A-MPDU or the BlockAckRequest.
Starting Sequence Control	12	The Starting Sequence Control field is 12 bits in length and contains the sequence number of the first MSDU or A-MSDU for which the NDP BlockAck frame is sent. The value of this field is defined in 9.21.7.5 (Generation and transmission of BlockAck by an HT STA).
BlockAck Bitmap	TBD	The Block Ack Bitmap field of the NDP BlockAck frame is TBD bits in length and is used to indicate the received status of up to TBD MSDUs and A-MSDUs. Each bit that is equal to 1 in the NDP Block Ack bitmap acknowledges the successful reception of a single MSDU or A-MSDU in the order of sequence number, with the first bit of the NDP Block Ack bitmap corresponding to the MSDU or A-MSDU with the sequence number that matches the value of the Starting Sequence Control field.

The NDP MAC frame body of NDP Block ACK for >=2MHz has the structure defined in Table 8-33m (NDP MAC frame body of NDP Block ACK (≥ 2MHz)).

Table 8-33m—NDP MAC frame body of NDP Block ACK (≥ 2MHz)

Field	Size (bits)	Description
NDP MAC Frame Type	3	NDP MAC Frame Type field is set to 4.

Table 8-33m—NDP MAC frame body of NDP Block ACK (≥ 2MHz)

BlockAck ID	TBD	The BlockAck ID field is TBD bits in length and contains the identifier of the NDP BlockAck frame. It is set to the TBD LSBs of the Scrambler (as defined in 20.3.11.3 (Scrambler)) of the PSDU that carries the soliciting A-MPDU or the BlockAckRequest.
Starting Sequence Control	12	The Starting Sequence Control field is 12 bits in length and contains the sequence number of the first MSDU or A-MSDU for which the NDP BlockAck frame is sent. The value of this field is defined in 9.21.7.5 (Generation and transmission of BlockAck by an HT STA).
BlockAck Bitmap	TBD	The Block Ack Bitmap field of the NDP BlockAck frame is TBD bits in length and is used to indicate the received status of up to TBD MSDUs and A-MSDUs. Each bit that is equal to 1 in the NDP Block Ack bitmap acknowledges the successful reception of a single MSDU or A-MSDU in the order of sequence number, with the first bit of the NDP Block Ack bitmap corresponding to the MSDU or A-MSDU with the sequence number that matches the value of the Starting Sequence Control field.

8.3.4a.1.6 NDP Beamforming Report Poll

The NDP MAC frame body of NDP Beamforming Report Poll for >=2MHz has the structure defined in Table 8-33n (NDP MAC frame body of NDP Beamforming Report Poll (≥ 2MHz)).

Table 8-33n—NDP MAC frame body of NDP Beamforming Report Poll (≥ 2MHz)

Field	Size (bits)	Description
NDP MAC Frame Type	3	NDP MAC Frame Type field is set to 5.
TA (AP Address)	9	Indicate Partial AID of the AP (beamformer)
RA (STA Address)	13	Indicate AID of intended STA (beamformee)
ACK Indication	2	Set to 11 to indicate a following Beamforming Report Poll; Otherwise, set to 00.
Feedback Segment retransmission bitmap	8	Indicate the feedback segments to be polled in a VHT Compressed Beamforming report, which is contained in one or more VHT Compressed Beamforming frames
Reserved	2	Reserved bit

8.3.4a.1.7 NDP Paging

The NDP MAC frame body of NDP Paging frame contains the information shown in Table 8-33o (NDP MAC frame body of NDP Paging (1 MHz))

Table 8-33o—NDP MAC frame body of NDP Paging (1 MHz)

Field	Size (bits)	Description
NDP MAC Frame Type	3	NDP MAC Frame Type field is set to 6.
P-ID	9	The P-ID field is the identifier of the paged STA, as described in 9.32f.5 (NDP Paging Setup).
APDI	8	The 7 MSBs of the APDI are set to the value of the PTSF field which stores the partial TSF of the transmitting STA as defined in 9.32f.5 (NDP Paging Setup). The LSB of the APDI is set to the Check Beacon bit that is an indicator of critical changes in the beacon as described in 9.32f.5 (NDP Paging Setup).
Reserved	5	All reserved bits are set to 1.

The NDP MAC frame body of NDP Paging frame contains the information shown in Table 8-33p (NDP MAC frame body of NDP Paging (≥ 2MHz))

Table 8-33p—NDP MAC frame body of NDP Paging (≥ 2MHz)

Field	Size (bits)	Description
NDP MAC Frame Type	3	NDP MAC Frame Type field is set to 6.
P-ID	9	The P-ID field is the identifier of the paged STA, as described in 9.32f.5 (NDP Paging Setup).
APDI	8	The 7 MSBs of the APDI are set to the value of the PTSF field which stores the partial TSF of the transmitting STA as defined in 9.32f.5 (NDP Paging Setup). The LSB of the APDI is set to the Check Beacon bit that is an indicator of critical changes in the beacon as described in 9.32f.5 (NDP Paging Setup).
Reserved	17	All reserved bits are set to 1.

8.3.4a.2 NDP management frame details

8.3.4a.2.1 NDP Probe Request

The NDP MAC frame body of NDP Probe Request frame contains the information shown in Table 8-33q (NDP MAC frame body of NDP Probe Request (1MHz)) and Table 8-33r (NDP MAC frame body of NDP Probe Request (≥ 2MHz)). See additional details and procedures in 10.1.4.3.4.

The NDP MAC frame body of NDP Probe Request for 1MHz has the structure defined in Table 8-33q (NDP MAC frame body of NDP Probe Request (1MHz)).

Table 8-33q—NDP MAC frame body of NDP Probe Request (1MHz)

Field	Size (bits)	Description
NDP MAC Frame Type	3	NDP MAC Frame Type field is set to 6.
SSID/ Interworking Present	1	Indicates the desired criteria of the probe response. Set to 0 if the NDP Propbe Request contains the desired SSID. Set to 1 if the NDP Propbe Request contains the Access Network Option.
Compressed SSID/Access Network Option	16	When SSID/Interworking Present bit field is set 0, Bit 4 – 19 are set to Compressed SSID which is the 2 LSBs of 32-bit CRC calculated as defined 8.2.4.8 FCS field, wherein the calculated fields is the desired SSID. When SSID/Interworking Present bit field is set 1, Bit 4 – 11 are set to Access Network Option which is defined in 8.4.2.94 Interworking element (see Figure 8-352-Access Network Options field format). Bit 12 – 19 are reserved.
Reserved	5	Reserved. Set to 1.

The NDP MAC frame body of NDP Probe Request for >=2MHz has the structure defined in Table 8-33r (NDP MAC frame body of NDP Probe Request (≥ 2MHz)).

Table 8-33r—NDP MAC frame body of NDP Probe Request (≥ 2MHz)

Field	Size (bits)	Description
NDP MAC Frame Type	3	NDP MAC Frame Type field is set to 6.
SSID/ Interworking Present	1	Indicates the desired criteria of the probe response. Set to 0 if the NDP Propbe Request contains the desired SSID. Set to 1 if the NDP Propbe Request contains the Access Network Option.
Compressed SSID/Access Network Option	32	When SSID/Interworking Present bit field is set 0, Bit 4 – 35 are set to Compressed SSID which is 32-bit CRC calculated as defined 8.2.4.8 FCS field, wherein the calculated fields is the desired SSID. When SSID/Interworking Present bit field is set 1, Bit 4 – 11 are set to Access Network Option which is defined in 8.4.2.94 Interworking element (see Figure 8-352-Access Network Options field format). Bit 12 – 35 are reserved.
Reserved	1	Reserved. Set to 1.

8.4 Management frame body components

8.4.1 Fields that are not information elements

8.4.1.6 Listen Interval field

Modify the first paragraph of sub-clause 8.4.1.6 as follows:

The Listen Interval field in Association Request frame is used to indicate to the AP how often a STA with dot11NonTIMModeActivated set to false in power save mode wakes to listen to Beacon management frames or it is used to indicate to AP the duration during which a STA with dot11NonTIMModeActivated set to true is required to transmit at least one PS-Poll or trigger frame. The value of this parameter is the Listen Interval parameter of the MLMEASSOCIATE.request or LME-REASSOCIATE.request primitive and is expressed in units of Beacon Interval. The length of the Listen Interval field is 2 octets. The Listen Interval field in Association Response frame is used to indicate to the STA a value of listen interval different from that in Association Request frame based on AP's buffer management consideration.

Insert the following paragraph and Figure 8.43a after Figure 8-43:

When dot11S1GOptionImplemented is true the first two MSBs of the Listen Interval field indicates the Scaling Factor (SF) and the remaining 14 bits indicate as the actual value. The Listen Interval is calculated as the value multiplied by SF. This Bit Encoding is illustrated in Figure 8-43a (Bit encoding).

	B0 B13	B14 B15
	Value	Scaling
Bits:	14	2

Figure 8-43a—Bit encoding

The definition of the unified scaling factors are shown in Table 8-36a (Unified scaling factor).

Table 8-36a—Unified scaling factor

Two MSBs (B15 B14)	Scaling Factor (SF)
00	1
01	10
10	1000
11	10000

8.4.1.11 Action field

Insert the following rows into Table 8-38:

Table 8-38—Category values

Code	Meaning	See subclause	Robust	Group addressed privacy
<ANA>	S1G	8.5.23a	No	No
<ANA>	Relay	8.5.23b	Yes	No

Insert the following subclause after subclause 8.4.1.15:

8.4.1.15a Originator Parameter field

The Originator Parameter field is used in ADDBA Response frame to signal the preferred MCS used for eliciting A-MPDUs from the data originator. The length of the Originator Parameter field is 2 octets. The Originator Parameter field is illustrated in Figure 8-52a (Originator Parameter field).

	B0 B11	B12 B15
	Reserved	MCS
Bits:	12	4

Figure 8-52a—Originator Parameter field

8.4.1.47 VHT MIMO Control Field

Insert the following paragraph at the end of sub-clause 8.4.1.47:

For S1G band, the same VHT MIMO control field is applied in the sounding feedback frame, with “VHT” replaced by “S1G”, and with the following exceptions.

- Nc index field shall not indicate a value that is more than 4
- Nr index field shall not indicate a value that is more than 4
- Channel Width field shall be reinterpreted as follows:
  - Set to 0 for 2 MHz
  - Set to 1 for 4 MHz
  - Set to 2 for 8 MHz
  - Set to 3 for 16 MHz
- Codebook information field shall be reinterpreted as follows:
  - If Feedback Type is SU, and Nc Index field is Nc=1,
    - i) Set to 0 for 2 bits for ϕ, and ψ is not fed back.

ii) Set to 1 for 2 bits for ψ, and 4 bits for ϕ.

- If Feedback Type is SU, and Nc Index field is set to Nc>1,
  - i) Set to 0 for 2 bits for ψ, and 4 bits for ϕ.
  - ii) Set to 1 for 4 bits for ψ, and 6 bits for ϕ.
- If Feedback Type is MU,
  - i) Set to 0 for 5 bits for ψ, and 7 bits for ϕ.
  - ii) Set to 1 for 7 bits for ψ, and 9 bits for ϕ.

8.4.1.48 VHT Compressed Beamforming Report field

Insert the following paragraphs at the end of sub-clause 8.4.1.48:

For S1G band, the same VHT Compressed Beamforming Report field is applied in the sounding feedback frame, with "VHT" replaced by "S1G", and with the following exceptions:

— Table 8-53d (Order of angles in the Compressed Beamforming Feedback Matrix subfield) is replaced by Table 8-53i (Order of angles in the Compressed Beamforming Feedback Matrix subfield if the Feedback Type is SU) and Table 8-53j (Order of angles in the Compressed Beamforming Feedback Matrix subfield if the Feedback Type is MU) as shown below.

The subcarriers indices corresponding to different tone grouping values (Ng) for 2MHz, 4MHz, 8MHz, and 16MHz are the same as the values defined for 20MHz, 40MHz, 80MHz, and 160MHz in Table 8-53g (Subcarriers for which a Compressed Beamforming Feedback Matrix subfield is sent back), respectively.

Table 8-53i—Order of angles in the Compressed Beamforming Feedback Matrix subfield if the Feedback Type is SU

Size of *V* (*Nr* × *Nc*)	Codebook Information Field	Number of angles (*Na*)	The order of angles in the Compressed Beamforming Feedback Matrix subfield
2×1	0	1	ϕ11
2×1	1	2	ϕ11, ψ21
2×2	0 or 1	2	ϕ11, ψ21
3×1	0	2	ϕ11, ϕ21
3×1	1	4	ϕ11, ϕ21, ψ21, ψ31
3×2	0 or 1	6	ϕ11, ϕ21, ψ21, ψ31, ϕ22, ψ32
3×3	0 or 1	6	ϕ11, ϕ21, ψ21, ψ31, ϕ22, ψ32
4×1	0	3	ϕ11, ϕ21, ϕ31
4×1	1	6	ϕ11, ϕ21, ϕ31, ψ21, ψ31, ψ41
4×2	0 or 1	10	ϕ11, ϕ21, ϕ31, ψ21, ψ31, ψ41, ϕ22, ϕ32, ψ32, ψ42
4×3	0 or 1	12	ϕ11, ϕ21, ϕ31, ψ21, ψ31, ψ41, ϕ22, ϕ32, ψ32, ψ42, ϕ33, ψ43

Table 8-53i—Order of angles in the Compressed Beamforming Feedback Matrix subfield if the Feedback Type is SU

4×4	0 or 1	12	ϕ11, ϕ21, ϕ31, ψ21, ψ31, ψ41, ϕ22, ϕ32, ψ32, ψ42, ϕ33, ψ43

Table 8-53j—Order of angles in the Compressed Beamforming Feedback Matrix subfield if the Feedback Type is MU

Size of *V* (*Nr* × *Nc*)	Codebook Information Field	Number of angles (*Na*)	The order of angles in the Compressed Beamforming Feedback Matrix subfield
2×1	0 or 1	2	ϕ11, ψ21
2×2	0 or 1	2	ϕ11, ψ21
3×1	0 or 1	4	ϕ11, ϕ21, ψ21, ψ31
3×2	0 or 1	6	ϕ11, ϕ21, ψ21, ψ31, ϕ22, ψ32
3×3	0 or 1	6	ϕ11, ϕ21, ψ21, ψ31, ϕ22, ψ32
4×1	0 or 1	6	ϕ11, ϕ21, ϕ31, ψ21, ψ31, ψ41
4×2	0 or 1	10	ϕ11, ϕ21, ϕ31, ψ21, ψ31, ψ41, ϕ22, ϕ32, ψ32, ψ42
4×3	0 or 1	12	ϕ11, ϕ21, ϕ31, ψ21, ψ31, ψ41, ϕ22, ϕ32, ψ32, ψ42, ϕ33, ψ43
4×4	0 or 1	12	ϕ11, ϕ21, ϕ31, ψ21, ψ31, ψ41, ϕ22, ϕ32, ψ32, ψ42, ϕ33, ψ43

8.4.1.52a Synch Control field

The Synch Control field is present in the Synch Control frame (see 8.5.23a.4). The Synch Control field is shown in Figure 8-80h (Synch Control field format).

	B0	B1	B2 B7
	Uplink Synch Request	Time Slot Protection Request	Reserved
Bits:	1	1	6

Figure 8-80h—Synch Control field format

The non-AP STA transmitting this field indicates its mode of operation for the synch frame transmission. The subfields of the Synch Control field are defined in Table 8-53m (Subfields of the S1G Capabilities Info field).

Table 8-53m—Subfields of the S1G Capabilities Info field

Subfield	Definition	Encoding
Uplink Synch Request	This subfield indicates request for synch frame transmission for uplink. (see 9.32b.1 (Synch frame transmission procedure for uplink traffic)	Set to 0 if not requested. Set to 1 if requested.
Time Slot Protection Request	This subfield indicates request for a time slot protection during a time slot in a RAW (8.4.2.170b (RPS element)) or during a time duration defined in the Nominal Minimum Wake Duration field for a TWT time (8.4.2.170j (Target Wake Time element)).	Set to 0 if not requested. Set to 1 if requested.

8.4.2 Information elements

8.4.2.1 General

Insert the following rows into Table 8-55:

Table 8-55—Element IDs

Element	Element ID	Length of indicated element (in octets)	Extensible
Open-Loop Link Margin Index	<ANA>	1	
RPS	<ANA>	2 to 257	
Segment Count	<ANA>	4 to 8	
AID Request	<ANA>	3 to 12	
AID Response	<ANA>	7	
Sector Operation	<ANA>	0-255	Yes
Short Beacon Compatibility	<ANA>	10	No
Short Beacon Interval	<ANA>	4	No

Table 8-55—Element IDs

Change Sequence	<ANA>	3	
Target Wake Time	<ANA>	23	
S1G Capabilities	<ANA>	TBD	
Sector Capabilities	<ANA>	TBD	
Subchannel Selective Transmission	<ANA>	0-252	
Modified EDCA Parameter Set	<ANA>	0-255	
Authentication Control	<ANA>	2	Yes
TSF Timer Accuracy	<ANA>	3	
Relay	<ANA>	7	Yes
Reachable Address	<ANA>	0-253	Yes
Relay Discovery	<ANA>	TBD	
Probe Response Option	<ANA>	3 to 11	
AID Announcement	<ANA>	10 or 250	Yes
AP Power Management	<ANA>	1	
Probe Response Option	<ANA>	0-255	
Activity Specification	<ANA>	8	
Group ID List	<ANA>	0-255	Yes

8.4.2.7 TIM element

Change section 8.4.2.7 as follows:

The Bitmap Control field is a single octet. Bit 0 of the field contains the Group Addressed Traffic Indicator bit associated with AID 0. This bit is set to 1 in TIM elements with a value of 0 in the DTIM Count field when one or more group addressed MSDUs/MMPDUs are buffered at the AP or the mesh STA. When dot11S1GOptionImplemented is false, ~~T~~the remaining 7 bits of the field form the Bitmap Offset. When dot11S1GOptionImplemented is true, bit 1 to bit 5 of the field form the TIM Segment Number subfield and bit 6 and bit 7 of the field form the Page Index subfield as shown in Figure 8-87i (Bitmap Control field (when dot11S1GOptionImplemented is true)).

Insert the following after the 5th paragraph:

	B0	B1 B5	B6 B7
	Group Addressed Traffic Indicator	TIM Segment Number	Page Index
Bits:	1	5	2

Figure 8-87i—Bitmap Control field (when dot11S1GOptionImplemented is true)

The TIM Segment Number subfield indicates the index of the TIM segment encoded in the Partial Virtual Bitmap field. Using this subfield, a STA computes the TIM segment range (start and end blocks within a Page segment) using the Page Offset and the Length of Page Segment (see 9.32j (TIM and Page segmentation)) values from the Segment Count element (see 8.4.2.170c (Segment Count element)) as:

For zero value in the TIM Segment Number field:

TIM segment start = Page Offset

For non-zero value in TIM Segment Number field:

TIM segment start = Page Offset + ((Length of Page Segment) × (TIM Segment Number -1)) + 1

TIM segment end = Page Offset + Length of Page Segment × TIM Segment Number

The Page Index subfield indicates the index of the Page encoded in the Partial Virtual Bitmap field.

Change section 8.4.2.7 as follows:

When dot11S1GOptionImplemented is false, ~~T~~the traffic-indication virtual bitmap, maintained by the AP or the mesh STA that generates a TIM, consists of 2008 bits, and is organized into 251 octets such that bit number N ($0 \le N \le 2007$) in the bitmap corresponds to bit number (N mod 8) in octet number $\lfloor N / 8 \rfloor$ where the low-order bit of each octet is bit number 0, and the high order bit is bit number 7. When dot11S1GOptionImplemented is true, the traffic-indication virtual bitmap consists of $64N_PN_B$ bits and is organized into N_P Pages where each Page consists of N_B Blocks, each Block consists of eight Subblocks, and each Subblock consists of 8 bits (N_P=4 and N_B=32). Bit number N in the bitmap corresponds to bit number $dec(N[0:2])$ of the $dec(N[3:5])$-th Subblock of the $dec(N[6:5+n_1])$-th Block of the $dec(N[6+n_1:12])$-th Page , where n_1 is $\log_2 N_B$ and N_B is power of 2. $N[a:b]$ represents bits a to b inclusive of the bit number N and $dec(N[a:b])$ is the cast to decimal operator where a is scaled by 2^0 and b is scaled by 2^{b-a}. The hierarchical structure of the traffic-indication virtual bitmap is as shown in Figure 8-87j (Hierarchical structure of traffic-indication virtual bitmap). Each bit in the traffic-indication virtual bitmap corresponds to traffic buffered for a specific neighbor peer mesh STA within the MBSS that the mesh STA is prepared to deliver or STA within the BSS that the AP is prepared to deliver at the time the Beacon frame is transmitted. Bit number N is 0 if there are no individually addressed MSDUs/MMPDUs buffered for the STA whose

AID is *N*. If any individually addressed MSDUs/MMPDUs for that STA are buffered and the AP or the mesh STA is prepared to deliver them, bit number *N* in the traffic-indication virtual bitmap is 1. A PC might decline to set bits in the TIM for CF-Pollable STAs it does not intend to poll (see 10.2.1.7 (AP operation during the CFP)).

Insert Figure 8-87j (Hierarchical structure of traffic-indication virtual bitmap) after the 6th paragraph:

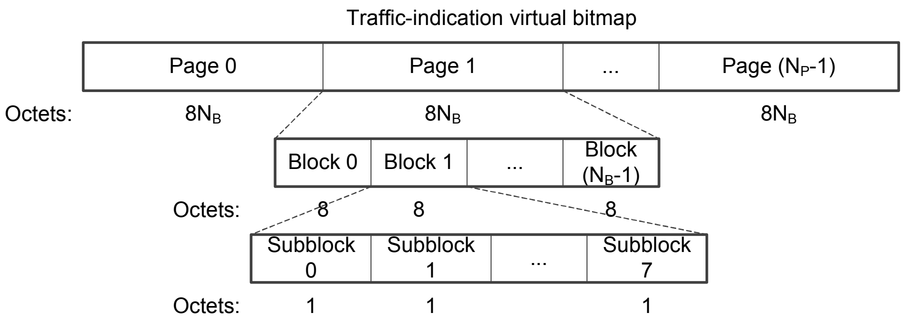

Figure 8-87j—Hierarchical structure of traffic-indication virtual bitmap

Insert a new subsection 8.4.2.7.1 after the last paragraph:

8.4.2.7.1 S1G Partial Virtual Bitmap encoding

When dot11S1GOptionImplemented is true, the Partial Virtual Bitmap field is constructed with one or more Encoded Block subfields if at least one bit in the traffic indication virtual bitmap is set to 1 as shown in Figure 8-87k (Partial Virtual Bitmap field). If there is no bit in the traffic indication virtual bitmap set to 1, the Partial Virtual Bitmap field is not present in the TIM element and the Length field of the TIM element is set to 3. The Encoded Block subfield consists of the Block Control subfield, the Block Offset subfield, and the Encoded Block Information subfield as shown in Figure 8-87l (Encoded Block subfield).

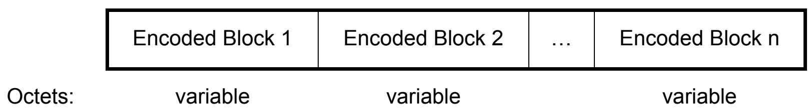

Figure 8-87k—Partial Virtual Bitmap field

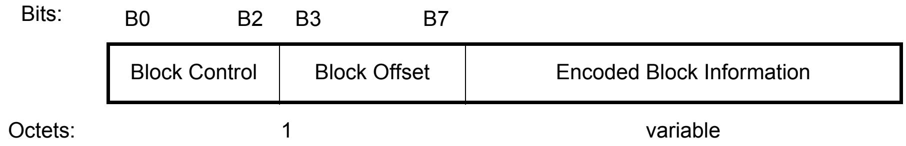

Figure 8-87l—Encoded Block subfield

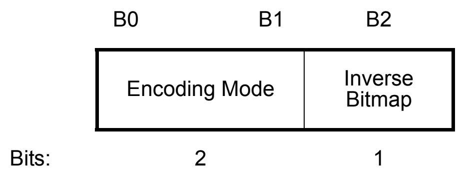

Figure 8-87m—Block Control subfield

The Block Control subfield is 3 bits in length and indicates the encoding mode used in the Encoded Block subfield as shown in Table 8-55a (Block Control field encoding). The format of the Block Control subfield is as shown in Figure 8-87m (Block Control subfield). The Block Control subfield consists of the Encoding Mode subfield and the Inverse Bitmap subfield.

The Inverse Bitmap subfield is set to 1, if the Block is encoded based on the inverted version of the Block, which inverts each bit value of the Block. The Inverse Bitmap subfield is set to 0, otherwise.

The Encoding Mode subfield indicates one of the four encoding modes: the Block Bitmap mode, the Single AID mode, the OLB (Offset, Length, Bitmap) mode, and the ADE (AID Differential Encode) mode. The four encoding modes are explained in the following subclauses.

Table 8-55a—Block Control field encoding

Bit 2	Bit 1	Bit 0	Encoding mode
0	0	0	Block Bitmap
0	0	1	Single AID
0	1	0	OLB
0	1	1	ADE
1	0	0	Inverse Bitmap + Block Bitmap
1	0	1	Inverse Bitmap + Single AID
1	1	0	Inverse Bitmap + OLB

Table 8-55a—Block Control field encoding

1	1	1	Inverse Bitmap + ADE

The Block Offset field is 5 bits in length and indicates the index of the Block that is encoded in the Encoded Block subfield.

The meaning of the Encoded Block Information subfield depends on the Encoding Mode subfield and explained within the subclause for each of the encoding modes.

8.4.2.7.1.1 Block Bitmap mode

The Encoded Block Information field consists of the Block Bitmap subfield and *n* Subblock subfields, where *n* is the number of bits equal to 1 in the Block Bitmap subfield. The format of the Encoded Block Information subfield is shown in Figure 8-87n (Encoded Block Information (Block Bitmap mode)).

The Block Bitmap subfield is 1 octet in length. The bit in position *m* of the Block Bitmap subfield, if equal to 1, indicates that the Subblock in position *m* of the Block is present in the Encoded Block Information subfield. The bit in position *m* of the Block Bitmap subfield, if equal to 0, indicates that the Subblock in position *m* of the Block is not present in the Encoded Block Information subfield. When *n* bits in the Block Bitmap subfield are equal to 1, *n* Subblock subfields follow the Block Bitmap field in ascending order of the Subblock positions in the Block.

Each Subblock subfield is 1 octet in length and contains a Subblock of the Block, which has at least one bit position equal to 1. The bit in position *q* of the Subblock subfield, which contains the Subblock in position *m* of the Block, indicates traffic buffered for the STA whose AID is *N*, where *N* is constructed by concatenating the Page Index field (*N*[12:11]), the Block Offset field (*N*[10:6]), *m* (*N*[5:3]), and *q* (*N*[2:0]) in sequence from MSB to LSB.

	Block Bitmap	Subblock 1	Subblock 2	…	Subblock *n*
Octets:	1	1	1		1

Figure 8-87n—Encoded Block Information (Block Bitmap mode)

8.4.2.7.1.2 Single AID mode

The Encoded Block Information subfield consists of the Single AID subfield as shown in Figure 8-87o (Encoded Block Information (Single AID mode)). The Single AID subfield is 6 bits in length and contains the 6 LSBs of the single AID in the Block. The rest of the bits of the Encoded Block Information subfield are reserved. The value in the Single AID subfield indicates traffic buffered for the STA whose AID is *N*, where *N* is constructed by concatenating the Page Index field (*N*[12:11]), the Block Offset field (*N*[10:6]), and the Single AID subfield(*N*[5:0]) in sequence from MSB to LSB.

B0 B5 B6 B7

Figure 8-87o—Encoded Block Information (Single AID mode)

	Single AID	Reserved
Bits:	6	2

Figure 8-87o—Encoded Block Information (Single AID mode)

8.4.2.7.1.3 OLB mode

The Encoded Block Information field consists of the Length subfield and *n* Subblock subfields. The format of the Encoded Block Information field is shown in Figure 8-87p (Encoded Block Information (OLB mode)).

The Length subfield is 1 octet. A value of the Length subfield equal to *n* indicates that the Encoded Block Information field contains *n* contiguous Subblocks in ascending order from multiple blocks starting from the first Subblock of the Block in position Block Offset.

Each Subblock subfield is 1 octet in length and contains a Subblock of the Partial Virtual Map. A Subblock *m* of the Encoded Block Information field is located in Block *k* where *k* is obtained as Block Offset $+\lfloor m / 8 \rfloor$. The bit in position *q* of the Subblock *m* which is located in Block *k* indicates that there is traffic buffered for the STA whose AID is *N*, where *N* is constructed by concatenating the Page Index field (*N*[12:11]), *k* (*N*[10:6]), mod(*m*, 8) (*N*[5: 3]), *q* (*N*[2:0]) and in sequence from MSB to LSB.

	Length	Subblock 1	Subblock 2	…	Subblock *n*
Octets:	1	1	1		1

Figure 8-87p—Encoded Block Information (OLB mode)

8.4.2.7.1.4 ADE mode

The Encoded Block Information field consists of the Encoding Word Length (EWL) subfield, Length subfield, *n* AID Differential Values (ΔAID) subfields and padding subfield, where *n* is the number of paged AIDs encoded in the ADE block. The paged AIDs refer to those AIDs with their corresponding bits being set to '1' if encoded by partial virtual bitmap. The format of the Encoded Block Information field is shown in Figure 8-87q (Encoded Block Information (ADE Block)).

The length of each ΔAID subfields (WL) represents the encoded word length (the number of bits of each encoded words) of each AID. All WL have the same length. WL is indicated by EWL subfield.

The EWL subfield is 3 bits in length with B0 being LSB. The values of EWL subfield ranging from 0 to 7 represent, WL being 1 to 8 respectively.

The Length subfield is 5 bits in length with B3 being LSB and it specifies the total length of the current ADE block in octets, excluding EWL and Length subfields.

The padding subfield contains 0-7 padding bits. The padding bits also indicate the end of the current ADE block.

	B0 B2	B3 B7				
	EWL	Length	ΔAID1	…	ΔAIDn	Padding
Bits:	3	5	8		8	0-7

Figure 8-87q—Encoded Block Information (ADE Block)

To encode a list of paged AIDs, denoted as AID1, AID2 … AIDn, an AP can derive the offset value in the Block Offset field (8.4.2.7.1) for the current ADE block by $\lfloor \mathrm{AID}_1 \text{ modulo } 2048 \rfloor \times 64$, where $\lfloor x \rfloor$ refers to the largest integer that is not larger than *x*.

The encoding procedure is as follows:

If all AIDs in the ADE blocks are paged, AP shall set the Inverse Bitmap subfield to 1 and ADE Block consists only EWL and Length fields, where both EWL and Length Field are set to zeros.

If all but one AIDs in the ADE blocks are paged, AP shall set the Inverse Bitmap subfield to 1 and ADE Block consists only one ΔAID subfield. AP shall set EWL to 7 and Length subfield to one. ΔAID subfield is set to (AID – (Page Index × 2048 + Block Offset × 64)).

If only one AID is paged in the ADE blocks, AP may set the Inverse Bitmap subfield to 0 and use the Single AID mode.

For all other cases, AP shall sort all AID*i*, *i* = 1, 2,…,*n* in an ascending order (AID1 < AID2 < … < AID*n*) and then calculate the AID differential values according to:

ΔAID1 = AID1 – (Page Index × 2048 + Block Offset × 64)

ΔAID*i* = AID*i* – AID*i*-1, *i* = 2, …, *n*.

Determine WL as the minimum bits that can represent the largest ΔAID*i* (or mathematically $\lfloor \log_2 MAX(\Delta \mathrm{AID}_i) \rfloor + 1$ where MAX($\Delta\mathrm{AID}_i$) denotes the largest $\Delta\mathrm{AID}_i$), *i*=1,2,…,*n*. The value of EWL subfield is set to WL-1. For *n* AID differential values, totally WL × *n* bits are required. The number of bits shall be less than or equal to 248 since maximum payload in an ADE block is 31×8=248. The total number of bits WL × *n* may not be a multiple of an octet. [WL×N/8]×8-WL×*n* zero bits shall be padded to make the ADE block end at octet boundary.

When decoding, if inverse bit is 1, EWL and Length subfield are zeros, all AIDs in the ADE blocks are paged.

If inverse bit is 1, EWL is 7 and Length subfield is 1, all AIDs except one in the ADE blocks are paged. The unpaged AID is ΔAID1 + Block Offset × 64.

For other cases, a STA can extract Page Index (8.4.2.7) and Block Offset ((8.4.2.7.1)), EWL and Length values from the respective fields. It derives WL by adding 1 to the value from EWL field. The paged AIDs are then derived with following formulas:

AID1 = ΔAID1 + (Page Index × 2048 + Block Offset × 64)

AID*i* = ΔAID*i* + AID*i* - 1, *i* = 2, …, *n*.

The decoder may stop the decoding when either one of following conditions is satisfied:

the number of bits left for decoding is less than WL

ΔAIDi is zero and $i>1$.

STA can derive the number of AIDs, including both paged and unpaged AIDS, encoded in one ADE block with following method:

If an ADE block is not the last encoded block in the TIM IE, the decoder can derive the number of AIDs encoded by this ADE block based on the block offset values in the current and the immediate next encoded blocks. For example, the offset values in the current ADE block and the next encoded block are Offset1 and Offset2. Then the AIDs encoded by this ADE block is [Offset1×64, Offset2×64), Offset1×64 is included and Offset2 is excluded.

If an ADE block is the last one in the TIM IE, the number of AIDs encoded by the last ADE block can be determined based on the offset value and page length or segment length if its TIM page is segmented.

8.4.2.28 EDCA Parameter Set element

Editor's Note: Numbering based on 802.11REVmc D1.0

Modify the Reserved field in Figure 8-196 as follows:

	Element ID	Length (18)	QoS Info	~~Reserved~~Control	AC_BE Parameter Record	AC_BK Parameter Record	AC_VI Parameter Record	AC_VO Parameter Record
Octets:	1	1	1	1	4	4	4	4

Figure 8-196—EDCA Parameter Set element

Add the following figure and sentences at the end of this sub-clause as follows:

The Control field is as in Figure 8-196a (Control field).

	B0	B1 B2	B3 B7
	Override	PS-Poll AC	Reserved
Bits:	1	2	5

Figure 8-196a—Control field

The Override field is used by S1G APs to indicate to S1G STAs that this element overrides previously stored EDCA parameters as described in 9.2.4.2.

The PS-Poll AC field is used by S1G APs to inform the S1G STAs of the access category for sending a PS-Poll frame.

8.4.2.30 TCLAS element

Editor's Note: Numbering based on 802.11REVmc D0.7

Modify the sub-clause 8.4.2.30 as the following:

The TCLAS element specifies an element that contains a set of parameters necessary to identify MPDUs. It is used to identify incoming MSDUs (from a higher layer in all STAs or from the DS in an AP) that belong to a particular TS. The TCLAS element is also used when the traffic does not belong to a TS, for example, by the FMS, DMS, and TFS services. If required, the TCLAS element is provided in ADDTS Request and ADDTS Response frames only for the downlink or bidirectional links. TCLAS element needs not be provided for the uplink or direct- link transmissions. The structure of this element is shown in Figure 8-200.

The Element ID and Length fields are defined in 8.4.2.1.

When t~~T~~he UP field contains ~~the~~ a value that is less than or equal to 7 and greater than or equal to 0, the value specifies ~~of~~ the UP of the associated MSDUs. When the UP field contains a value that is greater than or equal to 8 and less than or equal to 11, the value specifies the access category of the associated MPDUs. The UP field value of 255 is reserved and indicates that this field value needs not to be compared. The content of the User Priority field of an TCLAS element is specified in Table 8-111b (User Priority field of TCLAS element).

Table 8-111b—User Priority field of TCLAS element

User Priority	Meaning
0-- 7	The User Priority value of an MSDU
8	The AC value of an MPDU is AC-VO
9	The AC value of an MPDU is AC-VI
10	The AC value of an MPDU is AC-BE
11	The AC value of an MPDU is AC-BK
12 - 254	Reserved
255	The User Priority field is not used for comparison.

The Frame Classifier field is 3–255 octets in length and is defined in Figure 8-201.

	Classifier Type	Classifier Mask	Classifier Parameters
Octest:	1	1 or 3	~~1-252~~ variable

Figure 8-201—Frame Classifier field

Table 8-112—Frame classifier type

Classifier type	Classifier parameters
0	Ethernet parameters
1	TCP/UDP IP parameters
2	IEEE 802.1Q parameters
3	Filter Offset parameters
4	IP and higher layer parameters
5	IEEE 802.1D/Q parameters
6	IEEE 802.11 MAC header parameters (B1B0 of the Frame Control field = 00)
7	IEEE 802.11 MAC header parameters (B1B0 of the Frame Control field = 01, From DS = 1)
8	IEEE 802.11 MAC header parameters (B1B0 of the Frame Control field = 01, From DS = 0)
9-255	Reserved

When the Classifier type is a value less than or equal to 5, t~~T~~he Classifier Mask subfield specifies a bitmap in which bits that have the value 1 identify a subset of the classifier parameters whose values need to match those of the corresponding parameters in a given MSDU for that MSDU to be classified to the TS of the affiliated TSPEC. The bitmap is ordered from the LSB to the MSB, with each bit pointing to one of the classifier parameters of the same relative position as shown in this subclause based on classifier type. An incoming MSDU that failed to be classified to a particular TS may be classified to another active TS based on the frame classifier for that TS. If, however, all the frame classifiers for the active TS have been exhausted, the MSDU does not belong to any active TS and is classified to be a best-effort MSDU. In cases where there are more bits in the bitmap than classifier parameters that follow, the MSBs that do not point to any classifier parameters are reserved.

When the Classifier Type is equal to 6, 7 or 8, the Classifier Mask subfield specifies a bitmap in which every two bits correspond to one field of the MAC header, as specified in Table 8-112a (Classifier Mask for Classifier Type (6)), Table 8-112b (Classifier Mask for Classifier Type (7)) and Table 8-112c (Classifier Mask for Classifier Type (8)). Setting the LSB of the 2 bits to 1 indicates the use of the corresponding MAC Header field for comparison, and setting the LSB of the two bits to 0 indicates the corresponding MAC header field is not used for comparison, and the corresponding Match Specification is not included in the Classifier. The setting of the MSB of the two bit to 1 indicates the inclusion of the corresponding MAC Header Filter (a bit mask) in the corresponding Match Specification; the setting of the MSB of the two bits to 0 indicates the MAC Header Filter is not included in the corresponding Match Specification and every bit of the Match Specification, if included in the Classifier Parameter, needs to be compared. If an optional MAC Header field needs to be compared, the LSB of the two bits in the Classifier Mask corresponding to the optional MAC header field shall be set to 1, and an MPDU that does not include the optional field is not a matching MPDU.

Table 8-112a—Classifier Mask for Classifier Type (6)

Octet index	Bits index	Classifier parameters
0	B0B1	Frame Control
	B2B3	Duration/ID
	B4B5	Address 1
	B6B7	Address 2
1	B0B1	Address 3
	B2B3	Sequence Control
	B4B5	Address 4
	B6B7	QoS Control
2	B0B1	HT Control
	B2B3	Reserved
	B4B5	Reserved
	B6B7	Reserved

Table 8-112b—Classifier Mask for Classifier Type (7)

Octet index	Bits index	Classifier parameters

Table 8-112b—Classifier Mask for Classifier Type (7)

0	B0B1	Frame Control
	B2B3	Address 1 (AID)
	B4B5	Address 2 (BSSID)
	B6B7	Sequence Control
1	B0B1	Address 3
	B2B3	Address 4
	B4B5	Reserved
	B6B7	Reserved
2	B0B1	Reserved
	B2B3	Reserved
	B4B5	Reserved
	B6B7	Reserved

Table 8-112c—Classifier Mask for Classifier Type (8)

Octet index	Bits index	Classifier parameters
0	B0B1	Frame Control
	B2B3	Address 1 (BSSID)
	B4B5	Address 2 (AID)
	B6B7	Sequence Control
1	B0B1	Address 3
	B2B3	Address 4
	B4B5	Reserved
	B6B7	Reserved
2	B0B1	Reserved
	B2B3	Reserved
	B4B5	Reserved
	B6B7	Reserved

The Frame Classifier field for Classifier Type 5 is defined in Figure 8-209 (Frame Classifier field of Classifier Type 5).

	Classifier Type (~~4~~5)	Classifier Mask	802.1QPCP	802.1Q CFI	802.1Q VID
Octets:	1	1	1	1	2

Figure 8-209—Frame Classifier field of Classifier Type 5

The subfields in the classifier parameters are represented and transmitted in big-endian format.

The PCP subfield contains the value in the 4 LSBs; the 4 MSBs are reserved.

The CFI subfield contains the value in the LSB; the 7 MSBs are reserved.

The VID subfield contains the value in the 12 LSBs; the 4 MSBs are reserved.

For Classifier Type 6, the format of the Frame Classifier field of an TCLAS element is illustrated in Figure 8-209a (Frame Classifier field of Classifier Type 6).

	Classifier Type (6)	Classifier Mask	Frame Control Match Specification	Duration Match Specification	Address 1 Match Specification	Address 2 Match Specification
Octest:	1	3	0 or 2 or 4	0 or 2 or 4	0 or 6 or 12	0 or 6 or 12

Address 3 Match Specification	Sequence Control Specification	Address 4 Match Specification	QoS Control Specification	HT Control Specification
0 or 6 or 12	0 or 2 or 4	0 or 6 or 12	0 or 2 or 4	0 or 4 or 8

Figure 8-209a—Frame Classifier field of Classifier Type 6

For Classifier Type 6, the formats of the Frame Control Match Specification subfield, Duration/ID subfield, Address 1 subfield, Address 2 subfield, Address 3 subfield, Sequence Control subfield, Address 4 subfield, QoS Control subfield and HT Control subfield of the Frame Classifier field of a TCLAS element are illustrated in from Figure 8-209b (Frame Control Match Specification Subfield of Classifier Type 6, 7, 8) to Figure 8-209j (HT Control Match Specification Subfield of Classifier Type 6), respectively. The Match Specification subfield contains the match specification (i.e., the parameters) of the corresponding MAC header field with which an MPDU needs to be compared. When the corresponding Filter Mask is not present, every bit in a Match Specification needs to be compared; otherwise, only the bits with the same bit positions as the bits that are set to 1 in the corresponding Filter Mask subfield are compared.

	Frame Control Match Specification	Frame Control Filter Mask
Octets:	2	0 or 2

Figure 8-209b—Frame Control Match Specification Subfield of Classifier Type 6, 7, 8

	Duration/ID Match Specification	Duration/ID Filter Mask
Octets:	2	0 or 2

Figure 8-209c—Duration/ID Match Specification Subfield of Classifier Type 6

	Address 1 Match Specification	Address 1 Filter Mask
Octets:	6	0 or 6

Figure 8-209d—Address1 Match Specification Subfield of Classifier Type 6, 8

	Address 2 Match Specification	Address 2 Filter Mask
Octets:	6	0 or 6

Figure 8-209e—Address2 Match Specification Subfield of Classifier Type 6, 7

	Address 3 Match Specification	Address 3 Filter Mask
Octets:	6	0 or 6

Figure 8-209f—Address3 Match Specification Subfield of Classifier Type 6, 7, 8

	Sequence Control Match Specification	Sequence Control Mask
Octets:	2	0 or 2

Figure 8-209g—Sequence Control Match Specification Subfield of Classifier Type 6, 7, 8

	Address 4 Match Specification	Address 4 Filter Mask
Octets:	6	0 or 6

Figure 8-209h—Address4 Match Specification Subfield of Classifier Type 6, 7, 8

	QoS Control Match Specification	QoS Control Filter Mask
Octets:	2	0 or 2

Figure 8-209i—QoS Control Match Specification Subfield of Classifier Type 6

	HT Control Match Specification	HT Control Filter Mask
Octets:	4	0 or 4

Figure 8-209j—HT Control Match Specification Subfield of Classifier Type 6

For Classifier Type 7, the format of the Frame Classifier field of an TCLAS element is illustrated in Figure 8-209k (Frame Classifier field of Classifier Type 7).

	Classifier Type (7)	Classifier Mask	Frame Control Match Specification	Address 1 (SID) Match Specification	Address 2 Match Specification	Sequence Control Match Specification	Address 3 Match Specification	Address 4 Match Specification
Octets:	1	3	0 or 2 or 4	0 or 2 or 4	0 or 6 or 12	0 or 2 or 4	0 or 6 or 12	0 or 6 or 12

Figure 8-209k—Frame Classifier field of Classifier Type 7

For Classifier Type 7, the formats of the Frame Control Match Specification subfield, Address 1 (SID) subfield, Address 2 (BSSID) subfield, Sequence Control subfield, Address 3 subfield, and Address 4 subfield of the Frame Classifier field of a TCLAS element are illustrated in Figure 8-209b (Frame Control Match Specification Subfield of Classifier Type 6, 7, 8), Figure 8-209l (Address1 (SID) Match Specification Subfield of Classifier Type 7), Figure 8-209e (Address2 Match Specification Subfield of Classifier Type 6, 7), Figure 8-209g (Sequence Control Match Specification Subfield of Classifier Type 6, 7, 8), and Figure 8-209f (Address3 Match Specification Subfield of Classifier Type 6, 7, 8), and Figure 8-209h (Address4 Match Specification Subfield of Classifier Type 6, 7, 8), respectively. The Match Specification subfield contains the match specification (i.e., the parameters) of the corresponding MAC header field with which an MPDU needs to be compared. When the corresponding Filter Mask is not present, every bit in a Match Specification needs to be compared; otherwise, only the bits with the same bit positions as the bits that are set to 1 in the corresponding Filter Mask subfield are compared.

	Address 1 (SID) Match Specification	Address 1 Filter Mask
Octets:	2	0 or 2

Figure 8-209l—Address1 (SID) Match Specification Subfield of Classifier Type 7

For Classifier Type 8, the format of the Frame Classifier field of an TCLAS element is illustrated in Figure 8-209m (Frame Classifier field of Classifier Type 8)

	Classifier Type (8)	Classifier Mask	Frame Control Match Specification	Address 1 (BSSID) Match Specification	Address 2 (SID) Match Specification	Sequence Control Match Specification	Address 3 Match Specification	Address 4 Match Specification
Octets:	1	3	0 or 2 or 4	0 or 6 or 12	0 or 2or 4	0 or 2 or 4	0 or 6 or 12	0 or 6 or 12

Figure 8-209m—Frame Classifier field of Classifier Type 8

For Classifier Type 8, the formats of the Frame Control Match Specification subfield, Address 1 (BSSID) subfield, Address 2 (SID) subfield, Sequence Control subfield, and Address 3 subfield are illustrated in Figure 8-209b (Frame Control Match Specification Subfield of Classifier Type 6, 7, 8), Figure 8-209d (Address1 Match Specification Subfield of Classifier Type 6, 8), Figure 8-209n (Address2 (SID) Match Specification Subfield of Classifier Type 8), Figure 8-209g (Sequence Control Match Specification Subfield of Classifier Type 6, 7, 8), Figure 8-209f (Address3 Match Specification Subfield of Classifier Type 6, 7, 8), and Figure 8-209h (Address4 Match Specification Subfield of Classifier Type 6, 7, 8), respectively. The Match Specification subfield contains the match specification (i.e., the parameters) of the corresponding MAC header field with which an MPDU needs to be compared . When the corresponding Filter Mask is not present, every bit in a Match Specification needs to be compared; otherwise, only the bits with the same bit positions as the bits that are set to 1 in the corresponding Filter Mask subfield are compared.

	Address 2(SID) Match Specification	Address 2 Filter Mask
Octets:	2	0 or 2

Figure 8-209n—Address2 (SID) Match Specification Subfield of Classifier Type 8

8.4.2.32 TCLAS Processing element

The TCLAS Processing element is present in the ADDTS Request, ADDTS Response, FMS Request, DMS Request, and TFS Request frames if there are multiple TCLASs associated with the request. It indicates how an ~~MSDU received from higher layers~~MPDU should be processed by the classifier. The TCLAS Processing element is defined in Figure 8-211 (TCLAS Processing element).

Table 8-114—Encoding of Processing subfield

Processing subfield value	Meaning
0	Incoming MSDU's higher layer parameters have to match to the parameters in all the associated TCLAS elements.
1	Incoming MSDU's higher layer parameters have to match to at least one of the associated TCLAS elements.
2	Incoming MSDUs that do not belong to any other TS are classified to the TS for which this TCLAS Processing element is used. In this case, there are not any associated TCLAS elements.
3	Parameters of frames being processed by the classification function have to match to the parameters in all the associated TCLAS elements.
4	Parameters of frames being processed by the classification function have to match to at least one of the associated TCLAS elements.
5	Parameters of frames being processed by the classification function do not belong to any categorization by the associated TCLAS elements.
~~3~~6-255	Reserved

8.4.2.78 BSS Max Idle Period element

Editor's Note: Numbering based on 802.11REVmc D1.0.

Change the 4th paragraph of Section 8.4.2.81 as follows:

The Max Idle Period field indicates the time period during which a STA can refrain from transmitting frames to its associated AP without being disassociated. When dot11S1GOptionImplemented is false, t~~T~~he Max Idle Period field is a 16-bit unsigned integer. When dot11S1GOptionImplemented is true, the first two MSBs of the Max Idle Period field indicates the Scaling Factor and the remaining 14 bits indicate as the actual value. The Max idle Period is calculated as the value multiplied by SF. The unified scaling factor is shown in Table 8-36a (Unified scaling factor). The time period is specified in units of 1000 TUs. The value of 0 is reserved. A non-AP STA is considered inactive if the AP has not received a data frame or management frame of a frame exchange sequence initiated by the STA for a time period equal to or greater than the time specified by the Max Idle Period field value.

8.4.2.81 WNM-Sleep Mode element

Editor's Note: Numbering based on 802.11REVmc D1.0.

Modify the7th paragraph of Section 8.4.2.81 as follows:

The WNM-Sleep Interval field indicates to the AP how often a STA in WNM-Sleep Mode wakes to receive Beacon frames, defined as the number of DTIM intervals. The value set to 0 indicates that the requesting non-AP STA does not wake up at any specific interval. When dot11S1GOptionImplemented is false, the

WNM-SLeep Interval is a 16-bit unsigned integer. When dot11S1GOptionImplemented is true, the first two MSBs of the WNM-Sleep Interval field indicates the Scaling Factor and the remaining 14 bits indicate as the actual value. The WNM-Dleep Interval is calculated as the value multiplied by SF. The unified scaling factor is shown in Table 8-36a (Unified scaling factor).

Insert the following new sub-clauses after 8.4.2.170 as the following:

8.4.2.170a Open-Loop Link Margin Index element

The Open-Loop Link Margin Index element contains the link margin information. The Open-Loop Link Margin Index element is included in a Beacon frame or Probe Response frame without a corresponding request. The format of the Open-Loop Link Margin Index element is shown in Figure 8-401cj (Open-Loop Link Margin Index element format).

	Element ID	Length	Open-Loop Link Margin Index
Octets:	1	1	1

Figure 8-401cj—Open-Loop Link Margin Index element format

The Length field is set to 1.

The Open-Loop Link Margin Index field is defined as the summation of transmit power P_{tx} and the receiver sensitivity $RX_{sensitivity}$

$$\text{Open-Loop Link Margin Index} = P_{TX} + RX_{sensitivity}.$$

The transmit power P_{tx} is the transmit power used to transmit the frame containing the Open-Loop Link Margin Index element. The receiver sensitivity $RX_{sensitivity}$ is the minimum required receive power for reception of MCS10 for 1MHz channel.

The Open-Loop Link Margin Index element can be used for open-loop link adaptation and open-loop transmit power control.

The Open-Loop Link Margin Index is defined as (-128+D×0.5)dBm, where D is an unsigned integer number shown in Open-Loop Link Margin Index field. For example, if the value D shown in Open-Loop Link Margin Index field is 0, then it indicates the Open-Loop Link Margin Index is -128dBm. If the value D shown in Open-Loop Link Margin Index field is 255, then it indicates the Open-Loop Link Margin Index is -0.5dBm.

8.4.2.170b RPS element

The RPS element contains the set of parameters necessary for restricted medium access only to a group of STAs. The Information field contains the RAW assignment fields for groups 1 to N. The total length of the Information field is variable octets. The frame format of the RPS element is defined in Figure 8-401ck (RPS element format).

	Element ID	Length	RAW 1 Assignment	RAW 2 Assignment	...	RAW N Assignment
Octets:	1	1	variable	variable		variable

Figure 8-401ck—RPS element format

The RAW N Assignment field contains PRAW Indication, Same Group Indication, RAW Group (conditionally present), RAW Start Time, RAW Duration, Options, and RAW Slot Definition, Channel Indication, and AP PM subfields as shown in Figure 8-401cl (RAW N Assignment field format for RAW).

	PRAW Indication (0)	AP PM (0)	Same Group Indication	RAW Group	RAW Start Time (TU)	RAW Duration (TU)	Options	RAW Slot Definition	Channel Indication
bits:	1	1	1	24	8	TBD	4	TBD	8

Figure 8-401cl—RAW N Assignment field format for RAW

	PRAW Indication (0)	AP PM (1)	RAW Start Time (TU)	RAW Duration (TU)
bits:	1	1	8	TBD

Figure 8-401cm—RAW N Assignment field format for AP PM RAW

	PRAW Indication (1)	Same Group Indication (0)	PRAW Group	PRAW Start Time (TU)	PRAW Duration (TU)	PRAW Periodicity	PRAW Start Offset	Channel Indication
bits:	1	1	24	8	TBD	TBD	TBD	8

Figure 8-401cn—RAW N Assignment field format for PRAW

The PRAW Indicator subfield indicates whether the current RAW N Assignment field is for a regular RAW or PRAW and is of length 1 bit. A PRAW Indicator subfield value of 0 indicates that the current RAW N Assignment field is for a regular RAW, while a value of 1 indicates that the RAW N Assignment field is for a PRAW. Figure 8-401cl (RAW N Assignment field format for RAW) depicts RAW N Assignment field format for RAW with PRAW Indicator bit is set to 0. Figure 8-401cn (RAW N Assignment field format for PRAW) depicts RAW N Assignment field format for PRAW with PRAW Indicator bit is set to 1.

The Same Group Indication is of length 1 bit and it indicates whether the RAW Group defined in the current RAW Assignment is the same RAW Group that defined in the previous RAW Assignment. When the Same Group Indication bit is set to 1, the RAW Group defined in the current RAW Assignment is the same as the RAW Group defined in the previous RAW Assignment. When the Same Group Indication bit is set to 0, the RAW Group defined in the current RAW Assignment is different from the RAW Group defined in the previous RAW Assignment. The Same Group Indication bit shall be set to 0 in the first RAW Assignment. The Same Group Indication bit is defined similarly for PRAW.

When the Same Group Indication bit is set to 0, the RAW Assignment field contains RAW Group, RAW Start Time, RAW Duration, Options, RAW Slot Definition, Channel Indication, and AP in Doze State subfields as shown in Figure 8-401cl (RAW N Assignment field format for RAW). When the Same Group Indication bit is set to 1, the RAW Group subfield is not present in the current RAW Assignment field, and the RAW Group defined in current RAW Assignment is identical to the RAW Group defined in the previous RAW Assignment. In this case, the RAW Assignment field contains RAW Start Time, RAW Duration, Options, RAW Slot Definition, Channel Indication, and AP in Doze State subfields.

	Page Index	RAW Start AID	RAW End AID
bits:	2	11	11

Figure 8-401co—RAW Group subfield

The RAW Group subfield indicates the STA AIDs that are allowed restricted access within the RAW period. The RAW Group subfield contains Page Index, RAW Start AID, and RAW End AID sub-subfields according to the hierarchical addressing method of AIDs (see 8.87b). The Page Index sub-subfield indicates the page index of the subset of AIDs and is of length 2 bits.

The RAW Start AID field is 11 bits in length and indicates the 11 LSBs of the AID of the STA with the lowest AID allocated in the RAW.

The RAW End AID field is 11 bits in length and indicates the 11 LSBs of the AID of the STA with the highest AID allocated in the RAW.

The RAW Group field is set to all zeros to indicate that all STAs are allowed to access within the RAW.

The RAW Start Time subfield indicates the duration, in TU, from the end of beacon or Probe Response frame transmission that includes the RPS element to the start time of the RAW. This subfield is 1 octet in length. A RAW Start Time value of 0 indicates that the RAW starts immediately after the end of the beacon transmission.

The RAW Duration subfield indicates the duration, in TU, of restricted medium access allowed only for the group of STAs indicated in the RAW Group subfield. In other words, this interval indicated in the RAW Duration subfield is the difference between the end time of the RAW and the RAW Start Time. This duration is used by all other STAs to set their NAV in order to protect transmissions within the RAW period.

	Access Restricted to Paged STAs Only	Frame Type Restriction	Resource Allocation Frame Presence Indication	Sounding RAW Indication
bits:	1	1	1	1

Figure 8-401cp—Options subfield

The Options subfield contains Paged STAs' Access, Frame Type Restriction, Resource Allocation Frame Presence Indicator, and Sounding RAW indication sub-fields. The Options subfield is present when the PRAW Indicator subfield value is set to 0, and the Options subfield is not present when the PRAW Indicator subfield value is set to 1. The interpretation of the first two sub-subfields is illustrated in Table 8-191a (Illustration of Access restricted to Paged STAs Only sub-subfield in Option subfield).

	Slot Duration	Slot Assignment	Cross Slot Boundary
bits:	TBD	TBD	1

Figure 8-401cq—RAW Slot Definition subfield

Table 8-191a—Illustration of Access restricted to Paged STAs Only sub-subfield in Option subfield

Bit 0 (Paged STAs' Access)	Bit 1 (Frame Type Restriction)	Description
0	0	Any STA (paged or un-paged) may transmit UL frame of any type (*e.g.*, data, PS-Poll)
0	1	Any STA may transmit UL frame with durations shorter than duration specified in Slot Duration in the RAW Slot Definition subfield
1	0	Only paged STAs may transmit UL frame of any type
1	1	Only paged STAs may transmit UL frames with durations shorter than duration specified in Slot Duration in the RAW Slot Definition subfield

The Resource Allocation Frame Presence Indicator sub-subfield is of length 1 bit and it indicates if STAs that are part of the current RAW group need to wake up at the beginning of the next RAW to receive the

Resource Allocation frame (see 8.3.3.15f) for indication of downlink buffered data and their assigned time slots to next service period.

A Resource Allocation Frame Presence Indicator bit set to 1 indicates that a resource allocation frame in transmitted by the AP at the RAW Start Time. A Resource Allocation Frame Presence Indicator bit set to 0 indicates that STAs wake up and access the channel based on slot assignment procedure (9.19.4a.3 (Slot assignment procedure in RAW)).

The Sounding RAW Indication sub-field of length 1 bit indicates, when set to 1, that non-AP STAs are prohibited to transmit but may elect to listen to sector training for the entire RAW. When set to 0, it indicates otherwise.

The RAW Slot Definition subfield contains Slot Duration, Slot Assignments, and Cross Slot Boundary sub-subfields. The RAW Slot Definition subfield is present when the PRAW Indicator subfield value is set to 0, and the RAW Slot Definition subfield is not present when the PRAW Indicator subfield value is set to 1.

The Slot Duration sub-subfield indicates the duration of time slots of equal duration within the RAW.

The Slot Assignment sub-subfield indicates the assignment of slots to STAs based on their location in the TIM element. N_{offset} is indicated in the Slot Assignment sub-subfield and the two least significant bytes of the FCS field of the Beacon frame is used for the N_{offset}. The procedure of slot assignment is discussed in 9.19.4a.3 (Slot assignment procedure in RAW).

The Cross Slot Boundary sub-subfield is a binary bit and indicates whether STAs are allowed to transmit after the assigned slot boundary until the end of the RAW. If the bit is set to 1, crossing a slot boundary is allowed. If the bit is set to 0, crossing a slot boundary is not allowed for transmissions from STAs.

The Channel Indication field contains a bitmap allowing the identification of allowed operating channels for the STAs indicated in the RAW, as defined in 9.19.4a.1. Each bit in the bitmap corresponds to one minimum width channel within the current BSS operating channels, with the least significant bit corresponding to the lowest numbered operating channel of the BSS.

The AP PM field is 1 bit in length and indicates whether the AP is operating in Active or Power Save mode for this RAW, as defined in clause 10.2.1.19. If the AP PM bit is set to 1 and the PRAW Indication bit is set to 0, the RAW N Assignment field contains RAW Start Time and RAW Duration sub-subfields as shown in Figure 8-401cm (RAW N Assignment field format for AP PM RAW).

If the PRAW Indicator bit is set to 1, the RAW N Assignment field contains Same Group Indication, PRAW Group (conditionally present), PRAW Start Time, PRAW Duration, PRAW Periodicity, PRAW Start Offset, and Channel Indication sub-subfields. The PRAW Group, PRAW Start Time, and PRAW Duration are defined similarly as RAW Group, RAW Start Time, and RAW Duration, respectively.

The PRAW Periodicity sub-subfield indicates the period of current PRAW occurrence in the unit of short beacon interval, and is of length TBD bits.

The PRAW Start Offset sub-subfield indicates offset value to a short beacon frame that the first window of the PRAW appears from a reference point, and is of length TBD bits (Reference point details and unit is TBD).

8.4.2.170c Segment Count element

The Segment Count element contains the list of page segments included in TIM segments that will be served during the TIM intervals within a DTIM interval (see 9.32j (TIM and Page segmentation). The Information field contains Page Index, Page Segment Count, Page Offset, and Page Bitmap fields. The total length of the Information field is 4-8 octets. The frame format of the Segment Count element is defined in Figure 8-401cr (Segment Count element format).

	Element ID	Length	Page Index	Page Segment Count	Reserved	Page Offset	Reserved	Page Bitmap
Bits:			2	5	1	5	3	
Octets:	1	1		1			1	0-4

Figure 8-401cr—Segment Count element format

The Page Index field indicates the Page whose segments are served during TIM intervals within a DTIM interval. This field is of length 2 bits. A Page Index of 01 indicates the second page out of the four pages defined in the hierarchical AID addressing (See 8.4.2.7)

The Page Segment Count field indicates the number of TIM segments scheduled in one DTIM interval. This field is of length 5 bits indicating a maximum of 32 TIM segments in a DTIM interval. A Page Segment Count of 3 indicates 4 TIM segments in DTIM interval.

The Page Offset field indicates the offset of the block in the first Page segment from the first block in the Page assigned within the DTIM interval. This field is of length 5 bits. A Page Offset of 01000 indicates that the first page segment starts at the 16^{th} Block, *i.e.*, STAs in the second half of the page are assigned within this DTIM interval.

The Reserved field is kept for future use; this field is of length 4 bits.

The Page Bitmap field indicates presence of buffered data for each of the one or more blocks in all the assigned page segments within a DTIM interval. A bit in the Page Bitmap field indicates buffered data for one block in a Page segments corresponding to the location of the bit in the Bitmap. The first block in the Page Bitmap is the block indicated in the Page Offset field. Based on the number of Page segment assigned to TIM segments, this field is of variable length from 0-4 octets. A Page Bitmap of 10000001 indicates that there is buffered data for at least one STA in the first block and at least one STA in the last block. The bit sequence also indicates that only a Page segment of 8 blocks is assigned within a DTIM interval. Further, the bit sequence indicates that there is no downlink buffered data for any STA in blocks 1 to 6 and STAs in these blocks may enter doze state, avoiding waking up for the assigned TIM segment to check for downlink buffered data.

8.4.2.170d AID Request element

The AID Request element defines information about the device characteristic of the non-AP STA requesting AID assignment to the AP. The format of AID Request element is shown in Figure 8-401cs (AID request element format).

	Element ID	Length	AID Request Mode	Wakeup Interval/ Listen Interval/ Multicast Listen Interval (Optional)	Peer STA Address (Optional)	Service Type (Optional)	Group Address (Optional)
Octets:	1	1	1	0 or 2	0 or 6	0 or 1	0 or 6

Figure 8-401cs—AID request element format

The Element ID field is set to the value for AID Request element defined in Table 8-55 (Element IDs).

The Length field is a 1-octet field whose value is 1 plus the sum of the lengths of each optional field present in the element.

The format of AID Request Mode field is shown in Figure 8-401ct (AID Request Mode field format).

Bits:	B0	B1	B2	B3	B4	B5	B6 B7
	Wakeup Interval Present	Peer STA Address Present	Service Type Present	Non-TIM Mode Switch	TIM Mode Switch	Group Address Present	Reserved

Figure 8-401ct—AID Request Mode field format

Bit 0 is Wakeup Interval Present field. It is set to 1 if the Wakeup Interval field is present in the AID Request element and set to 0 if no Wakeup Interval field is present.

Bit 1 is Peer STA Address Present field. It is set to 1 if the Peer STA Address field is present in the AID Request element and set to 0 if no Peer STA Address field is present.

Bit 2 is Service Type Present field. It is set to 1 if the Service Type field is present in the AID Request element and set to 0 if no Service Type field is present.

Bit 3 is Non-TIM Mode Switch field. It is set to 1 if the non-AP STA requests to switch from the TIM mode to non-TIM mode. Otherwise, it is set to 0.

Bit 4 is TIM Mode Switch field. It is set to 1 if the non-AP STA requests to switch from the non-TIM mode to TIM mode. Otherwise, it is set to 0.

Bit 5 is Group Address Present field. It is set to 1 if the Group Address field is present in the AID Request element and set to 0 if no Group Address field is present.

Bit 6 and 7 are reserved.

The Wakeup Interval/Listen Interval// Multicast Listen Interval field indicates to the AP how often a non-AP STA with dot11NonTIMModeActivated set to false wakes to receive Beacon frames defined as the number of Beacon intervals, or indicates to AP the duration during which a non-AP STA with dot11NonTIMModeActivated set to true is required to transmit at least one PS-Poll or trigger frame, or indicates to AP how often the non-AP STA listens to the DTIM Beacon for group addressed BUs with Group Address Present field set to 1. The value of Multicast Listen Interval is the units of DTIM interval. Three fields are not required to be included simultaneously. The first two MSBs of the Wakeup Interval/ Listen Interval field indicates the Scaling Factor (see Table 8-36a (Unified scaling factor)) and the remaining 14 bits indicate the actual value (see Figure 8-43a (Bit encoding)). The Wakeup Interval / Listen Interval is calculated as the value multiplied by the Scaling Factor.

The Peer STA Address field indicates the MAC address of the peer STA for STA-to-STA communication.

The Service Type field indicates the service type of a non-AP STA.

The Group Address field indicates the group MAC address of the requesting STA.

8.4.2.170e AID Response element

The AID Response element defines information about the AID assignment. The format of AID Response element is shown in Figure 8-401cu (AID Response element format).

	Element ID	Length	AID/MID	AID Switch Count	Wakeup Interval/ Listen Interval
Octets:	1	1	2	1	2

Figure 8-401cu—AID Response element format

The Element ID field is set to the value for AID Response element defined in Table 8-55 (Element IDs).

The Length field is set to 5.

The AID/MID field is set to a new AID or MID assigned to the non-AP STA depending on whether there is a group MAC address in the AID Switch Request frame. If AP does not change the AID of the STA, the AID field is set to the current AID assigned to the non-AP STA.

The AID Switch Count field is set to the number of Beacon intervals until the non-AP STA switches to the new AID.

The Wakeup Interval field is set to the wakeup interval of a non-AP STA with dot11NonTIMModeActivated set to false for listening to Beacon frame having TIM segment of new AID, defined as the number of Beacon intervals. The Listen Interval field indicates the duration during which a non-AP STA with dot11NonTIMModeActivated set to true is required to transmit at least one PS-Poll or trigger frame. Two fields are not required to be included simultaneously. The first two MSBs of the Wakeup Interval/ Listen Interval field indicates the Scaling Factor (see Table 8-36a (Unified scaling factor)) and the remaining 14 bits indicate the actual value (see Figure 8-43a (Bit encoding)). The Wakeup Interval / Listen Interval is calculated as the value multiplied by the Scaling Factor.

8.4.2.170f Sector Operation element

The Sector Operation element includes the information necessary for a receiving STA to determine the type of sector operation, if it is allowed to transmit during a specified sector time interval and if it can perform sector training. The Sector Operation element can be provided in Probe Response, Beacon or Association Response.

The format of the Sector Operation element is presented in Figure 8-401cv (Sector Operation element (Sectorization Scheme is 0)).

Figure 8-401cv—Sector Operation element (Sectorization Scheme is 0)

	Element ID	Length	Sectorization Scheme	Period	Omni	Sector ID	GrpID	...	GrpID	Sector Duration	Reserved
Bits:	8	8	TBD	6	1	3	TBD		TBD	6	8

Figure 8-401cv—Sector Operation element (Sectorization Scheme is 0)

The Element ID has one octet length and specifies the corresponding value of the Sectorization Operation element specified in Table 8-55 (Element IDs).

The Length field is one octet length specifies the length of Sectorization Operation element in octets

The Sectorization Scheme is TBD bit length and specifies the type of sectorization. When the Sectorization Scheme is set to 0, it indicates Sectorization Type 0.

The Period field has 6 bit length and specifies the time interval expressed in time units equal to 10 milliseconds each until the next transmission of the same Sector ID

The Omni bit indicates if the present transmission is sectorized or Omni.

The Sector ID is 3 bit length and identifies the ID of the active sector.

The GrpID has TBD bit length and identifies the group of stations that are allowed to transmit during this sector interval. The GrpID 0 stations are allowed to transmit within a beacon interval regardless of whether it is a sectorized beacon interval or not.

The Sector Duration field has 6 bits, it indicates the duration of the current sector transmissions and it is measured in 10 milliseconds time units.

Sector Operation element may be provided in Association Response when dot11S1GSectorization-Activated is true and it indicates the GrpID allocated to that station to be used during for the sectorization purpose, the type of sectorization method, the value of the Period duration, and the Sector Duration if all the sector durations are equal. If the Sector Duration (the sector time duration) is not equal for all sectors the Sector Duration value provided at the association time has zero value. The values of Sector ID and Omni are omitted by the station in the Association Response message. By default all the stations consider themselves in GrpID zero unless is specified otherwise via the Association Response. This way all the stations can transmit at any time before their association. It is expected that during the association, stations receive a non-zero GrpID, which will restrict their activity to a particular sector interval or during Omni time interval. The AP may allow some stations to have the group zero even after association, for instance public safety stations or some high priority sensors.

The Sector Operation element in the Beacon will provide information related to the type of sectorization, indication if the Beacon is sectorized or not, the Sector ID the GrpID that identifies the group allowed transmitting during the currenct sector duration and respectively the duration of this sector. A station that receives a Beacon frame that includes a Sector Operation element determines if the received beacon is sectorized or Omni. If the received Beacon is Omni the stations are allowed to transmit in all geographical sectors provided that their group ID is group zero or it is listed in Sector Operation element. If the received Beacon is sectorized, the stations with group zero from any sector are allowed to transmit and the stations that receive the sectorized beacon and have the GrpID listed in the Sector Operation element are allowed to transmit during the current sector duration. A beacon that not carries a Sector Operation element does not impose any sectorization restriction on the receiving stations.

When the Sectorization Scheme is Type 1 the element is presented in Figure 8-401cw (Sectorization Operation Element (Sectorization Scheme =1)).

	Element ID	Length	Sectorization Scheme	Periodic Training Indicator	Training Period	Remaining Beacon Interval	Reserved
Bits:	8	8	TBD	1	6	6	2

Figure 8-401cw—Sectorization Operation Element (Sectorization Scheme =1)

The Sectorization Scheme field is set to 1 to indicate Sectorization Type 1 scheme.

The Periodic Training Indicator is set to 1 to indicate periodic sector training is conducted by the AP and stations may perform Sector training. The Periodic Training Indicator is set to 0 to indicate periodic sector training is not conducted by the AP.

The Training Period field is set to the number of beacon Intervals in which the AP repeats the Sector Training.

The Remaining Beacon Interval field is set to the remaining beacon intervals before the next Sector Training commences. A value of 0 indicates the sector training is conducted in the current beacon interval.

8.4.2.170g Short Beacon Compatibility element

	Element ID	Length	Capability	Beacon Interval	TSF Completion
Octets	1	1	2	2	4

Figure 8-401cx—Short Beacon Compatibility element format

The Capability field in the element is identical to the capability field defined in clause 8.4.1.4.

The Beacon Interval field in the element is identical to the Beacon Interval field defined in 8.4.1.3.

The TSF Completion field carries the 4 MSBs of the TSF at the AP at the time of transmission.

8.4.2.170h Short Beacon Interval element

	Element ID	Length	Short Beacon Interval
Octets	1	1	2

Figure 8-401cy—Short Beacon Interval element format

The Short Beacon Interval element carries the short beacon interval expressed in TUs.

8.4.2.170i Change Sequence element

A Change Sequence element indicates the change of system information within a BSS. The format of the Change Sequence element is shown in Figure 8-401cz (Change Sequence element format).

	Element ID	Length	Change Sequence
Octets:	1	1	1

Figure 8-401cz—Change Sequence element format

The Element ID is equal to the Change Sequence element value in Table 8-55 (Element IDs).

The value of the Length field is the length of the element and set to 1.

The Change Sequence field is 1 octet in length and is defined as an unsigned integer initialized to 0, that increments when a critical update occurs to any of elements inside Beacon frame; see 10.43c.1.

8.4.2.170j Target Wake Time element

The Target Wake Time element is shown in Figure 8-401da (Target Wake Time element format).

	Element ID	Length	Control	Request Type	Target Wake Time	TWT Group Assign ment	Nominal Minimum Wake Duration	Wake Interval Mantissa	TWT Channel	NDP Paging
Octets:	1	1	1	2	8	3	2	2	1	4

Figure 8-401da—Target Wake Time element format

The format of the Request Type field is shown in Figure 8-401db (Request Type field format).

	B0	B1 B3	B4	B5	B6	B7 B9	B10 B15
	TWT Request	TWT Command Reply	Direction	Implicit	Flow Type	TWT Flow Identifier	Wake Interval Exponent
Bits:	1	3	1	1	1	3	6

Figure 8-401db—Request Type field format

The TWT Request subfield is set to 1 to indicate that the TWT element is being sent from a TWT requesting STA to a TWT responding STA. The TWT Request subfield is set to 0 to indicate that the TWT element is from a TWT responding STA to a TWT requesting STA.

A STA that transmits a TWT element with the TWT Request subfield set to 1 is a TWT requesting STA. A STA that transmits a TWT element with the TWT Request subfield set to 0 is a TWT responding STA.

A STA that wakes at TWT to either transmit or receive frames is a TWT STA.

The TWT Command Reply field values indicate the type of TWT command, as shown in Table 8-191b (TWT Command Reply field values).

Table 8-191b—TWT Command Reply field values

TWT Command Reply field value	Command name	Description when transmitted by a TWT requesting STA	Description when transmitted by a TWT responding STA
000b	Request TWT	TWT requesting STA NULL TWT (TWT value invalid, TWT responding STA chooses the TWT value)	Reserved
001b	Suggest TWT	STA suggested TWT value	Reserved
010b	Demand TWT	TWT requesting STA demanded TWT value	Reserved
011b	N/A	Reserved	Reserved
100b	Accept TWT	Reserved	TWT responding STA accepts the TWT request with the TWT parameters* indicated
101b	Alternate TWT	Reserved	TWT responding STA suggests TWT parameters that are different from TWT requesting STA suggested or demanded TWT parameters
110b	Dictate TWT	Reserved	TWT responding STA demands TWT parameters that are different from TWT requesting STA TWT suggested or demanded parameters
111b	Reject TWT	Reserved	TWT responding STA rejects TWT setup
*TWT Parameters are: TWT value, Nominal Minimum Wake Duration, Wake Interval and TWT Channel			

The Direction subfield is set to 0 to indicate that the first frames to be transmitted in the TWT SP are from the TWT responding STA to the TWT requesting STA. The Direction subfield is set to 1 to indicate that the first frames to be transmitted in the TWT SP are transmitted either from the TWT responding STA to the TWT requesting STA or from the TWT requesting STA to the TWT responding STA.

When transmitted by a TWT requesting STA, the Implicit subfield is set to 1 to request an Implicit TWT.

When transmitted by a TWT responding STA, the Implicit subfield is set to 1 to indicate that the TWT is an Implicit TWT in which case the AP is not be required to transmit a next TWT value to the TWT STA for the TWTs associated with the flow identifier of the TWT element because the TWT STA will calculate the next TWT based on the parameters received in the TWT element with a TWT command code of Accept TWT. To calculate the next TWT, the TWT STA adds the value of Wake Interval indicated in the element to the current TWT value. The TWT values for an Implicit TWTs are periodic.

When transmitted by a TWT requesting STA, the Implicit subfield is set to 0 to request an Explicit TWT.

When transmitted by a TWT responding STA, the Implicit subfield is set to 0 to indicate that the TWT is an Explicit TWT in which case the AP transmits a next TWT value to the TWT STA for each of the TWTs associated with the flow identifier of the TWT element. The TWT values for an Explicit flow can be either periodic or aperiodic.

The Flow Type field indicates the type of interaction between the TWT requesting STA and the TWT responding STA at a TWT. A value of 0 in the Flow Type field indicates an Announced TWT in which the TWT requesting STA will send a PS-Poll or a trigger frame to signal its awake state to the TWT responding STA before a frame is sent from the TWT responding STA to the TWT requesting STA. A value of 1 in the Flow Type field indicates an Unannounced TWT in which the TWT responding STA will send a frame to the TWT requesting STA at TWT without waiting to receive a PS-Poll or trigger frame from the TWT requesting STA.

The TWT Flow Identifier field contains a 3-bit value which identifies the specific information for this TWT request uniquely from other requests made between the same TWT requesting STA and TWT responding STA pair.

The Wake Interval Exponent subfield is set to the value of the exponent of the TWT Wake Interval value in microseconds, base 2. The Wake Interval of the requesting STA is equal to (Wake Interval Mantissa) × $2^{(\text{Wake Interval Exponent})}$.

When transmitted by a TWT requesting STA, the Target Wake Time field contains a positive integer which corresponds to a TSF time at which the STA wants to wake. When transmitted by a TWT responding STA, the Target Wake Time field contains a positive integer which corresponds to a TSF time at which the TWT responding STA wants a TWT-requesting STA to wake. A TWT-requesting STA uses the value of 0 in the Target Wake Time field to indicate that the TWT-responding STA determines the TWT.

	Group ID	Zero Offset of Group	TWT Unit	Increment within Group
Bits:	8	8	3	5

Figure 8-401dc—TWT Group Assignment field format

The TWT Group Assignment field indicates the assignment of STAs to predefined TWT groups based on their requested TWTs. The TWT Group Assignment field provides information to a requesting STA about the assigned TWT group and this field contains Group ID, Zero Offset of Group, TWT Unit, and Increment Within Group subfields. The field and the corresponding subfields are depicted in Figure 8-401dc (TWT Group Assignment field format).

The Group ID subfield is 8-bit unsigned integer and indicates the identifier of the TWT group to which the requesting STA is assigned. The Group ID represents a set of STAs with adjacent TWT values. For group addressed traffic, a value of 00000000 in the TWT Group ID field is used for signaling all STAs in a TWT group instead of using individual AIDs.

The Zero Offset of Group subfield indicates the initial TWT value within the range of TWT values within a TWT Group. A Zero Offset of Group of value 00010100 indicates the first TWT value of the assigned group is 20, where the unit of the Offset is given in the TWT Unit subfield.

A non-AP STA uses the Zero Phase Offset, TWT Unit, and Increment within Group values to compute its location in the TWT Group. Based on the assigned TWT value, a STA computes the difference between its TWT value and the Zero Phase Offset value. If a TWT value is assigned to a single STA only, the computed difference and the value in Increment within Group subfield provides an estimate of the number of STAs already contending for the medium. For instance, if the value in Zero Offset of Group subfield for a TWT Group is "20" with TWT Unit subfield indicating "msec," and a STA's assigned TWT is 80msec, then the difference between its assigned TWT and first TWT of the Group is 60msec. If the value in Increment within Group subfield is 10msec, then this STA concludes that there are at most 6 STAs contending for the channel currently.

The TWT Unit subfield indicates the unit of the TWT values within the TWT group. The TWT Unit subfield is of length 3 bits. The TWT Unit value of 0 indicates millisecond, 1 indicates second, 2 indicates minute, 3 indicates hour, 4 indicates day, and the other values are reserved for future use.

The Increment Within Group subfield is 5-bit unsigned integer and indicates the difference between any two adjacent TWT values in the group. This difference is constant within the TWT group.

The Nominal Minimum Wake Duration field contains the minimum amount of time that the TWT-requesting STA expects that it needs to be awake in order to complete the frame exchanges associated with the Flow Identifier for the period of Wake Interval. The least significant bit of the field corresponds to 1 microsecond.

The Wake Interval Mantissa subfield is set to the value of the mantissa of the TWT Wake Interval value in microseconds, base 2.

When transmitted by a TWT requesting STA, the TWT Channel field contains a bitmap indicating on which channels the STA desires to transmit during a TWT SP. When transmitted by a TWT responding STA, the TWT Channel field contains a bitmap indicating on which channels the TWT requesting STA is allowed to operate during the TWT SP. Each bit in the bitmap corresponds to one minimum width channel for the band of operation with the least significant bit corresponding to the lowest numbered channel of the BSS. A value of 1 in a bit position in the bitmap transmitted by a TWT requesting STA means that operation on that channel is desired during a TWT SP. A value of 1 in a bit position in the bitmap transmitted by a TWT responding STA means that operation on that channel is allowed during the TWT SP.

	B0	B1	B2 B7
	NDP Paging Indicator	Responder PM Mode	Reserved
Bits:	1	1	6

Figure 8-401dd—Control field format

The NDP Paging field is present if the NDP Paging Indicator is set to 1; otherwise the NDP Paging field is not present.

The Responder PM Mode field indicates the Power Management mode as defined in 9.35.

The format of the NDP Paging field is defined in Figure 8-401de (NDP Paging field format).

	B0 B8	B9 B16	B17 B20	B21 B23	B24 B29	B30 B31
	P-ID	Max NDP Paging Period	Partial TSF Offset	Action	Min Sleep Duration	Reserved
Bits:	9	8	4	3	6	2

Figure 8-401de—NDP Paging field format

The P-ID field is the identifier of the paged STA, as described in section 9.32f.5.

The Max NDP Paging period indicates the maximum number of TWT intervals between two NDP Paging frames.

The Partial TSF Offset field includes timing indications, as described in section 9.32f.5.

The Action field indicates what action shall be taken by the STA upon reception of an NDP Paging Frame with matching P-ID field as defined in 9.32f.5 NDP Paging Setup. The content of the Action field is described in Table 8-191c (Action field).

Table 8-191c—Action field

Action	Options
0	Send a PS-Poll or uplink trigger frame
1	Wake up at the time indicated by Min Sleep Duration
2	STA to receive the Beacon
3	STA to receive the DTIM Beacon
4-7	Reserved

The Minimum Sleep Duration field in the NDP Paging Request indicates in units of SIFS the minimum duration that STA will be in the sleep mode after receiving an NDP Paging with matching P-ID.

Bits 30-31 of the NDP Paging field are reserved.

8.4.2.170k S1G Capabilities element

8.4.2.170k.1 S1G Capabilities element structure

A S1G STA declares that it is a S1G STA by transmitting the S1G Capabilities element.

The S1G Capabilities element contains a number of fields that are used to advertise S1G capabilities of a S1G STA. The S1G Capabilities element is defined in Figure 8-401df (S1G Capabilities element format).

	Element ID	Length	S1G Capabilities Info	TBD
Octets:	1	1	1	m (TBD)

Figure 8-401df—S1G Capabilities element format

The Element ID field is set to the value for S1G Capabilities element defined in Table 8-55 (Element IDs).

The Length field of the S1G Capabilities element is set to TBD.

8.4.2.170k.2 S1G Capabilities info field

The structure of the S1G Capabilities Info field is defined in Figure 8-401dg (S1G Capabilities Info field).

	B0	B1	B2	B3	B4	B5	B6 B7
	Uplink Synch Capable	Dynamic AID	BAT Support	TIM ADE Support	Non-TIM Support	TWT Support	STA Type Support
Bits:	1	1	1	1	1	1	2

Figure 8-401dg—S1G Capabilities Info field

The subfields of the S1G Capabilities Info field are defined in Table 8-191d (Subfields of the S1G Capabilities Info field).

Table 8-191d—Subfields of the S1G Capabilities Info field

Subfield	Definition	Encoding

Table 8-191d—Subfields of the S1G Capabilities Info field

Uplink Synch Capable	If sent by an AP STA, this subfield indicates support for synch frame transmission for uplink. If sent by a non-AP STA, this subfield indicates request for synch frame transmission for uplink. (see 9.32h.1 (Synch frame transmission procedure for uplink traffic)	If sent by an AP STA: Set to 0 if not supported. Set to 1 if supported. If sent by a non-AP STA: Set to 0 if not requested. Set to 1 if requested.
Dynamic AID	The STA sets the Dynamic AID field to 1 when dot11DynamicAIDActivated is true, and sets it to 0 otherwise. See 10.43b (Dynamic AID assignment operation).	Set to 1 if dot11DynamicAIDActivated is true. Set to 0 otherwise.
BAT Support	The BAT Support subfield indicates support for the use of the BAT frame in Block Agreements. When dot11BATImplemented is true, this field is set to 1 to indicate support for BAT frames as both originator and recipient.	Set to 1 if dot11BATImplemented is true. Set to 0 otherwise.
TIM ADE Support	This bit indicates support of the ADE mode of TIM bitmap encoding as described in 8.4.2.7.1.4 (ADE mode).	Set to 1 if a STA supports the ADE mode of TIM bitmap encoding as described in 8.4.2.7.1.4 (ADE mode). Set to 0 otherwise.
Non-TIM Support	This bit indicates support of Non-TIM mode.	For a non-AP STA: Set to 0: the non-AP STA does not support Non-TIM mode, it needs TIM entry as in legacy PS mode Set to 1: the non-AP STA supports Non-TIM mode and it does not need TIM entry when in Non-TIM mode For an AP STA: Set to 0: the AP STA does not support STA's Non-TIM mode Set to 1: the AP STA supports STA's Non-TIM mode
TWT Support	This bit indicates support of TWT described in 9.32f (Target Wake Time).	Set to 1 if dot11TWTOptionActive is true. Set to 0 otherwise.

Table 8-191d—Subfields of the S1G Capabilities Info field

STA Type Support	If sent by an AP STA, this subfield indicates STA types that are supported by the AP STA. If sent by a non-AP STA, this subfield indicates STA types of the non-AP STA.	If sent by an AP STA: Set to 0 if the AP STA supports both a Sensor type and a non-Sensor type STA. Set to 1 if the AP STA supports only a Sensor type STA. Set to 2 if the AP STA supports only a non-Sensor type STA. 3 is reserved. If sent by a non-AP STA: Set to 0 if the STA is both Sensor type and non-Sensor type STA. Set to 1 if the STA is a Sensor type STA. Set to 2 if the STA is a non-Sensor type STA. 3 is reserved.

8.4.2.170l Sector Capabilities element

An S1G STA may declare that it can support sectorization by transmitting the Sector Capabilities element during the association.

The Sector Capabilities element contains a number of fields that are used to advertise sector capabilities of an S1G STA including the Sectorized Beam Capable field, the Sectorization Type field, the Sector ID Feedback Capable field, the Total Sector Number field (0 to 7 represents the number of total sectors 1 to 8, respectively) and the Sector Training Capable field.

Table 8-191e—Sector Capabilities element format

Subfield	Bits	Definition	Encoding
Element ID	8		
Length	8		
Sectorization Beam Capable	1	indicate whether the AP or STA supports the sectorized operation	Set to 0 if not supported, Set to 1 if supported
Sectorization Type	2	indicate supports of which type of sectorization scheme	Set to 0 if only Type 0 Sectorization is supported, Set to 1 if only Type 1 Sectorization is supported, Set to 2 if both Type 0 Sectorization and Type 1 Sectorization are supported, Set to 3, else

Table 8-191e—Sector Capabilities element format

Total Sector Number	3	Indicate the total number of sectors AP supports in the BSS	Set to 0 to 7 to represents number of sector 1 to 8, respectively
Sector ID Feedback Capable	1	indicate whether the STA supports sector ID Feedback	Set to 0 if not supported, Set to 1 if supported
Sector Training Capable	1	Indicate whether the AP or STA supports sector training	Set to 0 if not supported, Set to 1 if supported
Reserved	TBD		

8.4.2.170m Subchannel Selective Transmission element

The Subchannel Selective Transmission element is shown in Figure 8-401dh (Subchannel Selective Transmission element format).

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	Element ID	Length	Channel Activity Schedule
Octets:	1	1	N×4

Figure 8-401dh—Subchannel Selective Transmission element format

N is the number of channels for which a channel activity schedule is being provided.

The format of the Channel Activity Schedule subfield is shown in Figure 8-401di (Channel Activity Schedule subfield format).

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	Channel Activity Bitmap	UL Activity	DL Activity	Maximum Transmission Width	Activity Start Time
Bits:	8	1	1	2	20

Figure 8-401di—Channel Activity Schedule subfield format

The Channel Activity Bitmap subfield contains a bitmap indicating on which channels there is expected or permitted to be transmission activity at a given time. Each bit in the bitmap corresponds to one minimum width channel for the band of operation with the LSbit corresponding to the lowest numbered operating channel of the BSS. A value of 1 in a bit position in the bitmap means that the AP expects activity or permits transmissions with bandwidth less than or equal to Maximum Transmission Width and that include that channel, after the time indicated in the Activity Start Time subfield. More than one bit in the bitmap can be set to 1.

Note - transmissions need to comply with the channelization for the regulatory domain of operation.

The UL Activity bit indicates whether STAs associated with the AP that transmits the subfield are permitted to transmit on the channel(s) identified by the Channel Activity Bitmap and Maximum Transmission Width at the time indicated in the Activity Start Time subfield.

The DL Activity bit indicates whether the AP that transmits the subfield intends to transmit on the channel(s) identified by the Channel Activity Bitmap and Maximum Transmission Width at the time indicated in the Activity Start Time subfield.

The Maximum Transmission Width field indicates the maximum permitted PPDU bandwidth for a transmission on the indicated channel.

The Activity Start Time subfield contains a value that defines a start time for when the AP expects activity on the channel(s) indicated in the corresponding Channel Activity Bitmap. The start time is equal to the next time, starting from the transmission of the frame containing the subfield, when the 20 least significant bits of the TSF for the BSS match the value in the Activity Start Time subfield.

8.4.2.170n Modified EDCA Parameter Set element

The format of the Modified EDCA Parameter Set element is same as the format of the EDCA Parameter Set element (8.4.2.28), except that the Control field is reserved.

8.4.2.170o Authentication Control element

An Authentication Control element indicates to STA whether it is allowed to transmit an Authentication Request frame to the AP which sends the element. The Information field contains only one field, the Authentication Control Threshold. The total length of the Information field is 2 octets. See Figure 8-401dj (Authentication Control element format).

	Element ID	Length	Authentication Control Threshold
Octets:	1	1	2

Figure 8-401dj—Authentication Control element format

The Authentication Control Threshold is a number and varies from 0 to 65535.

8.4.2.170p TSF Timer Accuracy element

The TSF Timer Accuracy element, shown in Figure 8-401dk (TSF Timer Accuracy element format), specifies fields describing the accuracy of TSF timer. This information is used by a receiving STA to estimate the clock accuracy of the transmitting STA and to schedule wake-up time for beacon reception by taking this clock accuracy into account.

	Element ID	Length	TSF Timer Accuracy
Octets:	1	1	1

Figure 8-401dk—TSF Timer Accuracy element format

The Element ID field is set to the value for TSF Timer Accuracy element defined in Table 8-55 (Element IDs).

The Length field is set to 1.

The TSF Timer Accuracy field is a 1 octet signed integer that specifies the accuracy of the TSF timer of transmitting STA. The unit of the TSF Timer Accuracy field is PPM.

8.4.2.170q Relay element

	Element ID	Length	Relay Control	RootAP BSSID
Octets:	1	1	1	6

Figure 8-401dl—Relay element format

The Relay element contains parameters necessary to support the Relay operation.

The Relay Control subfield indicates whether the AP is a Root AP or whether it relays an SSID, as specified in Table 8-191f (Relay Control subfield).

Table 8-191f—Relay Control subfield

Relay Control	Meaning
0	Root AP
1	Relayed SSID
2-255	Reserved

The RootAP BSSID subfield indicates BSSID of the root AP that current relay station is associated with.

8.4.2.170r Relay Address element

	Element ID	Length	Address Count Field	Reachable Addresses
Octets:	1	1	1	variable

Figure 8-401dm—Reachable Address element format

Address Count field is an integer representing the number of addresses in the Reachable Addresses field.

The Reachable Addresses field is n × 6 octets in length, where n is specified in the Address Count field. The Reachable Addresses field specifies the addresses that can be reached through the Relay STA.

8.4.2.170s Relay Discovery element

The Relay Discovery element is shown in Figure 8-401dn (Relay Discovery element format).

	Element ID	Length	Direct Path Link Budget Information	QoS Requirements
Octets:	1	1	TBD	TBD

Figure 8-401dn—Relay Discovery element format

8.4.2.170t AID Announcement element

The AID Announcement element is used to provide the mapping table between STA MAC Address and STA AID.

			One or more entries
	Element ID	Length	AID Entry
Octets:	1	1	8*n*

Figure 8-401do—AID Announcement element format

The Element ID field is set to the value for AID Announcement element defined in Table 8-55 (Element IDs).

The Length field is 8n, where n indicates the total number of AID Entry fields contained in the element.

The AID Entry field includes one or more STA MAC Address and Association ID pairs. The format of AID Entry field is shown in Figure 8-401dp (AID Entry field format).

	STA MAC Address	Association ID
Octets:	6	2

Figure 8-401dp—AID Entry field format

The STA MAC Address field indicates the MAC Address of STA. The Association ID field includes the AID for the corresponding STA.

8.4.2.170u AP Power Management element

The AP Power Management element is shown in Figure 8-401dq (AP Power Management element).

	Element ID	Length	AP PM Mode
Octets:	1	1	1

Figure 8-401dq—AP Power Management element

The AP PM Mode field is shown in 8-401dr (AP PM Mode field).

	B0	B1 B7
	PM Mode	reserved
Octets:	1	7

Figure 8-401dr—AP PM Mode field

The PM Mode field is 1 bit in length and indicates whether the AP is operating in Active or Power Save mode as described in 10.2.1.19 (AP Power management).

8.4.2.170v Probe Response Option element

The Probe Response Option element is included in the Probe Request frame to indicate which optional information is requested to be included in the Short Probe Response frame that is transmitted by the responding STAs.

The optional information requested by the STA is indicated as bitmaps in the Probe Response Option element. It is also indicated that which bitmap is included in the Probe Response Option element.

The format of the Probe Response Option element is shown in Figure 8-401ds (Probe Response Option element format).

	Element ID	Length	Probe Response Group bitmap	Probe Response Option bitmap 0	Probe Response Option bitmap 1	...	Probe Response Option bitmap n
Octets:	1	1	1	1	1		1

Figure 8-401ds—Probe Response Option element format

The Element ID field is set to the value for Probe Response Option element defined in Table 8-55 (Element IDs).

The value of the Length field is the total length of the Probe Response Group bitmap field and Probe Response Option bitmap fields and set to value between 1 and 9 depending on the number of Probe Response Option bitmaps included in the Probe Response Option element.

The Probe Response Group bitmap indicates which Probe Response Option bitmap is included in the Probe Response Option element. If Probe Response Option bitmap i is included in the Probe Response Option element, then i-th bit in the Probe Response Group bitmap is set to 1.

Each Probe Response Option bitmap indicates which optional information is requested to be included in the Short Probe Response frame by the responding STAs.

The optional information requested to be included in the Short Probe Response is categorized into 8 bitmaps (Probe Response Option bitmap 0 ~ 7).

Table 8-191g (Probe Response Option bitmap 0 (Default Bitmap)) ~ Table 8-191l (Probe Response Option bitmap 5) define the Probe Response Option bitmap 0 ~ 5.

Note: Probe Response Option bitmap 6 and 7 are reserved for future extension.

Table 8-191g—Probe Response Option bitmap 0 (Default Bitmap)

Subfield	Bits	Definition	Encoding
Request Full SSID	1	Indicates whether Full SSID or Compressed SSID is requested to be included in the short probe response	Set to 1 to request Full SSID Set to 0 to request Compressed SSID
Request Next TBTT	1	Indicates Next TBTT field is requested to be included in the short probe response	Set to 1 to request Next TBTT Set to 0 otherwise.

Table 8-191g—Probe Response Option bitmap 0 (Default Bitmap)

Request Access Network Options	1	Indicates Request Access Network Options field is requested to be included in the short probe response	Set to 1 to request Access Network Options Set to 0 otherwise.
Request Short Beacon Compatibility IE	1	Indicates Short Beacon Compatibility element (8.4.2.170g) is requested to be included in the short probe response	Set to 1 to request Short Beacon Compatibility element Set to 0 otherwise.
Request Supported Rates	1	Indicates Supported Rates in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Supported Rates. Set to 0 otherwise.
Request S1G Capability	1	Indicates S1G Capabilities element (8.4.2.170k) is requested to be included in the short probe response	Set to 1 to request S1G Capabilities element. Set to 0 otherwise.
Request Extended Capabilities	1	Indicates Extended Capabilities in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Extended Capabilities. Set to 0 otherwise.
Reserved	1	Reserved	

Table 8-191h—Probe Response Option bitmap 1

Subfield	Bits	Definition	Encoding
Request RPS	1	Indicates RPS element is requested to be included in the short probe response	Set to 1 to request RPS element Set to 0 otherwise.
Request Segment Count	1	Indicates Segment Count element is requested to be included in the short probe response	Set to 1 to request Segment Count Set to 0 otherwise.
Request TSF Timer Accuracy	1	Indicates TSF Timer Accuracy element is requested to be included in the short probe response	Set to 1 to request TSF Timer Accuracy. Set to 0 otherwise.

Table 8-191h—Probe Response Option bitmap 1

Request Relay Discovery	1	Indicates Relay Discovery element is requested to be included in the short probe response	Set to 1 to request Relay Discovery. Set to 0 otherwise.
Request RootAP BSSID	1	Indicates RootAP BSSID element is requested to be included in the short probe response	Set to 1 to request RootAP BSSID. Set to 0 otherwise.
Reserved	1	Reserved	
Reserved	1	Reserved	
Reserved	1	Reserved	

Table 8-191i—Probe Response Option bitmap 2

Subfield	Bits	Definition	Encoding
Request Country	1	Indicates Country element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Country element Set to 0 otherwise.
Request Power Constraint	1	Indicates Power Constraint element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Power Constraint Set to 0 otherwise.
Request TPC Report	1	Indicates TPC Report element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request TPC Report. Set to 0 otherwise.
Request Extended Supported Rates	1	Indicates Extended Supported Rates in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Extended Supported Rates. Set to 0 otherwise.
Request RSN	1	Indicates RSN element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request RSN. Set to 0 otherwise.

Table 8-191i—Probe Response Option bitmap 2

Request BSS Load	1	Indicates BSS Load element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request BSS Load. Set to 0 otherwise.
Request EDCA Parameter Set	1	Indicates EDCA Parameter in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request EDCA Parameter. Set to 0 otherwise.
Request Supported Operating Classes	1	Indicates Supported Operating Classes in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Supported Operating Classes. Set to 0 otherwise.

Table 8-191j—Probe Response Option bitmap 3

Subfield	Bits	Definition	Encoding
Request Measurement Pilot Transmission	1	Indicates Measurement Pilot Transmission element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Measurement Pilot Transmission Set to 0 otherwise.
Request Multiple BSSID	1	Indicates Multiple BSSID element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Multiple BSSID Set to 0 otherwise.
Request RM Enabled Capabilities	1	Indicates RM Enabled Capabilities element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request RM Enabled Capabilities. Set to 0 otherwise.
Request AP Channel Report	1	Indicates AP Channel Report in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request AP Channel Report. Set to 0 otherwise.
Request BSS Average Access Delay	1	Indicates BSS Average Access Delay element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request BSS Average Access Delay. Set to 0 otherwise.

Table 8-191j—Probe Response Option bitmap 3

Request Antenna	1	Indicates Antenna element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Antenna. Set to 0 otherwise.
Request BSS Available Admission Capacity	1	Indicates BSS Available Admission Capacity in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request BSS Available Admission Capacity. Set to 0 otherwise.
Request BSS AC Access Delay	1	Indicates BSS AC Access Delay in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request BSS AC Access Delay. Set to 0 otherwise.

Table 8-191k—Probe Response Option bitmap 4

Subfield	Bits	Definition	Encoding
Request Mobility Domain	1	Indicates Mobility Domain element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Mobility Domain Set to 0 otherwise.
Request DSE registered location	1	Indicates DSE registered location element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request DSE registered location Set to 0 otherwise.
Request CF Parameter Set	1	Indicates CF Parameter Set element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request CF Parameter Set. Set to 0 otherwise.
Request QoS Traffic Capability	1	Indicates QoS Traffic Capability in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request QoS Traffic Capability. Set to 0 otherwise.
Request Channel Usage	1	Indicates Channel Usage element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Channel Usage. Set to 0 otherwise.

Table 8-191k—Probe Response Option bitmap 4

Request Time Advertisement	1	Indicates Time Advertisement element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Time Advertise-ment. Set to 0 otherwise.
Request Time Zone	1	Indicates Request Time Zone in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Time Zone. Set to 0 otherwise.
Reserved	1	Reserved	

Table 8-191l—Probe Response Option bitmap 5

Subfield	Bits	Definition	Encoding
Request Interworking	1	Indicates Interworking element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Interworking Set to 0 otherwise.
Request Advertisement Protocol	1	Indicates Advertisement Protocol element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Advertisement Protocol Set to 0 otherwise.
Request Roaming Consortium	1	Indicates Roaming Consortium element in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Roaming Consortium. Set to 0 otherwise.
Request Emergency Alert Identifier	1	Indicates Emergency Alert Identifier in Table 8-30 (Probe Request frame body) is requested to be included in the short probe response	Set to 1 to request Emergency Alert Identifier. Set to 0 otherwise.
Reserved	1	Reserved	
Reserved	1	Reserved	
Reserved	1	Reserved	
Reserved	1	Reserved	

Setting a bit in a Probe Response Option bitmap to 1 indicates that the corresponding information is requested to be included in the Short Probe Response frame if the responding STA supports the indicated information.

If the Request full SSID bit in the Probe Response Option bitmap 0 is set to 1, then it indicates that the full SSID of the responding STA is requested to be included in the Short Probe Response frame. If it is set to 0, it indicates that compressed SSID of the responding STA is requested to be included instead of the full SSID.

Only Probe Response Option bitmaps with at least one bit set to 1 is included in the Probe Response Option element. The Probe Response Group bitmap field indicates which Probe Response Option bitmap is included in the Probe Response Option element. For example, if only Probe Response Option bitmap 0 and 2 have bits that are set to 1, then these two Probe Response Group bitmaps are included in the Probe Response Option element and the Probe Response Group bitmap is set to 10100000 to indicate that only the Probe Response Option bitmap 0 and 2 are included in the Probe Response Option element.

Probe Response Option bitmap 0 is defined to be a default bitmap that indicates most frequently requested information. If the default bitmap is the only Probe Response Option bitmap that is included in the Probe Response Option element, then the Probe Response Group bitmap is omitted. In that case, only Element ID, Length, and the default Probe Response Group bitmap (Probe Response Option bitmap 0) are included in the Probe Response Option element.

8.4.2.170w Activity Specification element

The Activity Specification element is used by a STA to inform the associated AP or peer TDLS STA about operating limitations of the STA, in terms of the maximum continuous time the STA is capable of being in the Awake state, and the minimum continuous time the STA must stay in Doze state in between Awake periods.

	Element ID	Length	Max Awake Interval	Recovery Time
Octets:	1	1	4	4

Figure 8-401dt—Activity Specification element format

The Length field is set to 8.

The Max Awake Interval field indicates a time in units of µs, used as defined in 9.32p (Support for energy limited STAs); a value 0 indicates that no limit applies.

The Recovery time indicates a time in units of µs, used as defined in 9.32p (Support for energy limited STAs).

8.4.2.170x Group ID List element

The Group ID List element includes the information necessary for a receiving STA to determine its group membership. A station could belong to one or more groups. An example of group use is the sector operation. In Sector operation, only a set of STA groups is allowed to transmit during the sector duration. The Group ID List element can be provided in Probe Response or Association Response.

The format of the Group ID List element is presented in Figure 8-401du (Group ID List element format).

	Element ID	Length	Group ID Type	Group ID	...	Group ID	Group ID
Bits:	8	8	4	4		4	4

Figure 8-401du—Group ID List element format

The Element ID has one octet length and specifies the corresponding value of the Group ID List element specified in Table 8-55 (Element IDs).

The Length field is one octet length specifies the length of Group ID List element in octets.

The Group ID Type field is a 4 bit field and indicates the group IDs usage. Group 0000 indicates that the group IDs list refers to sectorization use.

The Group ID field is a 4 bit field and it indicates a new group ID that it is associated to the receiver stations.

8.5 Action frame format details

8.5.4 DLS Action frame details

8.5.4.2 DLS Request frame format

Insert a row in Table 8-199 as follows:

Table 8-199—DLS Request frame Action field format

Order	Information	Notes
TBD	S1G Capabilities	S1G Capabilities element is optionally present if dot11S1GOptionImplemented is true.

8.5.4.2 DLS Response frame format

Table 8-200—DLS Request frame Action field format

Order	Information	Notes
TBD	S1G Capabilities	S1G Capabilities element is optionally present if dot11S1GOptionImplemented is true.

8.5.5 Block Ack Action frame details

8.5.5.1 General

Modify the text as shown:

The ADDBA frames are used to set up or, if PBAC is used, to modify Block Ack for a specific TC, TS, or GCR group address.(11aa) A Block Ack Action field, in the octet immediately after the Category field, differentiates the Block Ack Action frame formats. The most significant bit (MSB) of the Block Ack Action field is defined as the NDP Block Ack subfield. The Block Ack Action field values associated with each frame format within the Block Ack category are defined in Table 8-212 (Block Ack Action field values).

Table 8-212—Block Ack Action field values

Block Ack Action field values	Meaning
0	ADDBA Request
1	ADDBA Response
2	DELBA
3–127	Reserved
128	NDP ADDBA Request
129	NDP ADDBA Response
130	NDP DELBA
131	BAT ADDBA Request
132	BAT ADDBA Response
133	BAT DELBA
134-255	Reserved

8.5.5.2 ADDBA Request frame format

Modify the third paragraph of sub-clause 8.5.5.2:

The Block Ack Action field is set to either 0 or 128 (representing ADDBA request). The meaning for each value is described in 8.5.5.1.

8.5.5.3 ADDBA Response frame format

Modify the third paragraph of sub-clause 8.5.5.3:

The Block Ack Action field is set to either 1 or 129 (representing ADDBA response). The meaning for each value is described in 8.5.5.1.

Modify Table 8-214 as follows:

Table 8-214—ADDBA Response frame Action field format

Order	Information
1	Category
2	Block Ack Action
3	Dialog Token
4	Status Code
5	Block Ack Parameter Set
6	Block Ack Timeout Value
7	GCR Group Address element (optional)
8	Originator Parameter

Insert the following sentence at the end of the subclause:

The Originator Parameter field is defined in 8.4.1.15a.

8.5.13 TDLS Action frame details

8.5.13.2 TDLS Setup Request frame format

Insert a row in Table 8-239 as follows:

Table 8-239—Information for TDLS Setup Request frame

Order	Information	Notes
TBD	S1G Capabilities	S1G Capabilities element is optionally present if dot11S1GOptionImplemented is true.

8.5.13.2 TDLS Setup Response frame format

Insert a row in Table 8-240 as follows:

Table 8-239—Information for TDLS Setup Response frame

Order	Information	Notes

Table 8-239—Information for TDLS Setup Response frame

TBD	S1G Capabilities	S1G Capabilities element is optionally present if dot11S1GOptionImplemented is true.

8.5.23 VHT Action frame details

8.5.23.1 VHT Action field

8.5.23.4a VHT Sector ID Feedback frame format

The Sector ID Feedback frame is an Action or Action No Ack frame of category VHT. The format of its Action field is defined in Table 8-281al (Sector ID Feedback frame Action field format).

Table 8-281al—Sector ID Feedback frame Action field format

Order	Information
1	Category
2	VHT Action
3	Sector ID Index

The Category field is set to the value for VHT, specified in Table 8-38 (Category values).

The VHT action is set to TBD (3 or higher) and the Sector ID index is shown in Figure 8-401dv (Sector ID Index format).

	Preferred Sector ID	SNR	Receive Sector Bitmap
Bits:	3	5	8

Figure 8-401dv—Sector ID Index format

	I_0	I_1	I_2	I_3	I_4	I_5	I_6	I_7
Bits:	1	1	1	1	1	1	1	1

Figure 8-401dw—Receive Sector Bitmap format

The Preferred Sector ID field is 3 bits in length and indicates the sector in which highest quality of AP signal is received by the STA. The method in which a STA determines the high quality AP signal is out of the scope of this standard.

The SNR field is 5 bits in length and indicates the received SNR at the preferred Sector, 0 to 30 represents SNR values from -3 to 27 dB, respectively. If the SNR value is less than -3dB, set to 0. If the SNR value is greater than 27db, set to 30. 31 indicates no feedback.

The Receive Sector Bitmap field is 8 bits in length. A bit position set to 0 within the bit map indicates that the STA does not receive the AP signal in the corresponding Sector ID. A bit position set to 1 within the bit map indicates that the STA does receive the AP signal in the corresponding Sector ID. The position of the bit map (0 to 7) corresponding to the sector ID.

Insert the following new sub-clauses at the end of 8.5.23as the following:

8.5.23a S1G Action frame details

8.5.23a.1 S1G Action field

Several Action frame formats are defined to support S1G functionality. A S1G Action field, in the octet immediately after the Category field, differentiates the S1G Action frame formats. The S1G Action field values associated with each frame format within the S1G category are defined in Table 8-295am (S1G Action field values).

Table 8-295am—S1G Action field values

Value	Meaning	Time Priority
0	AID Switch Request	No
1	AID Switch Response	No
2	Synch Control	No
3	STA Information Announcement	No
4	EDCA Parameters Set	
5	Activity Specification	
6	TWT Setup	
7	Group ID List	
8 – 255	Reserved	

8.5.23a.2 AID Switch Request frame format

The AID Switch Request frame is an Action frame of category S1G. It is used to notify the responding STAs that the transmitting STA is changing its device characteristic. Also, it is used to request an AID for the multicast group from the responding STA. The Action field of the AID Switch Request frame contains the information shown in Table 8-295an (AID Switch Request frame action field format).

Table 8-295an—AID Switch Request frame action field format

Order	Information
1	Category
2	S1G Action
3	Dialog Token
4	AID Request Element (see 8.4.2.170d)

The Category field is set to the value for S1G, specified in Table 8-38 (Category values).

The S1G Action field is set to the value for AID Request, specified in Table 8-295am (S1G Action field values).

The Dialog Token field is a value chosen by the non-AP STA sending the AID Switch Request frame to identify the request/response transaction.

The AID Request Element field contains an AID Request element as specified in 8.4.2.170d (AID Request element).

8.5.23a.3 AID Switch Response frame format

The AID Switch Response frame is an Action frame of category S1G. It is sent by an AP in response to an AID Switch Request frame, or sent by the AP to the STA to instruct the non-AP STA to change the AID or the wakeup interval. Also, it is sent by an AP to assign an AID for the request multicast group from the requesting STA. The Action field of the AID Switch Response frame contains the information shown in Table 8-295ao (AID Switch Response frame action field format).

Table 8-295ao—AID Switch Response frame action field format

Order	Information
1	Category
2	S1G Action
3	Dialog Token
4	AID Response (see 8.4.2.170e)

The Category field is set to the value for S1G, specified in Table 8-38 (Category values).

The S1G Action field is set to the value for AID Switch Response, specified in Table 8-295am (S1G Action field values).

The Dialog Token field is the value in the corresponding AID Switch Request frame. If the AID Switch Response frame is not being transmitted in response to an AID Switch Request frame, then the Dialog token is set to 0.

The AID Response field contains an AID Response element as specified in 8.4.2.170e (AID Response element).

8.5.23a.4 Synch Control frame format

The Synch Control frame is an Action frame of category S1G. It is transmitted by a non-AP STA to a UL-Synch capable AP to enable or disable the synch frame transmission for uplink or downlink traffic. The Action field of a Synch Control frame contains the information shown in Table 8-295ap (Synch Control frame action field format).

Table 8-295ap—Synch Control frame action field format

Order	Information
1	Category
2	S1G Action
3	Synch Control (see 8.4.1.52a)

The Category field is set to the value for S1G, specified in Table 8-38 (Category values).

The S1G Action field is set to the value for Synch Control, specified in 8.5.23a.1 (S1G Action field).

8.5.23a.5 STA Information Announcement frame format

The STA Information Announcement frame is an Action frame of category S1G. It is used to inform the peer STAs of the updated AID information when a STA's AID is changed. Also, it is used for a relay station to indicate an associated STA's AID to the AP when the STA becomes associated or the STA's AID is changed. The Action field of the STA Information Announcement frame contains the information shown in Table 8-295aq (STA Information Announcement frame format).

Table 8-295aq—STA Information Announcement frame format

Order	Information
1	Category
2	S1G Action
3	AID Announcement element (8.4.2.170t)

The Category field is set to the value for S1G, specified in Table 8-38 (Category values).

The S1G Action field is set to the value for STA Information Announcement, specified in Table 8-295am (S1G Action field values).

8.5.23a.6 EDCA Parameters Set frame format

The EDCA Parameters Set frame is used to update the EDCA Parameter Set at the recipient STA, as defined in 9.2.4.2 (HCF contention-based channel access (EDCA)).

Table 8-295ar—EDCA Parameters Set Action field format

Order	Information
1	Category
2	S1G Action
3	Modified EDCA Parameter Set (8.4.2.170n)

8.5.23a.7 Activity Specification frame format

The Activity Specification frame is used to carry the Activity Specification element (8.4.2.170w (Activity Specification element)).

Table 8-295as—Activity Specification Action field format

Order	Information
1	Category
2	S1G Action
3	Activity Specification element (8.4.2.170w)

8.5.23a.8 TWT Setup frame format

The TWT Setup frame is an Action frame of category S1G. It is sent by a STA to request the setup of a TWT SP and it is sent by a responding STA to indicate the status of a requested TWT SP. The action field of the TWT Setup frame contains the information shown in Table 8-295at (TWT Setup frame action field format).

Table 8-295at—TWT Setup frame action field format

Order	Information
1	Category
2	S1G Action

Table 8-295at—TWT Setup frame action field format

3	Dialog Token
4	TWT element (8.4.2.170j)

The category field is set to the value for S1G specified in Table 8-38 (Category values).

The S1G Action field is set to the value for TWT Request frame specified in Table 8-295am (S1G Action field values).

In a TWT Setup frame with a TWT Request field that has a value of 1, the Dialog Token field is set to a value chosen by the transmitting STA to identify the request/response transaction. In a TWT Setup frame with a TWT Request field that has a value of 0, the Dialog Token field is set to the value copied from the corresponding received TWT Setup frame with a TWT Request field that had a value of 1.

8.5.23a.9 Group ID List frame format

The Group ID List frame is an Action or Action No Ack frame of category S1G Action. The frame is used to allocate/change group IDs to a station. When a STA receives such frame, the group IDs associated to Group ID Type field are replaced/initialized to the list of group IDs provided by this frame. The format of its Action field is defined in Table 8-295au (Group ID List frame action field format).

Table 8-295au—Group ID List frame action field format

Order	Information
1	Category
2	S1G Action
3	Group ID List element (8.4.2.170x)

The Category field is set to the value for S1G Action, specified in Table 8-38 (Category values).

The S1G Action field is set to the value for the Group ID List frame specified in Table 8-295am (S1G Action field values).

8.5.23b Relay Action frame details

8.5.23b.1 Relay Action field

The Relay Action field values are specified in Table 8-295av (Relay Action field values).

Table 8-295av—Relay Action field values

Relay Action field value	Description
0	Reachable Address Update
1-255	Reserved

8.5.23b.2 Reachable Address Update frame format

The Reachable Address Update frame is used to update the addresses that can be reached through a Relay STA. The format of the Reachable Address Update frame Action field is shown in Table 8-295aw (Reachable Address Update frame Action field format).

Table 8-295aw—Reachable Address Update frame Action field format

Order	Information
1	Category
2	Relay Action
3	Reachable Address element

The Category field is 1 octet and is set to the value in Table 8-39 (Category values) for category Relay Action.

The Relay Action field is set to the value in Table 8-295av (Relay Action field values) representing Reachable Address Update.

The one or more Reachable Address elements specify the addresses that can be reached through the Relay STA.

Add the following new clause and sub-clauses after clause 8.7:

8.7 MAC frame format for short frames

In this subclause, STA means non-AP STA.

8.7.1 Basic components

Each short frame consists of the following basic components:

a) A short *MAC header*, which comprises frame control, address, optional sequence control information;

b) A variable-length *frame body*, which contains information specific to the frame *type*;

c) An *FCS*, which contains an IEEE 32-bit CRC.

8.7.2 General short frame format

Figure 8-532a (Short frame format) depicts the general short MAC frame format. The first four fields (Frame Control, A1, A2, and Sequence Control) and the last two fields (Frame Body, and FCS) are always present in short frames. The A3 field and A4 field are optionally present. Each field is defined in 8.7.3 (Short frame fields).

	Frame Control	A1	A2	Sequence Control	A3	A4	Frame Body	FCS
Octets:	2	2 or 6	6 or 2	2	6	6	variable	4

Figure 8-532a—Short frame format

The Frame Body field is of variable size, constrained as defined in 8.2.4.7.1 (General).

8.7.3 Short frame fields

8.7.3.1 Frame Control field

The format of the Frame Control field of the short MAC header is illustrated in Figure 8-532b (Frame Control field).

	B0 B1	B2 B5	B6	B7	B8	B9	B10	B11	B12	B13 B15
	Protocol Version	Type	From DS	More Fragments	Power Manage ment	More Data	Protected Frame	End of Service Period	Relayed Frame	TID
Bits:	2	4	1	1	1	1	1	1	1	3

Figure 8-532b—Frame Control field

The Protocol Version field is 2 bits in length and is defined in 8.2.4.1.2. For Short frames the value of the protocol version is 1.

The Type field is 4 bits in length and identifies the type of the frame, as defined in Table 8-301a (Short frame types).

Table 8-301a—Short frame types

Type	Type description
0	Data — A1 or A2 is an SID (defined in 8.7.3.2), as determined by the From DS subfield in the FC field
1	Management — A1 or A2 is an SID (defined in 8.7.3.2), as determined by the From DS subfield in the FC field — Management subtypes are encoded in the TID subfield in the FC field
2-14	Reserved
15	Extension (currently reserved)

Short frames with type value set to 0 define a short data frame. Short frames with type value set to 1 define a short management frame. All other values of the type field are reserved.

The From DS field is 1 bit in length and defines the addressing of short frames, as defined in Table 8-301b (From DS values in short frames).

Table 8-301b—From DS values in short frames

From DS field	Meaning	Use
0	A1 contains the MAC address of the receiver A2 is an SID which contains the AID of the transmitter A3 (if present) contains the Destination Address "A4 (if present) contains the Source Address	STA to AP STA to STA (direct link)
1	A1 is an SID which contains the AID of the receiver A2 is the MAC address of the transmitter A3 (if present) contains the Destination Address "A4 (if present) contains the Source Address	AP to STA

The More Fragments field is 1 bit in length and is described in 8.2.4.1.5.

The Power Management field is 1 bit in length and is described in 8.2.4.1.7.

The EOSP subfield is 1 bit in length and is described in 8.2.4.5.3.

The Protected Frame field is 1 bit in length and is described in 8.2.4.1.9.

The More Data field is 1 bit in length and is described in 8.2.4.1.8.

The Relayed Frame field is 1 bit in length and indicates the current TXOP is shared with the Relay STA using the Explicit ACK procedure as described in 9.32n.3.1 (Explicit ACK procedure). The Relayed Frame field may be set to 1 only if the More Data field was set to 0 in the frame most recently received from the non-AP STA.

The TID field is 3 bits in length and contains the 3 LSBs of the TID field defined in 8.2.4.5.2 for short data frames (type value set to 0). The TID field for short management frames (type value set to 1) is used to indicate short management frame subtypes as described in TBD.

8.7.3.2 Address fields

There are up to four address fields in the short MAC frame format. These fields are used to indicate the recipient of the frame (A1), the transmitter of the frame (A2), and optionally the source and/or the destination of the frame (A3 and/or A4).

The recipient of the frame (A1) or the transmitter of the frame (A2) can be identified by the AID subfield located in the Short ID (SID) field depending on the value of the From DS subfield of the Frame Control field as described in 8.7.3.1. A group of receiving STAs of the frame can be identified by the AID subfield with a MID value located in the Short ID (SID) field. The length of the SID field is 2 octets and is illustrated in Figure 8-532c (SID field).

	B0 B12	B13	B14	B15
	Association ID (AID)	A3 Present	A4 Present	A-MSDU
Bits:	13	1	1	1

Figure 8-532c—SID field

The AID subfield contains an AID as specified in Table 8.7.3.1-2–From DS values in short data frames of Type 0-2.

The A3 Present subfield is 1 if the A3 is present in the short MAC header, otherwise it is 0.

The A4 Present subfield is 1 if the A4 is present in the short MAC header, otherwise it is 0.

The A-MSDU subfield is 1 if the MPDU contains a Dynamic A-MSDU as described in 8.7.4 (Dynamic A-MSDU format).

When the A3 field is not present, A3 is either stored at the recipient of the frame or, if an A3 is not stored at the recipient of the frame, A3 is equal to the address identified by A1. When the A4 field is not present, A4 is either stored at the recipient of the frame or, if an A4 is not stored at the recipient of the frame, A4 is equal to the address identified by A2.

8.7.3.3 Sequence Control field

The Sequence Control field is 16 bits in length and is described in 8.2.4.4.

8.7.3.4 Frame Body field

The Frame Body is a variable-length field and is described in 8.2.4.7.

8.7.3.5 Overhead for encryption

The overhead for encryption is described in Clause 11.

8.7.3.6 FCS field

The FCS field is a 32-bit field and is described in 8.2.4.8.

8.7.4 Dynamic A-MSDU format

A Dynamic A-MSDU is a sequence of one or more Dynamic A-MSDU subframes, as illustrated in Figure 8-532d (Dynamic A-MSDU structure). Each A-MSDU subframe consists of an A-MSDU subframe header, as defined in Figure 8-532e (Dynamic A-MSDU subframe structure).

Dynamic A-MSDU subframe 1	Dynamic A-MSDU subframe 2	...	Dynamic A-MSDU subframe n

Figure 8-532d—Dynamic A-MSDU structure

Octets:	2	6	6	0-2034	0-3
	Subframe Control	DA (Optional)	SA (Optional)	MSDU	Padding

Figure 8-532e—Dynamic A-MSDU subframe structure

A Dynamic A-MSDU subframe has 0, 1 or 2 addresses associated with it, as governed by the Subframe Control field.

The Subframe Control is defined in Figure 8-532f (Subframe Control field) and contains the Length, DA Present and SA Present fields.

	B0 B13	B14	B15
	Length	DA Present	SA Present
Bits:	14	1	1

Figure 8-532f—Subframe Control field

The Length field contains the length in octets of the MSDU.

The DA Present bit is set to 1 when the DA field is present in the Dynamic A-MSDU subframe header and is set to 0 when the DA field is not present.

The SA Present bit is set to 1 when the SA field is present in the Dynamic A-MSDU subframe header and is set to 0 when the SA field is not present.

If present, the DA field of the Dynamic A-MSDU subframe header contains the destination address of the MSDU. When the DA field is not present, the DA of the MSDU is stored at the recipient of the frame or, if a DA is not stored at the recipient of the frame, the DA is equal to the A3 field (if present in the header of the MPDU that carries the Dynamic A-MSDU subframe), or, if an A3 field is not present in the short MAC header of the MPDU that carries the Dynamic A-MSDU subframe, the DA is equal to the address identified by the A1 field of the short MAC header of the MPDU that carries the Dynamic A-MSDU subframe.

If present, the SA field of the Dynamic A-MSDU subframe header contains the source address of the MSDU. When the SA field is not present in a Dynamic A-MSDU subframe, the SA is either stored at the recipient of the frame or, if an SA is not stored at the recipient of the frame the SA is equal to the A4 field (if present in the short MAC header of the MPDU that carries the Dynamic A-MSDU subframe), or, if an A4 field is not present in the short MAC header of the MPDU that carries the Dynamic A-MSDU subframe, the SA is equal to the address identified by the A2 field of the short MAC header of the MPDU that carries the Dynamic A-MSDU subframe.

The MSDU field contains the MSDU that is carried in the Dynamic A-MSDU subframe.

The Padding field contains 0-3 octets of padding, so that the length of the Dynamic A-MSDU subframe is a multiple of 4 octets, except for the last Dynamic A-MSDU subframe in a Dynamic A-MSDU, which has no padding.

9. MAC sublayer functional description

9.2 MAC architecture

9.2.4 Hybrid coordination function (HCF)

9.2.4.2 HCF contention-based channel access (EDCA)

Add the following paragraphs after 4th paragraph in sub-clause 9.2.4.2 as follows:

A S1G QoS AP may assign to a S1G STA EDCA parameters different from the ones in dot11EDCATable, by sending to the STA a Modified EDCA Parameters Set element. A S1G STA receiving a Modified EDCA Parameters Set element shall update its MIB values of the EDCA parameters based on the values indicated by the Modified EDCA Parameters Set element.

A S1G STA that receives a Modified EDCA Parameters Set element shall disregard any EDCA Parameters Set element with the Override field set to 0 received afterward during the current association.

A S1G STA that receives a Modified EDCA Parameters Set element with the Override field set to 1 shall update its MIB values of the EDCA parameters as described for non-S1G STAs in this section.

Modify the 7th paragraph in sub-clause 9.2.4.2 as follows:

If dot11QMFActivated is false or not present for a QoS STA, a QoS STA should send individually addressed Management frames that are addressed to a non-QoS STA using the access category AC_BE and shall send all other Management frames using the access category AC_VO, whether or not it is associated with a BSS or there is a QoS facility in the BSS. If dot11QMFActivated is false or not present for a QoS STA, a QoS STA that does not send individually addressed Management frames that are addressed to a non-QoS STA using the access category AC_BE shall send them using the access category AC_VO. Management frames are exempted from any and all restrictions on transmissions arising from admission control procedures. If dot11QMFActivated is true for a STA, the STA shall send Management frames as described in 10.26 (Quality of-service management frame (QMF)). BlockAckReq and BlockAck frames shall be sent using the same access category as the corresponding QoS Data frames. PS-Poll frames with a Duration/ID field that contains an AID value shall be sent using the access category AC_BE (to reduce the likelihood of collision following a Beacon frame) and are exempted from any and all restrictions on transmissions arising from admission control procedures. When the first frame in a frame exchange sequence is an RTS or CTS frame, the RTS or CTS frame shall be transmitted using the access category of the corresponding QoS Data/QoS Null frame(s) or AC_VO for management frames. When the first frame in an exchange from a S1G STA is a PS-Poll frame, the PS-Poll frame shall be transmitted using the access category AC_VO by default, unless the overridden PS-Poll AC subfield in Control field in EDCA Parameter Set element indicates a different access category for sending PS-Poll. Control Wrapper frames shall be sent using the access category that would apply to the carried control frame.

9.3 DCF

9.3.2 Procedures common to the DCF and EDCAF

9.3.2.1 CS mechanism

Modify the 3rd paragraph of the subclause as follows:

~~A~~ Two virtual CS mechanisms shall be provided by the MAC. ~~This~~ The first mechanism is referred to as the NAV. The NAV maintains a prediction of future traffic on the medium based on duration information that is announced in RTS/CTS frames prior to the actual exchange of data. The duration information is also available in the MAC headers of all frames sent during the CP other than short MAC frames and PS-Poll frames with a Duration/ID field that contains an AID value. The mechanism for setting the NAV using RTS/CTS in the DCF is described in 9.3.2.4, use of the NAV in PCF is described in 9.4.3.3, and the use of the NAV in HCF is described in 9.19.2.2 and 9.19.3.4. Additional details regarding NAV usage and update appear in 9.3.2.5, 9.3.2.11, and 9.23.

Insert the following paragraph after the 3rd paragraph of the subclause:

The second virtual CS mechanism is referred to as Response Indication Deferral (RID), and this mechanism is only applicable to S1G STAs. RID begins immediately after the reception of a frame with RXVECTOR parameter ACK_INDICATION that has a value of ACK or BA or Not ACK, BlockAck or CTS. If the value of ACK_INDICATION is Not ACK, BlockAck or CTS, RID continues for MAX_PPDU + ACK + 2 × SIFS or until PHY-RXSTART.indication, whichever comes first. If the value of ACK_INDICATION is ACK, RID continues for ACK + 2 × SIFS or until PHY-RXSTART.indication, whichever comes first. If the value of ACK_INDICATION is BlockAck, RID continues for BlockAck + 2 × SIFS or until PHY-RXSTART.indication, whichever comes first. A STA that is undergoing RID shall not initiate a non-response transmission.

Modify the 4th paragraph of the subclause as follows:

Except for S1G STAs, ~~T~~the CS mechanism combines the NAV state and the STA's transmitter status with physical CS to determine the busy/idle state of the medium. For S1G STAs, the CS mechanism combines the NAV state, RID and the STA's transmitter status with physical CS to determine the busy/idle state of the medium. The NAV may be thought of as a counter, which counts down to 0 at a uniform rate. When the counter is 0, the virtual CS indication is that the medium is idle; when nonzero, the indication is busy. The medium shall be determined to be busy when the STA is transmitting.

9.3.2.4 Setting and resetting the NAV

Modify the 1st paragraph of the subclause as follows:

A STA that receives at least one valid frame within a received PSDU shall update its NAV with the information received in any valid Duration field from within that PSDU for all frames where the new NAV value is greater than the current NAV value, except for those where the RA is equal to the MAC address of the STA. Upon receipt of a PS-Poll frame with its Duration/ID field set to AID, a STA shall update its NAV settings as appropriate under the data rate selection rules using a duration value equal to the time, in microseconds, required to transmit one ACK frame plus one SIFS interval, but only when the new NAV value is greater than the current NAV value. If the calculated duration includes a fractional microsecond, that value is rounded up to the next higher integer. Various additional conditions may set or reset the NAV, as described in 9.4.3.3. When the NAV is reset, a PHY-CCARESET.request primitive shall be issued. This NAV update operation is performed when the PHYRXEND.indication primitive is received.

9.3.2.6 CTS procedure

Add the following sentence at the end of subclause 9.3.2.6 as follows:

When dot11S1GOptionImplemented is true, a STA shall support NDP CTS frame and shall use NDP CTS frame unless the CTS response is required to include information that is not present in the fields of the NDP CTS frame.

9.3.2.8 ACK procedure

Modify the last paragraph of sub-clause 9.3.2.8 as follows:

After transmitting an MPDU that requires an ACK frame as a response (see Annex G), the STA shall wait for an ACKTimeout interval, with a value of aSIFSTime + aSlotTime + aPHY-RX-START-Delay, starting at the PHY-TXEND.confirm primitive. If a PHY-RXSTART.indication primitive does not occur during the ACKTimeout interval, the STA concludes that the transmission of the MPDU has failed, and this STA shall invoke its backoff procedure upon expiration of the ACKTimeout interval. If a PHY-RXSTART.indication primitive does occur during the ACKTimeout interval, the STA shall wait for the corresponding PHYRXEND.indication primitive to determine whether the MPDU transmission was successful. The recognition of a valid ACK frame sent by the recipient of the MPDU requiring acknowledgment, corresponding to this PHYRXEND.indication primitive, shall be interpreted as successful acknowledgment, permitting the frame sequence to continue, or to end without retries, as appropriate for the particular frame sequence in progress. The recognition of anything else, including any other valid frame, shall be interpreted as failure of the MPDU transmission. In this instance, the STA shall invoke its backoff procedure at the PHY-RXEND.indication primitive and may process the received frame. An exception is that recognition of a valid data frame sent by the recipient of a PS-Poll frame shall also be accepted as successful acknowledgment of the PS-Poll frame. Another exception exists under TXOP sharing relay operation: If an MPDU is transmitted by a STA associated with a relay AP under TXOP sharing relay operation, and the PARTIAL_AID in the PHY-RXSTART.indication primitive that occurs within aPHY-RX-START-delay is identical to the PARTIAL_AID corresponding to the BSSID of the root AP then the reception shall be accepted as a successful acknowledgement of the MPDU transmission. Another exception is when an AP transmits an MPDU to a Relay STA under TXOP sharing relay operation and the PARTIAL_AID in the PHY-RXSTART.indication primitive that occurs within aPHY-RX-START-delay is identical to the PARTIAL_AID corresponding to the DA of the transmitted MPDU shall be accepted as a successful acknowledgement of the MPDU transmission.

Add the following paragraphs at the end of subclause 9.3.2.8 as follows:

When dot11S1GOptionImplemented is true, a STA shall support NDP ACK frame and shall use NDP ACK frame unless the ACK response is required to include information that is not present in the fields of the NDP ACK frame.

In S1G BSS, the ACKTimeout interval is varied by the TXVECTOR parameter PREAMBLE_TYPE. When the TXVECTOR parameter PREAMBLE_TYPE is equal to >= 2MHz short/long preamble, the ACKTimeout interval is calculated with aPHY-RX-START-Delay value for >= 2MHz short/long preamble. When the TXVECTOR parameter PREAMBLE_TYPE is equal to 1MHz preamble, the ACKTimeout interval is calculated with aPHY-RX-START-Delay value for 1MHz preamble.

9.3.2.10 Duplicate detection and recovery

Modify 4^{th}, 5^{th}, 6^{th} paragraphs of the sub-clause 9.3.2.10 as the following:

A STA operating as a QoS STA shall maintain one modulo-4096 counter, per < STA MAC Address identified by Address 1, TID>, for individually addressed QoS Data frames. Sequence numbers for these frames are assigned using the counter identified by the STA MAC Address identified by Address 1 field and the TID subfield of the QoS Control field of the frame, and that counter is incremented by 1 for each MSDU or A-MSDU corresponding to that < STA MAC Address identified by Address 1, TID> tuple. Sequence numbers for management frames, QoS data frames with a group address in the Address 1 field, and all non-QoS data frames transmitted by QoS STAs shall be assigned using an additional single modulo-4096 counter, starting at 0 and incrementing by 1 for each such MSDU, A-MSDU, or MMPDU, except that a QoS STA may use values from additional modulo-4096 counters per < STA MAC Address identified by Address 1, TID> for sequence numbers assigned to time priority management frames. A transmitting STA should cache the last used sequence number per RA for frames that are assigned sequence numbers from this counter and should ensure that the successively assigned sequence numbers for frames transmitted to a single RA do not have the same value by incrementing the counter by 2, if incrementing by 1 would have produced the same sequence number as is found in the cache for that RA. Sequence numbers for QoS (+)Null frames may be set to any value.

A receiving STA shall keep a cache of recently received <Address 2, sequence-number, fragment-number> tuples from frames that are not QoS Data frames. The receiving STA shall keep at least the most recent cache entry per <Address 2> value in this cache. The receiving QoS STA shall also keep a cache of recently received <STA MAC Address identified by Address 2, TID, sequence-number, fragment-number> tuples from QoS Data frames from all STAs from which it has received QoS data frames. The receiving QoS STA shall keep at least the most recent cache entry per < STA MAC Address identified by Address 2, TID> pair in this cache. The receiving STA should maintain two additional caches, one containing entries of recently received <Address 2, sequence-number, fragment-number> tuples from received management frames that are not time priority management frames and the other containing entries of recently received <Address 2, sequence-number, fragment-number> tuples from received time priority management frames. The receiving STA should not include the entries in these two additional caches in any other caches. In each of these two caches, the receiving STA should keep at least the most recent cache entry per <Address 2> value. A receiving STA should omit tuples obtained from group addressed and ATIM frames from all caches.

A receiving STA shall reject as a duplicate frame any frame that is not a QoS Data frame in which the Retry bit in the Frame Control field is 1 and that matches an <Address 2, sequence-number, fragment-number> tuple of an entry in the cache that contains tuples of that format, unless the frame is a management frame and the STA is maintaining separate caches for <Address 2, sequence-number, fragment-number> tuples from received management frames. A receiving QoS STA shall also reject as a duplicate frame any QoS Data frame in which either the Retry bit in the Frame Control field is 1 or the Retry bit in the Frame Control field is not present and that matches an <STA MAC Address identified by Address 2, TID, sequence-number, fragmentnumber> tuple of an entry in the cache that contains tuples of that format. A STA that is maintaining separate caches for <Address 2, sequence-number, fragment-number> tuples from received management frames shall reject as a duplicate frame any management frame that is not a time priority management frame in which the Retry bit in the Frame Control field is 1 and that matches an <Address 2, sequence-number, fragment-number> tuple of an entry in the management cache that contains tuples from frames that are not time priority management frames. A STA that is maintaining separate caches for <Address 2, sequence-number, fragmentnumber> tuples from received management frames shall reject as a duplicate frame any time priority management frame in which the Retry bit in the Frame Control field is 1 and that matches an <Address 2, sequence-number, fragment-number> tuple of an entry in the cache that contains tuples from time priority management frames.

9.3.6 Group addressed MPDU transfer procedure

Modify 1st paragraphs of the sub-clause 9.3.6 as the following:

In the absence of a PCF, when group addressed MPDUs in which the To DS field is 0 are transferred from a STA, only the basic access procedure shall be used. Regardless of the length of the frame, no RTS/CTS exchange shall be used. In addition, no ACK shall be transmitted by any of the recipients of the frame. Any group addressed MPDUs in which the To DS field is 1 transferred from a STA shall, in addition to conforming to the basic access procedure of CSMA/CA, obey the rules for RTS/CTS exchange and the ACK procedure because the MPDU is directed to the AP. When dot11SSPNInterfaceActivated is true, an AP shall distribute the group addressed message into the BSS only if dot11NonAPStationAuthSourceMulticast in the dot11InterworkingEntry identified by the source MAC address in the received message is true. When dot11SSPNInterfaceActivated is false, the group addressed message shall be distributed into the BSS, except when dot11RelayInterfaceActivated is true and the group addressed message is received from a STA, in which case, the group addressed message shall not be distributed into the BSS and it shall be sent as a directed frame to an associated parent Relay AP. The STA originating the message receives the message as a group addressed message (prior to any filtering). Therefore, all STAs shall filter out group addressed messages that contain their address as the source address. When dot11SSPNInterfaceActivated is false, group addressed MSDUs shall be propagated throughout the ESS. When dot11SSPNInterfaceActivated is true, group addressed MSDUs shall be propagated throughout the ESS only if dot11NonAPStationAuthSourceMulticast in the dot11InterworkingEntry identified by the source MAC address in the received message is true.

9.7 Multirate support

9.7.6 Rate selection for control frames

9.7.6.5 Rate selection for control response frames

9.7.6.5.2 Selection of a rate or MCS

Modify the third bullet in the first paragraph as follows:

— If a BlockAck frame is sent as an immediate response to either an implicit BlockAck request or to a BlockAckReq frame that was carried in an HT PPDU and the BlockAck frame is carried in a non-HT PPDU, the primary rate is defined to be the highest rate in the BSSBasicRateSet parameter that is less than or equal to the rate (or non-HT reference rate; see 9.7.9) of the previous frame. If no rate in the BSSBasicRateSet parameter meets these conditions, the primary rate is defined to be the highest mandatory rate of the attached PHY that is less than or equal to the rate (or non-HT reference rate; see 9.7.9) of the previous frame. The STA may select an alternate rate according to the rules in 9.7.6.5.4. The STA shall transmit the non-HT PPDU BlockAck control response frame at either the primary rate or the alternate rate, if one exists. When in asymmetric Block Ack Operation, the STA shall transmit the non-HT PPDU BlockAck control response frame at the MCS according to the rules in 9.7.6.5.4a (MCS for asymmetric Block Ack Operation).

9.7.6.5.3 Control response frame MCS computation

9.7.6.5.4 Selection of an alternate rate or MCS for a control response frame

Insert the following subclause after the subclause 9.7.6.5.4:

9.7.6.5.4a MCS for asymmetric Block Ack Operation

The primary MCS for asymmetric Block Ack operation is defined as the MCS which is MCSDifference (see 9.21.2) lower than that of the eliciting A-MDPU. An alternate MCS may be selected provided that the duration of the frame at the alternate MCS is the same as the duration of the frame at the primary MCS.

9.7.6.5.5 Control response frame TXVECTOR parameter restrictions

9.7.6.6 Channel Width selection for control frames

Insert the following paragraphs at the end of sub-clause 9.7.6.6:

When a S1G capability element of a S1G STA indicates that 1MHz control response can be used, 1MHz preamble transmission as the response of >= 2MHz short/long preamble is allowed and the S1G STA behaves as follows:

- A S1G STA that sends a control frame in response to a frame carried in an S1G PPDU shall set the TXVECTOR parameter CH_BANDWIDTH to indicate a channel width that is the same or lower as the channel width indicated by the RXVECTOR parameter CH_BANDWIDTH of the frame eliciting the response.
- Channel Bandwidth of PPDU during the multiple frame exchange sequences in a TXOP shall be the same or narrower than the Channel Bandwidth of the preceding PPDU.

Otherwise, in S1G BSS, 1MHz preamble transmission as the response of >= 2MHz short/long preamble is not allowed and the S1G STA behaves as follows:

- A S1G STA that sends a control frame in response to a frame carried in an S1G PPDU shall set the TXVECTOR parameter CH_BANDWIDTH to indicate a channel width that is the same as the channel width indicated by the RXVECTOR parameter CH_BANDWIDTH of the frame eliciting the response.

When operating in a 2/4/8/16MHz BSS, a STA that sends a NDP ACK in response to a frame carried in an S1G PPDU may set the TXVECTOR parameter CH_BANDWIDTH to indicate a channel width that is less than the channel width indicated by the RXVECTOR parameter CH_BANDWIDTH of the frame eliciting the response.

Add a new sub-clause 9.17b after 9.17a in TGac D5.0 as the following:

9.17b Group ID and partial AID in S1G PPDUs

The S1G partial AID is a non-unique identifier of a S1G STA as defined in Table 9-19b (Settings for the TXVECTOR parameters PARTIAL_AID). The partial AID is carried in the TXVECTOR parameter PARTIAL_AID of a S1G SU PPDU with the TXVECTOR parameter CH_BANDWIDTH set to a value greater than 1MHz and is limited to 9 bits

A STA transmitting a S1G PPDU carrying one or more group addressed MPDUs or transmitting a S1G NDP intended for multiple recipients shall set the TXVECTOR parameters PARTIAL_AID to 0. The intended recipient of a S1G NDP is defined in 9.31.7 (Transmission of a S1G NDP).

A STA transmitting a S1G SU PPDU carrying one or more individually addressed MPDUs or a S1G NDP intended for a single recipient shall set the TXVECTOR parameters PARTIAL_AID as shown in Table 9-19b (Settings for the TXVECTOR parameters PARTIAL_AID).

Table 9-19b—Settings for the TXVECTOR parameters PARTIAL_AID

Condition	PARTIAL_AID
Addressed to AP	$(dec(\text{BSSID}[39:47])\,mod(2^9\text{-}1))+1$
Sent by an AP and addressed to a STA associated with that AP or sent by a DLS or TDLS STA in a direct path to a DLS or TDLS peer STA	$(dec(\text{AID}[0:8])+dec(\text{BSSID}[44:47] \oplus \text{BSSID}[40:43]\times 2^5)\,mod\ 2^9$ (9-8b) where $\oplus$ is a bitwise exclusive OR operation *mod* X indicates the X-modulo operation *dec*(A[*b*:*c*]) is the cast to decimal operator where *b* is scaled by 2^0 and *c* by 2^{c-b}
Otherwise	0

NOTE- In Table 9-19b (Settings for the TXVECTOR parameters PARTIAL_AID) the last row includes the cases of a PPDU carrying MPDUs

- sent to an IBSS STA,
- sent by an AP to a non associated STA, and
- any other condition not explicitly listed elsewhere in the table.

In Table 9-19b (Settings for the TXVECTOR parameters PARTIAL_AID)

- AID[b:c] represents bits b to c inclusive of the AID of the recipient STA with bit 0 being the first transmitted
- BSSID[b:c] represents bits b to c inclusive of the BSSID, with bit 0 being the Individual/Group bit. In this representation, the Individual/Group bit is BSSID[0] and BSSID[47] is the last transmitted bit.

A S1G STA shall include the values computed in Table 9-19b (Settings for the TXVECTOR parameters PARTIAL_AID) in the PHYCONFIG_VECTOR parameter PARTIAL_AID_LIST.

A S1G STA that transmits a S1G PPDU to a DLS or TDLS peer STA obtains the AID for the peer STA from the DLS Setup Request, DLS Setup Response, TDLS Setup Request or TDLS Setup Response frame.

An S1G AP should not assign an AID to a S1G STA that results in the PARTIAL_AID value, as computed using Equation (9-8b), being equal to either

$(dec(\text{BSSID}[39:47])\,mod(2^9\text{-}1))+1$ or $(\text{dec}(\text{Overlapping BSSID}[39:47])\text{mod}(2^9\text{-}1))+1$.

A S1G STA transmitting a S1G MU PPDU sets the TXVECTOR parameter GROUP_ID as described in 22.3.11.4 (Group ID).

As an example of the PARTIAL_AID setting, consider the case of a BSS with BSSID 00-21-6A-AC-53-52 that has as a member a non-AP S1G STA assigned AID 5. In S1G PPDUs sent to an S1G AP, the PARTIAL_AID is set to 165. In S1G PPDUs sent by the S1G AP to the non-AP S1G STA associated with that S1G AP, the PARTIAL_AID is set to 229.

NOTE-As described in(#7009) IEEE Std 802-2001, the use of hyphens for the BSSID indicates hexadecimal representation rather than bit-reversed representation.

9.19 HCF

9.19.2 HCF contention-based channel access (EDCA)

9.19.2.1 Reference implementation

9.19.2.2 EDCA TXOPs

Modify the 3rd paragraph in sub-clause 9.19.2.2 as follows:

A TXOP limit value of 0 indicates that the TXOP holder may transmit or cause to be transmitted (as responses) the following within the current TXOP:

d) A single MSDU, MMPDU, A-MSDU, A-MPDU, or PS-Poll <u>with its Duration/ID field set to AID</u> at any rate, subject to the rules in 9.7

9.19.2.3 Obtaining an EDCA TXOP

9.19.2.3a Sharing an EDCA TXOP

9.19.2.4 Multiple frame transmission in an EDCA TXOP

Insert the following at the end of the subclause 9.19.2.4:

If a TXOP of a 2/4/8/16MHz BSS is protected by an RTS or CTS frame carried in a S1G PPDU, the TXOP holder shall set the TXVECTOR parameter CH_BANDWIDTH of a PPDU as follows:

— To be the same or narrower than RXVECTOR parameter CH_BANDWIDTH of the last received NDP ACK frame in the same TXOP, if the TBD capability field (transmitter and receiver capability information) is set to Dynamic.

— Otherwise, to be the same or narrower than the TXVECTOR parameter CH_BANDWIDTH of the RTS frame that has been sent by the TXOP holder in the last RTS/CTS in the same TXOP.

9.19.2.7 Truncation of TXOP

TGah editor: Modify the sub-clause 9.19.2.7 as the following:

When a STA gains access to the channel using EDCA and empties its transmission queue, it may transmit a CF-End frame provided that the remaining duration is long enough to transmit this frame. By transmitting the CF-End frame, the STA is explicitly indicating the completion of its TXOP.

A TXOP holder that transmits a CF-End frame shall not initiate any further frame exchange sequences within the current TXOP.

A non-AP STA that is not the TXOP holder shall not transmit a CF-End frame.

A STA that is not an S1G STA shall interpret the reception of a CF-End frame as a NAV reset, i.e., it resets its NAV timer to 0 at the end of the PPDU containing this frame. After receiving a CF-End frame with a matching BSSID, an AP may respond by transmitting a CF-End frame after SIFS.

NOTE—The transmission of a single CF-End frame by the TXOP holder resets the NAV of STAs hearing the TXOP holder. There may be STAs that could hear the TXOP responder that had set their NAV that do not hear this NAV reset. Those STAs are prevented from contending for the medium until the original NAV reservation expires.

Figure 9-21 shows an example of TXOP truncation. In this example, the STA accesses the medium using EDCA channel access and then transmits a nav-set sequence (e.g., RTS/CTS) (using the terminology of Annex G). After a SIFS, it then transmits an initiator-sequence, which may involve the exchange of multiple PPDUs between the TXOP holder and a TXOP responder. At the end of the second sequence, the TXOP holder has no more data available to send that fits within the TXOP; therefore, it truncates the TXOP by transmitting a CF-End frame.

A STA that is not an S1G STA that receive the CF-End frame reset their NAV and can start contending for the medium without further delay.

An S1G STA may transmit a CF-End frame containing a non-zero value in the Duration/ID field.

When an S1G STA receives a CF-End frame with the Duration/ID field set to a non-zero duration value that is equal to the NAV value +/- 8 usec at the time of the reception of the PHY-RXEND.indication, it shall reset the NAV and may start contending for the medium without further delay. If the received duration value is not equal to the NAV value +/- 8 usec at the time of the reception of the PHY-RXEND.indication, the STA shall discard the CF-End frame.

After receiving a CF-End frame with a matching BSSID, an S1G AP may respond by transmitting a CF-End frame after SIFS in which the Duration field is adjusted by subtraction of aSIFSTime and the time required to transmit the CF-End frame in unit of microseconds.

TXOP truncation shall not be used in combination with L-SIG TXOP protection when the HT Protection field of the HT Operation element is equal to nonmember protection mode or non-HT mixed mode.

9.19.3 HCCA

Insert the following new sub-clause at the end of 9.19.4 as the following:

9.19.4a Restricted Access Window (RAW) Operation

9.19.4a.1 General

The restricted channel access control mechanism manages access to the WM to avoid simultaneous transmissions from a large number of STAs hidden from each other and enables fair channel access among the STAs. For example, the TIM element can cover few hundred to few thousand STAs with their TIM bits set to one. This can trigger too many simultaneous PS-Poll/trigger frame transmissions from the STAs right after the Beacon reception. Restricting uplink channel access to a small number of STAs and spreading their uplink access attempts over a much longer period of time significantly improves the efficiency of the utilization of the medium by reducing collisions. When dot11RAWOptionActivated is true, an AP may allocate a medium access interval called RAW (restricted access window) for a group of STAs within a beacon interval. Only the STAs in the group are allowed to access the WM in the RAW. Assigning restricted uplink channel access windows to different groups of STA increases fairness.

A STA is in the RAW group indicated by the RAW Group field in RPS element if the AID of the STA (n) is greater than or equal to the lowest AID of the STA allocated in the RAW (N_1) and the AID of the STA is less than or equal to the highest AID of the STA (N_2) allocated in the RAW (i.e. $N_1 \leq n \leq N_2$), where N_1 is constructed by concatenating the Page Index (2bits) subfield and the RAW Start AID (11 bits) in RPS element and N_2 is constructed by concatenating the Page Index (2bits) subfield and the RAW End AID (11 bits) in RPS element.

A STA that receives an RPS element in a beacon transmitted by the AP with which it is associated determines whether it belongs to the group indicated in the RAW Group field, the start time of the RAW, and the duration of the RAW.

The RAW is divided into one or more time slots. The Slot Duration subfield of the Slot Definition field in the RPS element defines the duration of a time slot in the RAW.

If the STA belongs to the group, it is allowed to contend for medium access at the start of the assigned time slot (see 9.19.4a.3).

The AP may allocate more than one RAW for different groups of STAs within a beacon interval with different RAW parameters.

The AP may assign to each STA or a group of STAs a time slot inside the RAW at which the STA(s) is (are) allowed to contend for medium access. After determining its channel access time slot assigned by the AP, the STA starts to access the channel not earlier than its assigned slot based on EDCA. But, a STA not within the group indicated by the RAW Group field in the RPS element shall not access the WM for the RAW duration, except for a STA that is allowed not to check the beacon (e.g. non-TIM STA).

AP may further indicate on which channel(s) the STA(s) that are granted access to the RAW are allowed to transmit, through the Channel Indication field (see 8.4.2.170b). A value of 1 in a bit position in the bitmap indicates that operation is allowed on the BSS operating channel, with any allowed operating bandwidth that includes that channel, subject to the limitations described in clause 9.32k (Subchannel Selective Transmission (SST)). Access to the channel shall be performed according to the procedure described in 9.32k (Subchannel Selective Transmission (SST)) assuming the primary channel is a channel identified by a value of 1 in one of the bitmap bits in the Channel Indication field.

9.19.4a.2 RAW structure and timing

An illustration of the RAW structure and timing diagram is shown in Figure 9-24a (Restricted Access Window (RAW)).

An AP indicates the RAW allocation and slot assignment within the RAW by including the RPS element and the TIM element in a Beacon frame.

The AP indicates in the RPS element which Cross Slot Boundary rule is applied in each RAW.

If Cross Slot Boundary is allowed, a TXOP or transmission within a TXOP is allowed to extend beyond the end of the allocated time slot.

If Cross Slot Boundary is not allowed, a TXOP or transmission within a TXOP shall not extend across the end of the allocated time slot and the STA that is changing from Doze to Awake state at the start of the allocated time slot may immediately start contending for the WM the channel access without performing CCA until a frame sequence is detected, or until a period of time equal to the ProbeDelay has transpired.

As shown in Figure 9-24a (Restricted Access Window (RAW)), if Cross Slot Boundary is not allowed, STA shall complete the transmission and any acknowledgement or other immediate response expected from the peer MAC entity prior to the end of the allocated slot boundary. Otherwise, it shall not initiate transmission of a frame even though the remaining slot duration is nonzero.

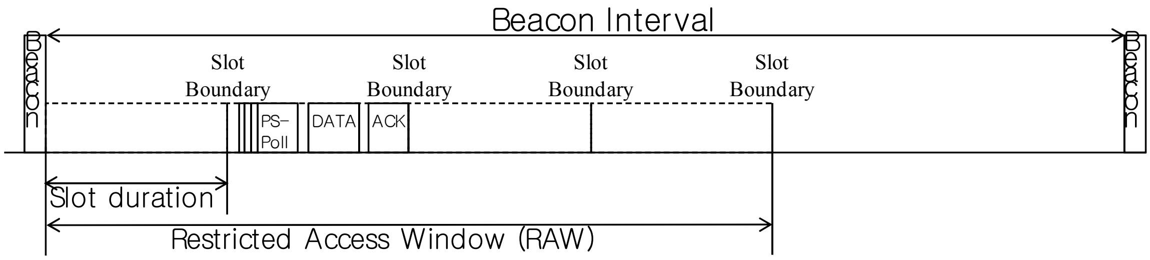

Figure 9-24a—Restricted Access Window (RAW)

9.19.4a.3 Slot assignment procedure in RAW

This sub-clause defines a simple slot assignment procedure for STAs that are allowed to access the medium within a RAW based on the RPS element and the TIM element in a Beacon frame.

A STA shall calculate the number of time slots in the RAW (N_{RAW}) by dividing the duration of the RAW (T_{RAW}), which is defined in the RAW Duration field of the RPS element, with the duration (T_{slot}) of a time slot in the RAW, which is defined in the Slot Definition field of the RPS element. The time slots in the RAW are indexed from 0 to (N_{RAW} - 1) as shown in Figure 9-24b (Illustration of the RAW slot assignment procedure (RAW not restricted to STAs whose AID bits are set to 1)).

The STA shall determine the index of the time slot, i_{slot}, in which the STA is allowed to start accessing the medium based on the following mapping function

$i_{slot} = (x + N_{offset})\ mod\ N_{RAW}$

where

if the RAW is restricted to STAs whose AID bits in the TIM element are set to 1, x is the position index of the AID of the STA when the AIDs are arranged in ascending order and each AID is assigned with a position index, which starts from 0 (see Figure 9-24c (Illustration of the RAW slot assignment procedure (RAW restricted to STAs whose AID bits are set to 1))); x is the AID of the STA, otherwise (see Figure 9-24b (Illustration of the RAW slot assignment procedure (RAW not restricted to STAs whose AID bits are set to 1)));

N_{offset} represents the offset value in the mapping function, which improves the fairness among the STAs in the RAW, and the two least significant bytes of the FCS field of the Beacon frame shall be used for the N_{offset};

mod X indicates the modulo *X* operation.

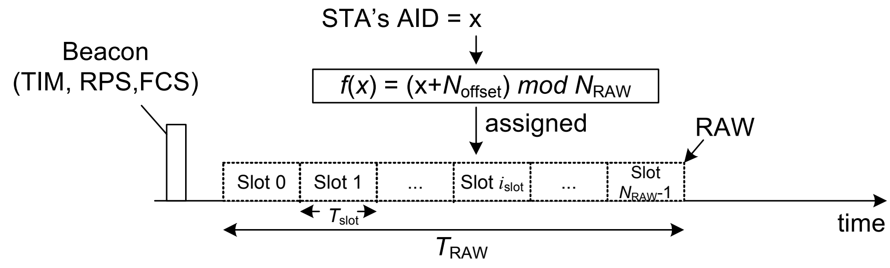

Figure 9-24b—Illustration of the RAW slot assignment procedure (RAW not restricted to STAs whose AID bits are set to 1)

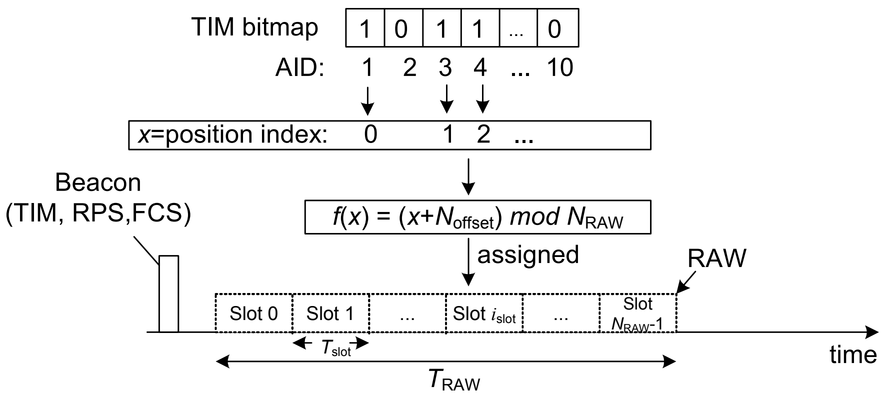

Figure 9-24c—Illustration of the RAW slot assignment procedure (RAW restricted to STAs whose AID bits are set to 1)

9.19.4a.4 Slotted channel access procedure in RAW

When the Access Restricted to Paged STA Only field in the RPS element indicates that all STAs that belong to a RAW group are allowed to access the medium in the RAW of the RAW group, an AP assigns a time slot for each STA that belongs to the RAW group (9.19.4a.3). Each STA shall start to contend for the WM not earlier than the start of the assigned time slot. The channel access is based on EDCA.

When an AP indicates that paged STAs only are allowed the access the medium in the RAW, after receiving a TIM element, the paged STA starts to contend for the WM not earlier than the allocated time slot within the RAW defined as the function of STA position in the TIM element and the RAW group information in the RPS element (9.19.4a.3), and non-paged STAs are not allowed to access the RAW.

The STA transmits a PS-Poll frame or a trigger frame to the AP not earlier than the start of its channel access slot based on EDCA.

After receiving the PS-Poll frame or the trigger frame from the paged STA in the RAW, the AP responds immediately with either the downlink BU or an ACK frame.

When the AP responds to the paged STA with an ACK frame, the downlink BU data for the paged STA may be delivered in a RAW, which is allocated after the current RAW.

The AP may send a Resource Allocation frame at the beginning of the RAW to indicate presence of downlink buffered data for paged STAs and the slot assignment within the RAW.

The AP may protect transmissions of PS-Poll or trigger frames by setting the NAV for the RAW indicated in the RPS element.

Inside the protected RAW duration, the STAs that belong to the group of the RAW ignore the NAV set by the AP.

9.19.4a.5 EDCA backoff procedure in RAW

An illustration of EDCA backoff procedure in RAW is shown in Figure 9-24d (Backoff procedure for restricted channel access control).

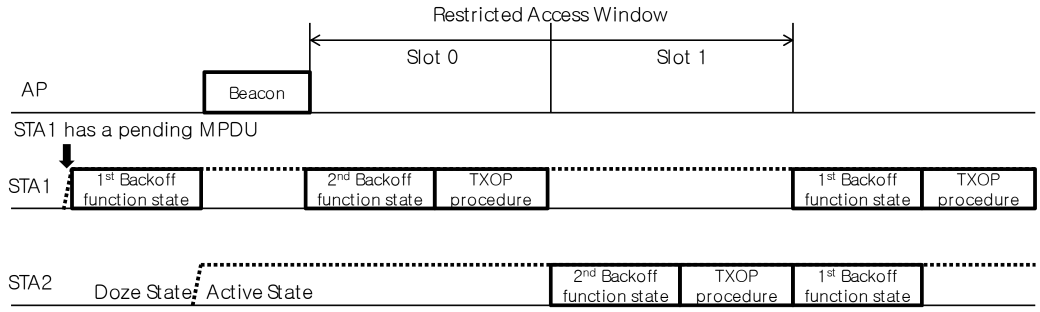

Figure 9-24d—Backoff procedure for restricted channel access control

For supporting the restricted channel access control based on EDCA, a STA maintains two backoff function states. First backoff function state is used in outside RAW and second backoff function state is used in inside RAW.

When a STA is allowed to contend in the RAW, the STA suspends its backoff at the start of a RAW and stores the backoff function state. And, at the end of RAW, the previously stored backoff function state is restored and the backoff function resumes. If the previously stored backoff function state is empty, the STA invokes a backoff procedure.

If a STA is participating in the RAW, STA invokes a new backoff function using the RAW backoff parameters.

STA may count down backoff only in its assigned slots within the RAW unless Cross Slot Boundary is allowed, in which case the STA may continue to count down backoff after its slot.

9.19.4a.6 Periodic RAW (PRAW) operation

PRAW is a series of RAWs that are allocated to one or a group of non-TIM STAs in a periodic manner with identical resource allocation. An AP may indicate to TIM STAs information of scheduled RAW during which no TIM STAs are allowed to contend as described in 9.32g.2, and PRAW can be used for this purpose.

An AP may schedule and indicate TWT for a non-TIM STA within the PRAW duration in periodic manner, when the STA is associated with the AP or reschedule is needed. Operation details for TWT is described in 9.32f. By allocating PRAW only for one or a group of STAs that an AP scheduled TWT, the AP can indicate to TIM STAs information of periodically scheduled RAWs during which no TIM STAs are allowed to contend.

PRAW allocation may be indicated by an RPS element included in Beacon and/or Probe Response frames. Once a PRAW is allocated, the allocation indication is broadcasted by the AP periodically such that every TIM STA can identify the allocation of PRAW. However, it is not necessary for an AP to indicate the PRAW allocation in every (short) beacon frame transmitted in the beacon interval for which PRAW is allocated. The allocated resource for PRAW will not be changed until updated PRAW information is broadcasted.

An example of the basic operation of PRAW allocation is shown in Figure 9-24e (Example of PRAW operation). In this figure, PRAW is allocated at every Beacon and Short Beacon frame, but the allocation of the PRAW is indicated only in every Beacon frame. STA1 is a TIM STA that is not included in the PRAW allocation and STA2 is a non-TIM STA for which the AP has scheduled TWT and is included in the PRAW allocation. When STA1 listens to the Beacon frame, it can identify the allowed user group, start time, duration, and the periodicity of the allocated PRAW. As STA1 is not included in the allowed user group of the PRAW, STA1 will not access the channel during allocated PRAW in every Beacon and Short Beacon frame. And, STA2 wakes up at its scheduled TWT which is within the PRAW, and send its uplink data if it has a data frame to send.

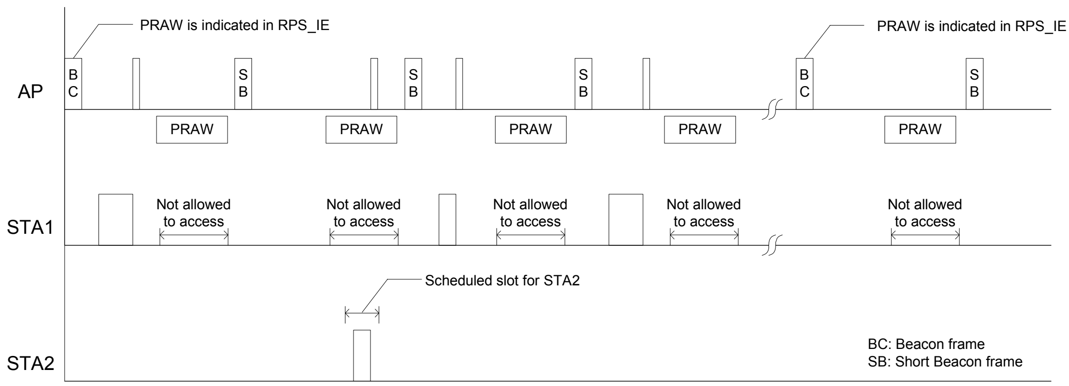

Figure 9-24e—Example of PRAW operation

9.21 Block Acknowledgment (Block Ack)

9.21.1 Introduction

Insert the following sentence after the 2nd paragraph of 9.21.1 as follows:

When dot11S1GOptionImplemented is true, a STA shall support NDP Block ACK frame and shall use NDP Block ACK frame unless the Block Ack response is required to include information that is not present in the fields of the NDP Block Ack frame.

Insert the following after the third paragraph:

An asymmetric Block Ack operation may be used when the originator AP has better capability (e.g. higher maximum transmit power) than the recipient STA. When used, the responding STA may use a different MCS for transmitting the immediate Block Ack control response frame than is computed according to the rules of 9.7. The intended recipient STA maintains a measure of the degree of asymmetry between the AP and the STA and implicitly indicates the value to the originator AP during the Block Ack setup phase. This degree of asymmetry is represented as the difference in MCS values between AP and STA, and referred to as MCSDifference (see 9.21.2). In the Data & Block Ack phase, the originator AP uses the MCSDifference to compute the duration field for A-MPDUs of regular frames as described in Clause 8 (Frame formats) and immediate Block Ack control response frame.

9.21.2 Setup and modification of the Block Ack parameters

Modify the first paragraph as follows:

An originator that intends to use the Block Ack mechanism for the transmission of QoS data frames to an intended recipient should first check whether the intended recipient STA is capable of participating in Block Ack mechanism by discovering and examining its Delayed Block Ack and Immediate Block Ack capability bits. If the intended recipient STA is capable of participating, the originator sends an ADDBA Request frame indicating the TID for which the Block Ack is being set up. For an ADDBA set up between STAs where one is a non-HT STA, the Block Ack Policy and Buffer Size fields in the ADDBA Request frame are advisory and may be changed by the recipient. The Buffer Size field in the ADDBA Request frame is advisory and may be changed by the recipient for an ADDBA set up between HT STAs. If the intended recipient is capable of participating in an Immediate Block Ack session, the S1G originator shall set the Block Ack Action field value to NDP ADDBA, unless the normal Block ACK response frame is required to include information that is not present in the fields of the NDP Block Ack frame, indicating that the recipient STA should use only NDP BlockAck frames during the Block Ack session. If the intended recipient is capable of participating in an Immediate Block Ack session and both the originator and the recipient support BAT BA operation, the originator may set the Block Ack Action field value to BAT ADDBA, indicating that the recipient STA requests that the originator use only BAT frames during the Block Ack session.

Modify the 3rd paragraph as follows:

When the recipient STA accepts, it indicates the type of Block Ack, the type of BlockAck frames and the number of buffers that it shall allocate for the support of this Block Ack agreement within the ADDBA Response frame. Each Block Ack agreement that is established by a STA may have a different buffer allocation. If the intended recipient STA rejects the request, then the originator shall not use the Block Ack mechanism. When the recipient STA accepts an Immediate Block Ack session, it shall indicate which type of BlockAck frames it will use, by transmitting an NDP ADDBA Response for NDP BlockAck frames, by transmitting a BAT ADDBA Response for BAT frames and by transmitting an ADDBA Response for BlockAck frames. The value indicated in the Buffer Size field of the NDP ADDBA Response shall not be greater than the maximum number of MSDUs and A-MSDUs that can be acknowledged with the selected

NDP BlockAck frame. This value is 8 for NDP BlockAck (1MHz) frames as described in 8.3.4a.1.5 (NDP Block ACK) and 16 for NDP BlockAck (1MHz) frames as described in 8.3.4a.1.5 (NDP Block ACK). The value indicated in the Buffer Size field of the BAT ADDBA Response shall not be greater than 12.

Modify the fourth paragraph as follows:

When the Block Ack Policy subfield value is set to 1 by the originator of an ADDBA Request frame between HT STAs, then the ADDBA Response frame accepting the ADDBA Request frame shall contain 1 in the Block Ack Policy subfield and have the MCS parameter in the Originator Parameter field set to the preferred MCS if asymmetric Block Ack operation is used. The preferred MCS implicitly indicates the MCSDifference value, which is the difference between the preferred MCS indicated and the MCS at which the ADDBA Response frame is sent.

9.21.6 Selection of BlockAck and BlockAckReq variants

Modify the 3rd paragraph as shown below:

Where the terms BlockAck and BlockAckReq are used within 9.21.7 (HT-immediate Block Ack extensions) and 9.21.8 (HT-delayed Block Ack extensions), the appropriate variant according to this subclause (e.g., Compressed, Multi-TID) is referenced by the generic term. The term BlockAck as used within 9.21.7 (HT-immediate Block Ack extensions) includes the additional NDP BlockAck variants (1MHz or ≥ 2MHz) and BAT.

Insert the following paragraphs after the 4th paragraph as shown below:

The recipient of an accepted Block Ack agreement that was negotiated with NDP ADDBA shall use NDP BlockAck frames during an HT-immediate Block Ack session.

The recipient of an accepted Block Ack agreement that was negotiated with BAT ADDBA shall use BAT frames to acknowledge MPDUs within AMPDUs during an HT-immediate Block Ack session.

9.21.7.3 Scoreboard context control during full-state operation

Modify bullet b) of sub-clause 9.21.7.3:

b) For each received data MPDU that is related with a specific full-state operation HT-immediate Block Ack agreement, the block acknowledgment record for that agreement is modified as follows, where *SN* is the value of the Sequence Number subfield of the received data MPDU:

   1) If $WinStart_R \leq SN \leq WinEnd_R$, set to 1 the bit in position *SN* within the bitmap.

      i) If $WinEnd_R < SN + FN$, set $WinEnd_R = SN + FN$ and $WinStart_R = SN + FN - WinSize_R + 1$.

   2) If $WinEnd_R < SN < WinStart_R + 2^{11}$,

      i) Set to 0 the bits corresponding to MPDUs with Sequence Number subfield values from $WinEnd_R+1$ to $SN+FN-1$.

      ii) Set $WinStart_R = SN + FN - WinSize_R + 1$.

      iii) Set $WinEnd_R = SN + FN$.

      iv) Set to 1 the bit at position *SN* in the bitmap.

Add a second note after the first note in sub-clause 9.21.7.3 as below:

Note2- Fragmentation is not allowed during an HT-immediate Block Ack agreement with NDP BlockAck. All MPDUs generated during HT-immediate Block Ack with NDP BlockAck shall have the Fragment Number subfield of the received data MPDU set to an offset to $WinEnd_O$ when the received MPDU is part of an A-MPDU and NDP BlockAck is used as described in Clause 9.21.7.7 (Originator's behavior).

9.21.7.4 Scoreboard context control during partial-state operation

Modify bullet b) of sub-clause 9.21.7.4:

b) For each received data MPDU that is related with a specific partial-state operation HT-immediate Block Ack agreement, when no temporary record for the agreement related with the received data MPDU exists at the time of receipt of the data MPDU, a temporary block acknowledgment record is created as follows, where *SN* is the value of the Sequence Number subfield of the received data MPDU and *FN* is the value of the Fragment Number subfield of the received data MPDU of an A-MPDU:

   1) $WinEnd_R = SN+FN$.

9.21.7.5 Generation and transmission of BlockAck by an HT STA

Modify the 2nd paragraph as shown below:

When responding with a BlockAck frame to either a received BlockAckReq frame or a received A-MPDU with ACK Policy equal to Normal Ack (i.e., implicit Block Ack request) during either full-state operation or partial-state operation, any adjustment to the value of $WinStart_R$ according to the procedures defined within 9.21.7.3 (Scoreboard context control during full-state operation) and 9.21.7.4 (Scoreboard context control during partial-state operation) shall be performed before the generation and transmission of the response BlockAck frame. The Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield of the BlockAck frame shall be set to any value in the range from ($WinEnd_R$ - 63) to $WinStart_R$. The starting sequence number stored in the Starting Sequence Control field of NDP BlockAck frames shall be set to $WinStart_R$. The starting sequence number stored in the Starting Sequence Control field of BAT frames shall be set to $WinStart_R$. The values in the recipient's record of status of MPDUs beginning with the MPDU for which the Sequence Number subfield value is equal to $WinStart_R$ and ending with the MPDU for which the Sequence Number subfield value is equal to $WinEnd_R$ shall be included in the bitmap of the BlockAck frame.

9.21.7.7 Originator's behavior

Add three new paragraphs after the 1st, 3rd, 5th paragraph of sub-clause 9.21.7.7:

If the received BlockAck response is of an expected NDP BlockAck (1MHz) (or ≥ 2MHz), the originator shall accept it as correctly received if the value of the BlockAck ID field equals the TBD LSBs of the Scrambler subfield in the Service field of the immediately previously transmitted A-MPDU or BlockAckReq frame and the starting sequence number included in the Starting Sequence Control field equals $WinStart_O$. The originator will otherwise consider the NDP BlockAck frame to be lost.

Under an HT-Immediate BlockAck agreement with NDP BlockAck, the originator of an A-MPDU shall set the Fragment Number subfield value of the Sequence Control field of each MPDU of the A-MPDU to $WinStart_O + WinSize_O - 1 - SN$, where SN is the Sequence Number subfield value of the corresponding MPDU within the A-MPDU.

9.31 Null data packet (NDP) sounding

9.31.5 VHT sounding protocol

***Insert the following paragraphs at the end*:**

For S1G band, the same sounding protocol is applied, with “VHT” replaced by “S1G”.

Add the following new subclauses after subclause 9.32 Mesh forwarding framework based on REVmc D1.1:

9.32f Target Wake Time

9.32f.1 TWT overview

Target Wake Times (TWTs) allow an AP to manage the activity in the BSS to minimize contention and to reduce the required amount of time that a STA utilizing a power management mode needs to be awake to exchange frames with other STAs. The principle mechanism to facilitate TWT is the assignment of specific times for a participating STA (TWT STA) to wake to access the medium. TWT STAs need to communicate their wake requirements to APs and APs need to devise a schedule and deliver TWT values to STAs. During a TWT, the AP can send information about the next TWT to each participating TWT STA. When a TWT STA wakes and performs a frame exchange, it receives the next TWT information if Explicit TWT is being used, otherwise, the TWT STA can calculate each next TWT in a implicit series of TWT values. Individual STAs need not be made aware of the TWT values of other STAs. There are no restrictions on the assignment of TWT values to STAs. APs may protect TWT times with protection mechanisms including, but not limited to NAV-setting frame exchanges and RAW scheduling.

A non-AP STA may transmit a TWT element to its associated AP with a value of Request TWT, Suggest TWT or Demand TWT in the TWT Command field and a value of 1 in the TWT Request field.

An AP with dot11TWTOptionActive set to true shall transmit a TWT element to a STA with which it is associated and from which it received a TWT element that contained a value of Request TWT, Suggest TWT or Demand TWT in the TWT Command field and a value of 1 in the TWT Request field. The AP shall include a value of Accept TWT, Alternate TWT, Dictate TWT or Reject TWT in the TWT Command field of the response and shall set the TWT Request field to 0. If the AP response’s TWT Command field includes anything other than Accept TWT or Reject TWT, the STA should send a new request for a TWT value by sending another frame that contains a TWT element. If the STA receives a TWT response to a TWT request with the TWT Command value of Accept TWT, then the STA becomes a TWT STA and the STA may sleep until the TSF matches the TWT value, provided that the STA has indicated that it is in a power save mode.

An AP may transmit a TWT element in a TWT Setup frame to an associated non-AP STA with a value of Request TWT, Suggest TWT or Demand TWT in the TWT Command field and a value of 1 in the TWT Request field.

The non-AP STA with dot11TWTOptionActive set to true shall transmit a TWT element to the AP with which it is associated and from which it received a TWT element that contained a value of Request TWT, Suggest TWT or Demand TWT in the TWT Command field and a value of 1 in the TWT Request field. The non-AP STA shall include a value of Accept TWT, Alternate TWT, Dictate TWT or Reject TWT in the TWT Command field of the response and shall set the TWT Request field to 0. If the non-AP STA response’s TWT Command field includes anything other than Accept TWT or Reject TWT, the AP should send a new request for a TWT value by sending another frame that contains a TWT element. If the AP receives a TWT response to a TWT request with the TWT Command value of Accept TWT, then the AP STA becomes a TWT STA and the STA may sleep, depending on PM mode (10.2.1.19), until the TSF matches the TWT value, provided that the STA has indicated that it is in a power save mode.

A TWT STA shall be in the awake state for at least the Nominal Minimum Wake Duration time associated with a TWT Flow Identifier following a TWT associated with that TWT Flow Identifier even if no PS-Poll or U-APSD trigger frame has been transmitted by the STA. The time during which the TWT STA is awake is a TWT Service Period (TWT SP). A TWT SP associated with an implicit TWT is an implicit TWT SP. A TWT SP associated with a non-implicit TWT is a non-implicit TWT SP.

A TWT STA should transmit frames only within TWT SPs.

A TWT STA that transmits a frame during a TWT SP uses the normal rules for transmission (see clause 9 MAC sublayer functional description and 10.2.1.2 STA Power Management modes).

A single pair of STAs can create multiple TWT agreements. Each unique TWT agreement is identified by a Flow Identifier.

The MAC parameter Adjusted Minimum Wake Duration is equal to (Nominal Minimum Wake Duration + 40×10^{-6} × Wake Interval).

A TWT STA may wake to receive Beacons, but is not required to do so.

An AP should include a Partial Timestamp field in at least one frame transmitted to a TWT STA during an unannounced TWT for that STA.

9.32f.2 Explicit TWT operation

An AP that receives a frame from a TWT STA for an Explicit TWT shall respond to the STA with a frame that contains a Next TWT field (e.g. BAT, TACK, STACK) if it has not already transmitted a Next TWT field to the STA within this TWT SP. If the AP has already transmitted a Next TWT field to the STA within this TWT SP, the AP may respond to the STA with a frame that contains a Next TWT field. A TWT STA awake for an Explicit TWT SP shall not transition to doze state until it has received a Next TWT field from the AP and has been in the awake state for at least Adjusted Minimum Wake Duration time from the TWT SP start time as identified by the TWT STA or has received an EOSP field with a value of 1. If more than one Next TWT field is received from the AP during a TWT SP, the STA shall discard all but the most recently received value. If no Next TWT field is received from the AP during the TWT SP, the STA may transmit a frame following the end of the TWT SP when not otherwise prohibited from transmitting, which solicits a response that contains a Next TWT value.

9.32f.3 Implicit TWT operation

A TWT STA operating in an Implicit TWT SP shall determine the next TWT SP start time by adding to the current TWT, the value of Wake Interval associated with this TWT SP.

A TWT STA awake for an Implicit TWT SP may transition to the doze state after Adjusted Minimum Wake Duration time has elapsed from the TWT SP start time as identified by the TWT STA.

An AP that receives a frame from a TWT STA for an Implicit TWT may respond to the STA with a frame that contains a Next TWT field (e.g. BAT, TACK, STACK). A TWT STA that is awake for an Implicit TWT SP and receives a frame with a Next TWT field from its AP shall use the received Next TWT field value as the start of the next TWT, instead of the TWT value calculated by adding the value of Wake Interval associated with the TWT SP to the current TWT. Subsequent TWT are calculated based on the next TWT that was sent by the AP.

9.32f.4 TWT Grouping

When a TWT STA transmits within its TWT SP, the AP can protect this period from TIM STAs using mechanisms like NAV-setting frame exchanges and RAW scheduling. Information of these protected periods are to be broadcasted to TIM STAs for NAV setting or prohibiting TIM STAs from uplink transmissions.

Alternatively, an AP may have a predefined range of TWT groups as in Figure 9-44a (TWT grouping assignment). This TWT group may be represented by a Group ID (see 8.4.2.170j). The first TWT value of a TWT group is termed as Zero Offset of Group (see 8.4.2.170j). The value in Zero Offset of Group subfield corresponds to the value of the Target Wake Time field in the TWT element that contains the corresponding TWT Assignment. Examples of grouping assignments are depicted in Figure 9-44a (TWT grouping assignment). The AP should define all TWT groups, each group identified by its Group ID, Zero Offset of Group, TWT Unit, and Increment within Group (see 8.4.2.170j).

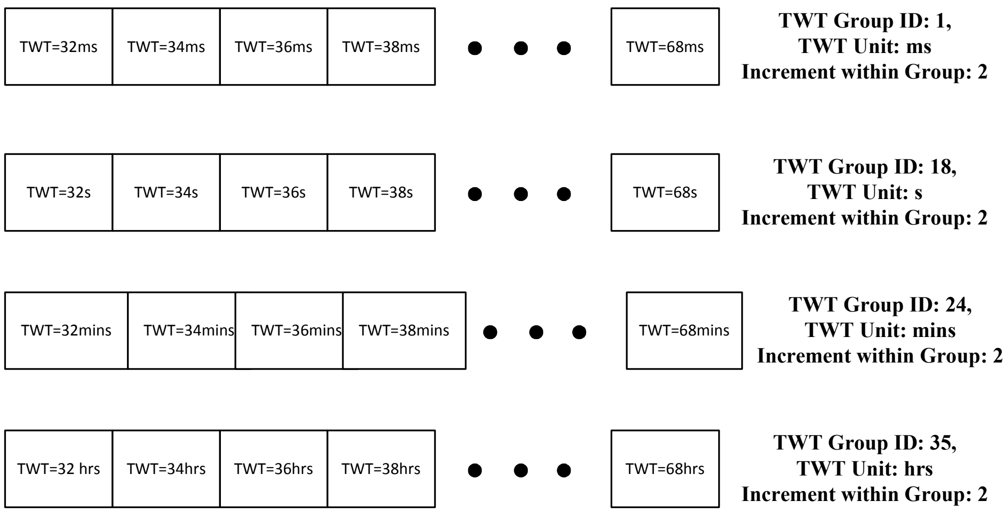

Figure 9-44a—TWT grouping assignment

A TWT STA suggests or demands a TWT value using either Suggest TWT or Demand TWT Command in the Request Type field (see Figure 8-401db (Request Type field format)) within a TWT element (see Figure 8-401da (Target Wake Time element format)). Based on the requested or demanded TWT value from a STA, an AP assigns it to one of the predefined TWT Groups. If the requested TWT does not belong to any of the TWT Groups, the AP may assign a modified TWT value. The AP sends the Group ID and Zero Offset of Group values within the TWT element to a requested STA (TWT Request bit set to 0) in order to indicate its TWT Group and the modified TWT value by using the Alternate TWT Command (see Figure 8-401da (Target Wake Time element format)).

An AP may use the Increment within Group subfield to spread the contention among TWT STAs. Based on the type of access categories of STAs within a TWT group, an AP may estimate their typical TXOP durations and set the Increment within Group value accordingly. For instance, higher the TXOP durations, higher the value indicated in Increment within Group subfield and vice versa.

The TWT grouping information may be beneficial when STAs already have their TWT values. The value in the TWT field of the TWT element provides the wake-up time for a STA. Other STAs that are members of the same TWT group wake at their assigned TWT times. In order to reduce contention among the waking STAs with closer TWT values, each waking STA can perform either of the following steps:

1) STA wakes up at its assigned TWT;
2) It computes the difference between its assigned TWT value and the Zero Offset of the Group;
3) Based on the difference and value in Increment within Group subfield, it estimates the number of STAs already contending for the medium;
4) For large number of contending STAs , it may use a large back-off counter value; and
5) If the difference is equal to 0, this STA is the only one contending for medium because the STA is the first of the TWT group with its TWT value being identical to the value in the Zero Offset of group field.

9.32f.5 NDP Paging Setup

This section defines a protocol for power saving at a STA by using the TWT protocol to setup scheduled wakeup intervals and by defining an efficient signalling for the presence of BUs and synchronization.

For the purpose of this clause, a frame including a TWT element with NDP Paging field present is referred to as NDP Paging Request or NDP Paging Response as clarified later. A STA sending an NDP Paging Request is referred to as NDP Paging Requester. A STA sending a NDP Paging Response in a response to an NDP Paging Request is referred to as NDP Paging Responder.

A STA can request an NDP Paging TWT by sending an NDP Paging Request as described in this clause.

The setup procedure follows the protocol described in 9.32f.4 (TWT Grouping), unless otherwise described in this clause.

A non-AP STA sending an NDP Paging Request to a NDP Paging Responder STA, shall set the P-ID field to one of the partial AIDs assigned to the non-AP STA (see 9.17b).

Upon receiving an NDP Paging Request, the recipient STA shall respond with an NDP Paging Response with an NDP Paging Field defined as follows:

— The P-ID should be set to the same value as the P-ID field in the NDP Paging Request.
— The Max NDP Paging period field shall be set to any value that is less than or equal to the Max NDP Paging period in the NDP Paging Request.
— The Action field shall be set to one of the values in Table 8-191c (Action field).
— The Partial TSF Offset field and Min Sleep Duration field are reserved.

The NDP Paging setup is successful if the TWT Command Reply field of NDP Paging Response TWT element is set to 4, otherwise the setup is considered as failed.

A STA which has sent an NDP Paging Response frame with the TWT Command Reply field set to 4 shall schedule an NDP Paging frame as the first frame for transmission at the TWTs indicated by the NDP Paging Response, if any of the following conditions is satisfied:

— There are BUs for the Requesting STA
— There is critical update to the Beacon as defined in clause (TBD)
— No NDP Paging frame was sent in the N consecutive preceding TWT(s), where N is equal to the value of the Max NDP Paging Period field in the NDP Paging Response.

The STA may additionally send an NDP Paging frame as the first frame for transmission at any of the TWT times indicated by the NDP Paging Response.

The first frame sent by the STA to the NDP Paging Requesters during the indicated TWT duration shall be an NDP Paging Frame (if any).

The P-ID field of the NDP Paging frame shall be set to the same value as P-ID field in the NDP Paging Response if and only if there are BUs for the paged STA. The value of the P-ID field shall be set to 0 to indicate the presence of group addressed BUs.

The APDI field in the NDP Paging frame shall be set as follows:

— The PTSF field is set to TSF[Partial TSF Offset+4: Partial TSF Offset+10] (inclusive), where TSF is the 8 bytes value of the TSF and Partial TSF Offset is the value of the Partial TSF Offset field in the NDP Paging Request.
— The Check Beacon field is initialized to 0 and incremented after each critical update to the Beacon frame; the value of the Check Beacon field shall be same as the LSB of the Check Beacon field in the most recent TIM Broadcast frame, if any was sent before the NDP Paging frame.

If no NDP Paging frame is received during the TWT, the TWT requester STA may transition to Doze state at the end of the Minimum Awake Duration for the TWT. If an NDP Paging frame is received, the TWT requester STA may transition to Doze state immediately after receiving the NDP Paging frame.

Upon reception of a NDP Paging frame with the P-ID field matching the value of the P-ID field in the NDP Paging Response, the NDP Paging Requester STA shall behave as follows:

— If the Action subfield is 0, the STA shall send a PS-Poll or uplink trigger frame addressed to the NDP Paging Responder.
— If the Action subfield is 1, the STA shall be in the Awake state starting at a time indicated by the Min Sleep Duration field after the end of reception of the NDP Paging frame.
— If the Action subfield is 2, the STA shall be in the Awake state at the first TBTT that occurs after a time indicated by the Min Sleep Duration field in the NDP Paging Response after the end of reception of the NDP Paging frame.
— If the Action subfield is 3, the STA shall be in the Awake state at the first DTIM that happens after a time indicated by the Min Sleep Duration field in the NDP Paging Response after the end of reception of the NDP Paging frame.

A STA which has setup NDP Paging shall receive the Beacon or Short Beacon frame at the next TBTT if it receives an NDP Paging frame from the NDP Paging responding STA with a Check Beacon bit value that is different from the most recently received value.

9.32f.6 TWT Sleep Setup

If the TWT Sleep identifier is set in TWT response exchange, the Responder STA may be in Doze state outside the TWT Adjusted SP, except for the Active periods defined through other TWT or RAWs.

9.32g Non-TIM STA operation

9.32g.1 General

9.32g.2 Resource protection for non-TIM STAs

When an AP schedules Target Wake Times (TWT) for non-TIM STAs, it is recommended that the AP protects the scheduled TWT of the non-TIM STAs from medium access by TIM STAs. For this purpose, the

AP may indicate to TIM STAs a Restricted Access Window (RAW) information during which no TIM STA is allowed to contend.

The AP may set up RAWs to protect the TWTs for non-TIM STAs and transmit the RAW parameters to TIM STAs by including them in RPS elements in beacons.

Instructions to Editor: How to indicate such information in the RPS IE is TBD

If the RPS element indicates that the RAW is allocated only to non-TIM STAs, then any TIM STA that checks it in the beacon shall not access the medium for the duration indicated by the RAW Duration in that RAW within the RPS element.

For instance, if scheduled TWTs for non-TIM STAs are periodic, the AP may set up a PRAW, which is defined in Clause 9.19.4a.6 (Periodic RAW (PRAW) operation).

9.32g.3 Rescheduling of wake/doze cycle of non-TIM STAs

This clause defines a procedure for a S1G STA that does not listen to the beacon to reschedule its awake/doze cycle.

A low power S1G STA can send a PS-Poll/trigger frame any time to its associated AP upon waking up without listening to the beacon. The low power S1G STA can be a non-TIM STA.

Upon receiving the PS-Poll/trigger frame, an S1G AP may respond with a control frame that includes a timer. The control frame is either the NDP ACK frame in 8.3.4a.1.3 or the Modified NDP ACK frame in 8.3.4a.1.4, both of which use the Duration field to indicate the wakeup timer value when the Duration Indication field is set to 1. The S1G STA can re-synchronize to the beacon with the help of the wakeup timer value.

The S1G AP shall set More Data field to 1 in the responding control frame if there is BU buffered for the low power S1G STA. If the low power S1G STA receives the responding control frame in which the Duration Indication field is equal to 1 and the Duration field is a nonzero value, there is no frame transmission for the STA in the indicated duration in which the S1G STA may go to sleep. After the amount of time that is equal to the value in the Duration field, it shall be at the awake state.

An S1G AP may set the wakeup timer (Duration field) as the duration to a TBTT in the responding control frame (either NDP ACK or Modified NDP ACK frame) and treat the non-TIM STA as a TIM STA starting from the TBTT. After the amount of time that is equal to the Duration field value in the responding control frame from the S1G AP, the dozing low power S1G STA may wake up to receive the beacon and operate as a TIM STA. The S1G STA returns to the non-TIM STA operation mode if the S1G AP indicates that there is no more data buffered for the S1G STA and the S1G STA indicates to the S1G AP that there is no more data to transmit. The S1G AP treats the S1G STA as a non-TIM STA if the STA indicates that there is no more data to transmit and the S1G AP indicates that there is no more data buffered for the STA. If the S1G AP sets the timer to 0, it indicates that there is no sleep duration for the low power S1G STA.

9.32g.4 Active polling procedure for non-TIM STAs

This clause defines the active polling procedure for a STA that can solicit information from AP upon waking up.

Upon waking up and without listening for a beacon, an active polling STA may solicit BSS change sequence and/or current timestamp information from an AP by sending a polling message (PS-Poll). In this polling message, it indicates whether the STA solicits the information of BSS change sequence and/or current timestamp by setting Poll Type bits to 01, or whether the STA solicits the information of Next TWT or Duration to a TBTT by setting Poll Type bits to 10.

In response to the received polling message sent by an active polling STA, an AP may send a TACK that its Next TWT Present field is set to 0 and S1G Control Frame Extension field is set to the value corresponding to TACK in FC field with the solicited information to the STA immediately. An AP may also send the STA either a NDP ACK that includes a wakeup timer or TACK in which Next TWT field is set to the value of a TBTT, which the AP uses to direct the STA to check the beacon. STA shall listen to the beacon when the timer with the value as indicated by Duration field of NDP ACK expires or Next TWT of TACK is due.

9.32g.5 Listen interval update procedure for Non-TIM STAs

When a STA changes TIM operation mode from TIM mode to Non-TIM mode and updates the listen interval that is different from the value established in the association request frame, the STA can request the listen interval change to an AP by transmitting the AID Request element in 8.4.2.170d (AID Request element) that contains the Listen Interval field instead of Wakeup Interval field. As the response to the corresponding request, the AP may responds to the STA with the AID Response element in 8.4.2.170e (AID Response element) that includes the Listen Interval field instead of Wakeup Interval field.

9.32h Synchronization (Synch) Frame Operation

9.32h.1 Synch frame transmission procedure for uplink traffic

This subclause describes a synchronization (synch) frame transmission procedure for uplink traffic, which minimizes the time for medium synchronization for a STA that is changing from Doze to Awake in order to transmit.

If dot11S1GUplinkSynchOptionImplemented is true, an AP shall set the Uplink Synch Capable field in the S1G Capabilities element to 1. If dot11S1GUplinkSynchOptionImplemented is false, the AP shall set the Uplink Synch Capable field in the S1G Capabilities element to 0.

An AP is an UL-Synch (Uplink Synch) capable AP if it sets the Uplink Synch Capable field to 1.

A STA may request to an UL-Synch capable AP to transmit a synch frame at the slot boundary of the STA in a RAW or at the target wake time of the STA.

A STA may request for a synch frame transmission to the UL-Synch capable AP either during the association by sending a (Re)Association Request frame in which the Uplink Synch Capable field in the S1G Capabilities element is set to 1 or at any time by sending a Synch Control frame (an Action frame of category S1G) in which the Uplink Synch Request field in the Synch Control field is set to 1.

A STA may request to stop the synch frame transmission to the UL-Synch capable AP at any time by sending a Synch Control frame in which the Uplink Synch Request field in the Synch Control field is set to 0.

When a STA is requesting for the sync frame transmission, a STA may also request to an AP to protect a time slot in a RAW defined in the Slot Duration field (8.4.2.170b (RPS element)) or a time duration for a TWT time defined in the Nominal Minimum Wake Duration field (8.4.2.170j (Target Wake Time element)) by setting the Time Slot Protection Request field in the Synch Control field to 1. The time slot protection is not requested, if the Time Slot Protection Request field is set to 0. When an AP receives a Sync frame from a STA with the Time Slot Protection Request field set to 1, the AP shall protect a time slot that is assigned for the STA in a RAW or a TWT time of the STA with NAV-setting frame exchanges.

For a STA that requested for a synch frame transmission, the UL-Synch capable AP shall schedule a synch frame at the slot boundary of the STA in the RAW or at the target wake time of the STA as the next frame for transmission according to the medium access rules specified in Clause 9.

If the medium is busy at the slot boundary of the STA in the RAW or at the target wake time of the STA, and if the UL-Sync capable AP determines that the remaining time in the time slot or the TWT SP to be too short to transmit a synch frame, the UL-Synch capable AP shall cancel the scheduled synch frame transmission. When the STA is changing from Doze to Awake in order to transmit, the STA shall follow the rules defined in 10.2.1.2 STA Power Management modes.

The UL-Synch capable AP should use the NDP CTS frame as a synch frame.

Figure 9-44b (Example of the uplink synch frame transmission procedure in a RAW) illustrates an example of the uplink synch frame transmission procedure in a RAW. STA1 is allocated Slot1 in the RAW and STA2 is allocated Slot3 in the RAW. Both STA1 and STA2 have requested the UL-Synch capable AP to transmit a synch frame at the slot boundary. At the slot boundary of Slot1, the medium is idle and thus the AP transmits a synch frame at the slot boundary. However, at the slot boundary of Slot3, the medium is busy and thus the AP cancels the scheduled synch frame transmission for STA2.

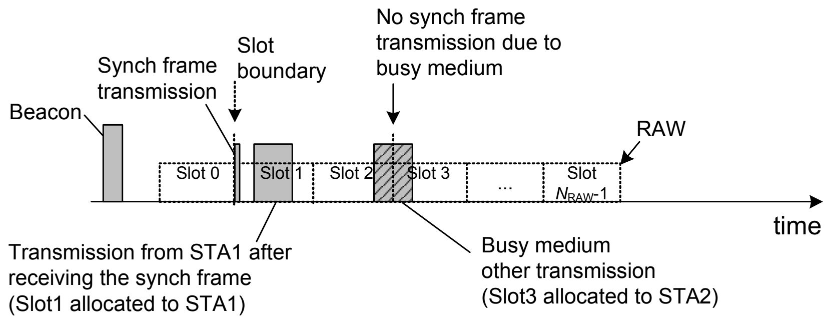

Figure 9-44b—Example of the uplink synch frame transmission procedure in a RAW

9.32i Speed Frame Exchange

9.32i.1 Overview

Speed frame (SF) exchange allows an AP and non-AP STA to exchange a sequence of uplink and downlink PPDUs separated by SIFS. This operation combines both uplink and downlink channel access into a continuous frame exchange sequence between a pair of STAs. The objective of this operation is to minimize the number of contention-based channel accesses, improve channel efficiency by reducing the number of frame exchanges, and reduce STA power consumption by shortening Awake times.

9.32i.2 Rules for SF exchange

An AP may send any frame as the initial frame of a SF exchange. An AP may set the ACK Indication field of the PLCP signal field to ACK for the initial frame of a SF exchange.

A non-AP STA may send a trigger frame or a PS-Poll frame as the initial frame of a SF exchange. A non-AP STA shall set the ACK Indication field of the PLCP signal field to Not ACK, BlockAck or CTS in a frame that initiates an SF exchange.

A STA sending an immediate response to a frame that had the More Data field set to 1 shall set the ACK Indication field to Not ACK, BlockAck or CTS.

A non-AP STA sending an immediate response that is an ACK frame or a BlockAck frame after receiving a frame that had the More Data field set to 0 shall set the ACK Indication field to No ACK.

An AP sending an immediate response that is an ACK frame or a BlockAck frame after receiving a frame that had the More Data field set to 0 may set the ACK Indication field to Not ACK, BlockAck or CTS or to No ACK.

A STA that receives a frame with a unicast address in the RA field that matches its address within SIFS after the transmission of a frame accepts the reception as an acknowledgement for the immediately previous transmission.

An AP sending an immediate response with the More Data field set to 1 and the ACK Indication field set to Not ACK, BlockAck or CTS shall transmit a frame to the STA that elicited the response SIFS after the transmission of the response frame if the More Data field was set to 0 in the frame most recently received from the non-AP STA.

An AP sending an immediate response with the More Data field set to 1 and the ACK Indication field set to Not ACK, BlockAck or CTS shall not transmit a frame to the STA that elicited the response SIFS after the transmission of the response frame if the More Data field was set to 1 in the frame most recently received from the non-AP STA.

An AP sending an immediate response with the More Data field set to 1 and the ACK Indication field set to No ACK shall transmit a frame to the STA that elicited the response within the current TXOP, but not SIFS after the transmission of the response frame.

An AP sending an immediate response to a non-AP STA that sets the More Data field to 0 and ACK Indication to No ACK in the response frame shall not transmit a frame to the STA within the current TXOP.

A non-AP STA shall remain in the Awake state until the end of the current TXOP if it receives a frame from the AP addressed to itself with a value of 1 in the More Data field.

A non-AP STA may transition to the Doze state if it receives a frame from the AP addressed to itself with a value of 0 in the More Data field.

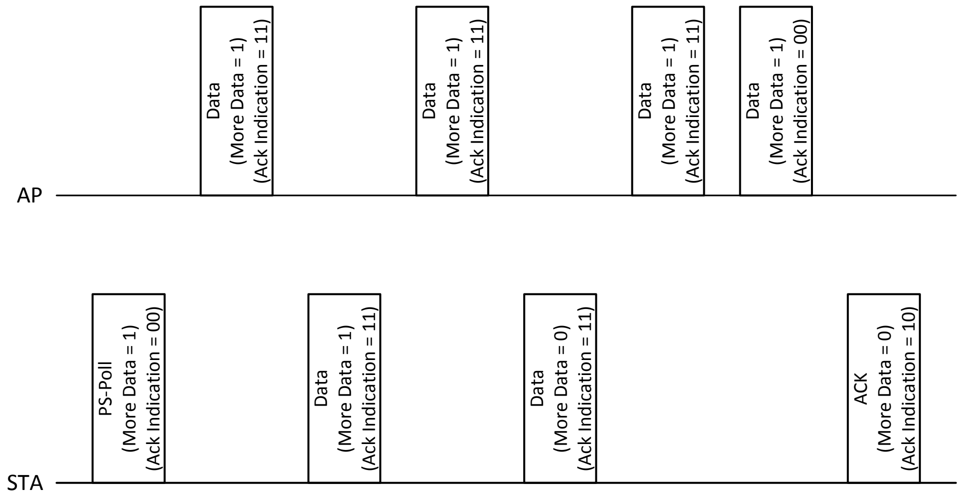

Figure 9-44c—Example of SF exchange sequence

NOTE 1- A SF exchange is subjected to TXOP duration limits for the current AC.

NOTE 2- For error recovery, a STA participating in a SF exchange may transmit the next frame when the medium is idle at TxPIFS slot boundary.

9.32j TIM and Page segmentation

The TIM element usually indicates downlink buffered data for all STAs in the BSS. However, in a BSS with large amount of associated STA, it is not viable to indicate downlink buffered data for all STAs in a Page in the TIM element. Hence, when dot11TIMSegmentSupported is true, an AP may fragment the TIM element into equal sized TIM segments consisting only of Page segment with a subset of STA AIDs as depicted in Figure 9-44d (Illustration of TIM and Page Segmentation with Segment Count IE).

STAs with a dot11TIMSegmentationCapability set to true shall follow the TIM Segmentation rules.

Multiple such TIM segments may be assigned within a DTIM beacon interval and the Segment Count element indicates the sequence of Page segments among scheduled TIM segments. The Segment Count element is only transmitted in DTIM beacon frames and not in TIM segments. Each TIM segment shall use a fixed length Page segment within one DTIM beacon interval. However, the length of Page segment may vary over multiple DTIM intervals. Each ordered page segment is assigned sequentially to TIM segments, where the first Page segment may be assigned to the DTIM segment, second Page segment in first TIM segment, and so on. Figure 9-44d (Illustration of TIM and Page Segmentation with Segment Count IE) is an illustration with 4 Page segments that are assigned to the DTIM segment and three TIM segments.

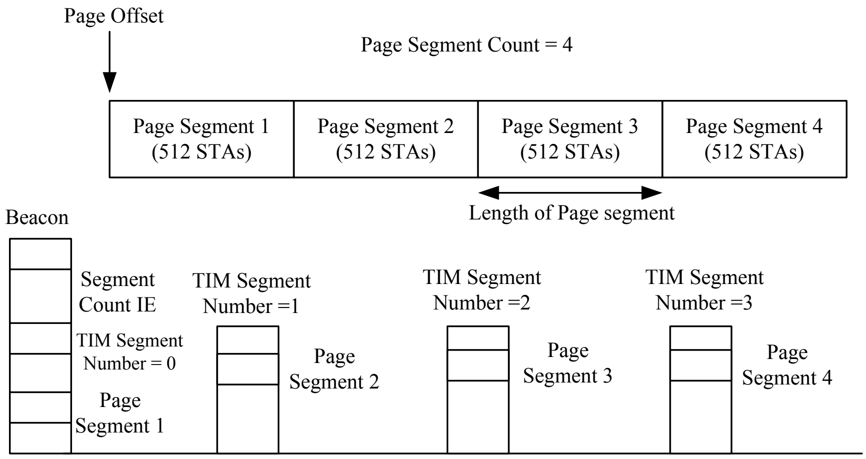

Figure 9-44d—Illustration of TIM and Page Segmentation with Segment Count IE

The Segment Count element indicates assignment of STAs in Page segments corresponding to their assigned TIM segments. STAs within the assigned Page segment wake up at corresponding TIM segment sequentially to receive buffered data from AP and access medium for uplink traffic. In order to wake up at the appropriate TIM segment, the STAs may compute the Page segment assignment to the TIM segments using the length of the Page Bitmap field and the value in the Page Segment Count fields of Segment Count IE. The length of Page segment assigned to each TIM segment is calculated as:

Length of Page segment = (Number of blocks in Page Bitmap /Page Segment Count),

where the number of blocks in Page Bitmap is defined from the size of the Page Bitmap field in Segment Count IE and the Page Segment Count field is defined in Segment Count element. At every TIM segment, the STAs may compute the initial block offset and block range indicated in the segment based on the following equations:

For zero value in the TIM Segment Number field:
Block offset / start = Page Offset

For non-zero value in the TIM Segment Number field:
Block offset / start = Page Offset + ((length of page segment) * (TIM Segment Number -1)) + 1

Block Range = Page Offset + length of page segment * TIM Segment Number

The TIM segment number is obtained from the TIM Segment Number field in the TIM segment.

If an STA does not support the segmentation, it's corresponding bit in the TIM shall be included in all the Beacons irrespective of segmentation.

The STAs supporting TIM Segmentation, wake up to receive the DTIM beacon frame from the AP. The STAs check the DTIM frame comprising of the Page Bitmap field and the block bitmap fields in Segment Count element and TIM segments, respectively. The Page Bitmap field in the Segment Count IE provides an early indication of buffered data for all blocks in the assigned Page segments. If a bit in Page Bitmap field is set to 0, it indicates that there is no buffered data for STAs with AIDs located in that block. They may return to Doze state immediately or after receiving buffered broadcast/multicast data as indicated in the DTIM. If the block bit in Page Bitmap is set to 1, then it indicates that there is buffered data at the AP for at least one of the STAs with AIDs in that block.

For STAs with their block bit in Page Bitmap set to 1, they compute the Length of the Page segment and the corresponding TIM segment to wake up. If they are not assigned in Page segment 1 that is allocated to DTIM segment, then these STAs may return to Doze state immediately or after receiving buffered broadcast/ multicast data as indicated in the DTIM till their scheduled TIM segment.

At the assigned TIM segment, the STAs decode the TIM segment in order to determine whether there is buffered data available at the AP. The method of decoding is based on the Block Bitmap Mode (see 8.4.2.7.1.1). This determination is with respect to a STA's AID in the TIM segment and the corresponding bit at that AID position. If the bit corresponding to that AID is set to 0, then it indicates that there is no buffered data for that STA. This STA may return to Doze state immediately. If the bit corresponding to an AID location is set to 1, then it indicates that there is buffered data for this STA.

9.32k Subchannel Selective Transmission (SST)

9.32k.1 Overview

S1G STAs that are associated with an S1G AP transmit and receive on the channel or channels that are selected advertised by the AP as the allowed operating channels for the BSS. An SST STA is a S1G STA that is associated with an AP and that chooses a subset of the allowed operating channels for the BSS on which to operate when SST operation is permitted by the AP as indicated in the Subchannel Selective Transmission element. The set of permitted SST channels indicated by the AP is dynamic.

At each TBTT, an S1G AP may send Beacons on more than one channel from the set of allowed operating channels for the BSS.

An S1G AP that wishes to allow SST operation within a beacon interval shall include the SST element in the Beacon that immediately precedes the beacon interval. An S1G AP that wishes to indicate to SST STAs the presence of activity within a beacon interval that can be used in the selection of an operating shall include the SST element in the Beacon that immediately precedes the beacon interval.

An S1G AP may include a Subchannel Selective Transmission element in a Beacon to indicate on which channels an SST STA is permitted to transmit within the BSS as described in 8.4.2.170m.

An S1G AP may indicate on which channels it intends to transmit following the transmission of a beacon by including a Subchannel Selective Transmission element in the beacon with a non-zero value in at least one Channel Activity bitmap subfield and a value of 1 in the corresponding DL Activity subfield

A local Beacon is one that is transmitted by the AP with which a STA is associated. An SST STA may select one or more channels from the allowed operating channels of the BSS corresponding to the S1G AP with which it is associated and operate on those channels for the Beacon Interval following a TBTT if a local Beacon with an SST element indicating the selected channel as permitted for SST operation has been received by the SST STA during that Beacon Interval. If no local Beacon is received following a TBTT, then no SST STA transmission is allowed during the Beacon Interval that begins at that TBTT. If an SST STA receives a local Beacon which contains no SST element, the SST STA may transmit on the primary channel of the BSS a PPDU of width up to the BSS bandwidth indicated in the beacon during the Beacon Interval that began at the TBTT immediately previous to the reception of the Beacon.

9.32l Sensor STA medium access operation

An S1G AP may indicate the Sensor-Only Access Window in some Beacon frames by allocating the RAW or PRAW. During the Sensor-Only Access Window, only sensor S1G STAs can access medium. And both sensor S1G STAs and offloading S1G STAs can access medium outside Sensor-Only Access Window. An S1G AP can decide on the duration of Sensor-Only Access Window based on the number of sensor STAs in its network, their expected uplink data amount and data rate and any other factors that the S1G AP chooses.

9.32m Sectorized beam operation

9.32m.1 Introduction

The partition of the coverage area of a BSS into sectors, each containing a subset of stations, is called sectorization. This partitioning is generally achieved by the AP transmitting or receiving through a set of antennas or a set of synthesized antenna beams to cover different sectors of the BSS. The goal of the sectorization is to reduce medium contention or interference by the reduced number of stations within a sector. All stations associated with the BSS shall be covered by at least one sector. Stations are allowed to move from one sector to another sector. The entire BSS is assumed to be covered by the omni-directional beam or the omni-directional antenna of the AP.

9.32m.1.1 Sector Capabilities Exchange

A sectorized beam-capable STA shall exchange its Sector Capabilities element with an AP. After the STA associated with a sectorized beam-capable AP, the AP can transmit through its sectorized beam to a sectorized beam-capable STA of the same sectorization Type.

If dot11S1GSectorImplemented is true, an STA shall set the sectorized beam-capable field in the Sector Capabilities element to 1 in the Association Request Frame. The STA also sets the Sectorization Type field in accordance with whether it is Type 0 or Type 1 Sectorization operation in the Sector Capabilities element. If dot11S1GSectorImplemented is false, the STA shall set the sectorized beam-capable field in the Sector Capabilities element to 0.

If dot11S1GSectorImplemented is true, an AP shall set the sectorized beam-capable field in the Sector Capabilities element to 1 in the Association Response Frame. The AP also sets the Sectorization Type field in accordance with whether it is Type 0 or Type 1 Sectorization operation and indicates the total number of Sectors in the Sector Capabilities element. If dot11S1GSectorImplemented is false, the AP shall set the sectorized beam-capable field in the Sector Capabilities element to 0.

An AP is a sectorized beam-capable AP if it sets the sectorized beam-capable field to 1.

After the exchange of the Sector Capabilities element during the Association, a Type 0 sectorized beam-capable AP shall transmit Type 0 Sectorization Scheme element. with the Sectorization Scheme field sets to 0 to advertise its sectorization rotation cycle, omni-directional indicator, current sector ID, and allowable group IDs, and the sub-period for the current sector ID in the Sector Operation element in a sectorized beacon to start a beacon interval. A Type 0 sectorized beam-capable AP may optionally omit the Type 0 Sectorization Scheme element if it transmits a non-sectorized (omni) beacon to start a beacon interval. A Type 1 sectorized beam-capable AP may transmit Type 1 Sectorization Scheme element with the Sectorization Scheme field sets to 1 to advertise if periodic sector training is on or off, its training period, and the remaining beacon interval to periodic training in the Sector Operation element in a beacon.

A sectorized beam-capable AP may (re)assign a specific Sector ID to a sectorized beam-capable STA after the Association. A sectorized beam-capable STA may optionally send Sector ID feedback to its associated sectorized beam-capable AP. A sectorized beam-capable STA may optionally request Sector Training from its associated sectorized beam-capable AP.

9.32m.2 Type 0 Sectorization

Type 0 Sectorization is based on the AP transmitting a sectorized beacon through a sectorized beam. A sectorized beacon is a beacon transmitted through a sectorized beam which covers a specific sector of the BSS. A BSS that employing a sectorization scheme is called a Sectorized BSS. The sectorization scheme of operation in a BSS is signaled by the presence of a Sector Operation element in beacon, probe response, and association response frames. In a Sectorized BSS, the AP may alternate the sectorized beacons and the non-sectorized (omni) beacons. During the omni time interval all the stations may transmit regardless their geographical location. All beacons in a sectorized BSS carry the Sector Operation element. The one-bit omni field indicator within the Sector Operation element distinguishes between the sectorized beacon and the omni beacon transmission. The Sector Operation element further specifies the type of sectorization scheme, the type of beacon (sectorized or omni), the complete rotation period of all (sectorized and omni) beacons, the sub-period for the current beacon, and the list of groups of stations that are allowed to transmit during the current beacon interval. In a Sectorized BSS of Type 0 Sectorization scheme, each station is allocated a group ID related to the sectorization operation. Stations that have group ID zero are allowed to transmit in all beacon intervals. During a beacon interval, the stations which are Sectorization Type 0 capable and with its group ID (GrpID) contained in the list of group IDs carried in the Sector Operation element are allowed to transmit within that beacon interval. By default all stations have GrpID zero unless otherwise specified at the association. Because by default all stations belong to GrpID zero before association, all the stations can transmit at any time before their association. It is expected that during the association, stations receive a non-zero GrpID, which will restrict their activity to a particular sector interval and Omni time interval. The AP may allow some stations to have the group zero even after association, for instance public safety stations or some high priority sensors. A station that receives a beacon in a Sectorized BSS shall verify if its group ID is contained in the group ID list of the Sector Operation element in the beacon if it intends to transmit within the beacon interval. A station that has a non-zero group ID, which is not listed in the Sector Operation element of the beacon it is not allowed to transmit during that sector duration.

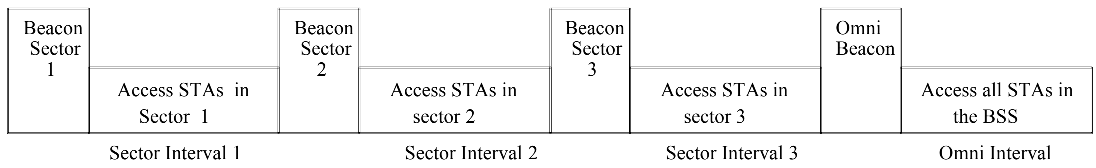

Figure 9-44e—Sectorized BSS operation

9.32m.3 Type 1 Sectorization

9.32m.3.1 Type 1 Sectorization operation

Type 1 Sectorization is based on the AP transmitting or receiving through the sectorized beam within a TXOP. At the beginning of a frame exchange, AP may start with the omni-directional beam transmission to establish a link with a station and to set up protection duration within a TXOP before switching to the sectorized beam transmission and reception. In different TXOPs, the AP may use different sectorized beams to communicate with different stations. A Type 1 Sectorization capable AP shall be able to transmit or receive through both the omni-direcitonal beam or the sectorized beams. In a BSS with Type 1 Sectorization, the AP shall signal the operation in beacons, probe response, association response, or other frames using the Sector Operation element. The operation of Type 1 Sectorization is defined by the following rules:

- The switching between the omni-direcctional beam and the sectorization beam occurs during the interframe spacing between two consecutive packets or in-between the omni preamble and the beamformed preamble of a long preamble.
- When an AP is aware of the sector in which a station is in, AP may transmit to or receive from the station using the sectorized beam either during the scheduled transmission such as RAW or within a TXOP. Otherwise, AP transmits or receives through omni directional beam to a station.
- Once AP transmits to a station through a sectorized beam, it shall use the same sectorized beam to receive from the station within the same TXOP.
- Once the AP switches to the sectorized beam transmission during an exchange, it shall continue with sectorized beam transmission with the same sectorized beam and the TXOP truncation is not allowed for the remainder of the protected duration.

The forming of the sectorized beam(s) is beyond the scope of the standard.

In Type 1 Sectorization, during a frame exchange between the AP employing sectorized beam and a station, spatial re-use by OBSS APs or stations sharing the same wireless medium is allowed under the following rules:

When the protection is set up by the AP's omni-directional beam transmission for a duration within a TXOP and if the spatially orthogonal (SO) condition is confirmed by an OBSS station or AP, the OBSS station or AP can reset its NAV to initiate a new spatially orthogonal exchange starting with a non-beamformed RTS/CTS.

The spatially orthogonal (SO) condition is satisfied if an OBSS station or AP which receives the omni-directional transmission but not the subsequent the sectorized beam transmission from the AP and not the transmission from the station involving in the frame exchange.

Four types of frame exchange sequences which can lead to the SO conditions by OBSS stations or APs are described.

a) SO frame exchange sequence 1: The AP starts a frame exchange with the omni-directional beam to establish a link with a station and then uses the omni-preamble of a long preamble to set up the protection for the duration of the sectorized beam transmission and the switches to the sectorized beam transmission starting with the beamformed preamble of the long preamble. The AP continues with the sectorized beam transmission for the remainder of the protected duration. SO condition is confirmed by an OBSS station or AP which observes the omni-transmission of the AP but not the beamformed preamble of the AP and not the station's transmission. Note that an OBSS station or OBSS AP infers its spatial orthogonality with the AP by observing the first omni-beam packet and the omni-preamble of the long preamble but not observing the subsequent sectorized beam transmission and with the station by observing a gap of no transmission between the first omni-beam packet and the omni-preamble of the long preamble.

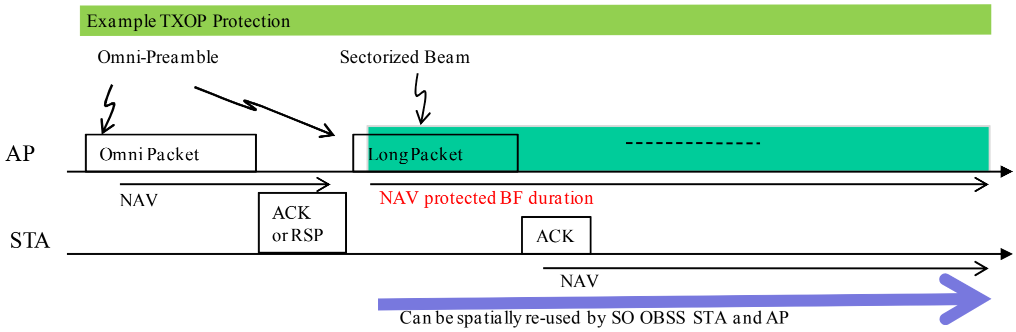

Figure 9-44f—SO frame exchange sequence 1

b) SO frame exchange sequence 2: The AP starts a frame exchange with the omni-transmission of a packet to establish a link with a station and then uses the omni-transmission of a subsequent packet to set up the protection for the duration of the sectorized beam transmission and the switches to the sectorized beam transmission for the remainder of the protected duration. SO condition is confirmed by an OBSS station or AP which observes the omni-transmission of the AP but not the beamformed transmission of the AP and not the station's transmission. Note that an OBSS station or OBSS AP infers its spatial orthogonality with the AP by observing the omni-beam transmission but not observing the sectorized beam transmission and with the station by observing a gap of no transmission between the first two omni-beam packets by the AP.

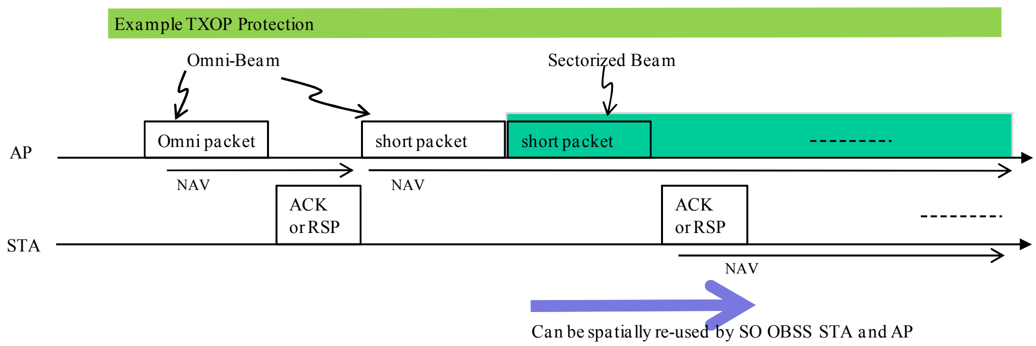

Figure 9-44g—SO frame exchange sequence 2

c) SO frame exchange sequence 3: The AP starts a frame exchange with an omni-RTS to solicit a CTS response from a station and then uses the omni-transmission to set up the protection for the duration of the sectorized beam transmission and the switches to the sectorized beam transmission for the remainder of the protected duration. SO condition is confirmed by an OBSS station or AP which observes the omni-transmission of the AP but not the beamformed transmission of the AP and not the station's transmission. Note that in the first diagram in Figure 9-44h (SO frame exchange sequence 3), an OBSS station or OBSS AP infers its spatial orthogonality with the AP by observing the omni RTS and omni-preamble of the long preamble but not the subsequent sectorized beam transmission and with the station by observing a gap of no transmission between the omni RTS and the omni-preamble of the long preamble. Note that in the second diagram in Figure 9-44h (SO frame exchange sequence 3), an OBSS station or OBSS AP infers its spatial orthogonality with the AP by observing the omni-RTS and the omni-beam short packet transmission but not observing the subsequent sectorized beam transmission and with the station by observing a gap of no transmission between the omni-RTS and the omni-beam short packets by the AP.

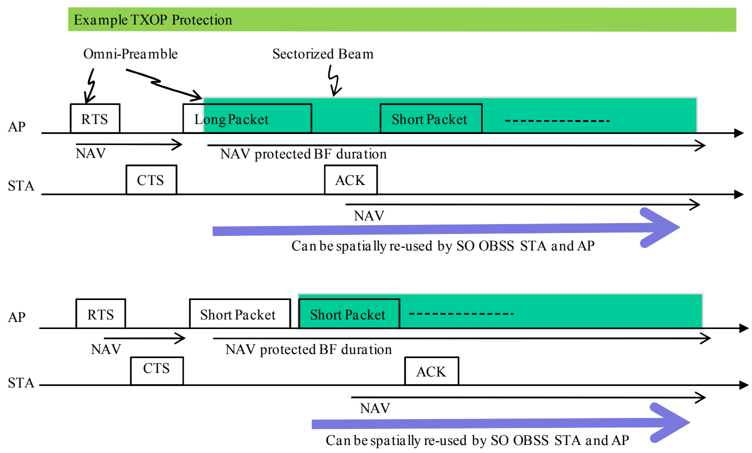

Figure 9-44h—SO frame exchange sequence 3

d) SO frame exchange sequence 4: A station starts with the omni-directional beam to establish a link with the AP. AP uses omni-transmission to set up the protection for the duration of the sectorized beam transmission and the switches to the sectorized beam transmission. The AP continues with the sectorized beam transmission for the remainder of the protected duration. SO condition is confirmed by an OBSS station or AP which observes the omni-transmission of the AP but not the beamformed transmission of the AP and not the station's transmission. Note that in the first diagram in Figure 9-44i (SO frame exchange sequence 4), an OBSS station or OBSS AP infers its spatial orthogonality with the AP by observing the omni-preamble of the long preamble but not the subsequent sectorized beam transmission and with the station by observing a gap of no transmission before the AP response to PS-Poll or trigger frame from the station. Note that in the second diagram in Figure 9-44i (SO frame exchange sequence 4), an OBSS station or OBSS AP infers its spatial orthogonality with the AP by observing the first omni-beam short packet but not observing the subsequent sectorized beam transmission and with the station by observing a gap of no transmission before the first omni-beam short packets by the AP.

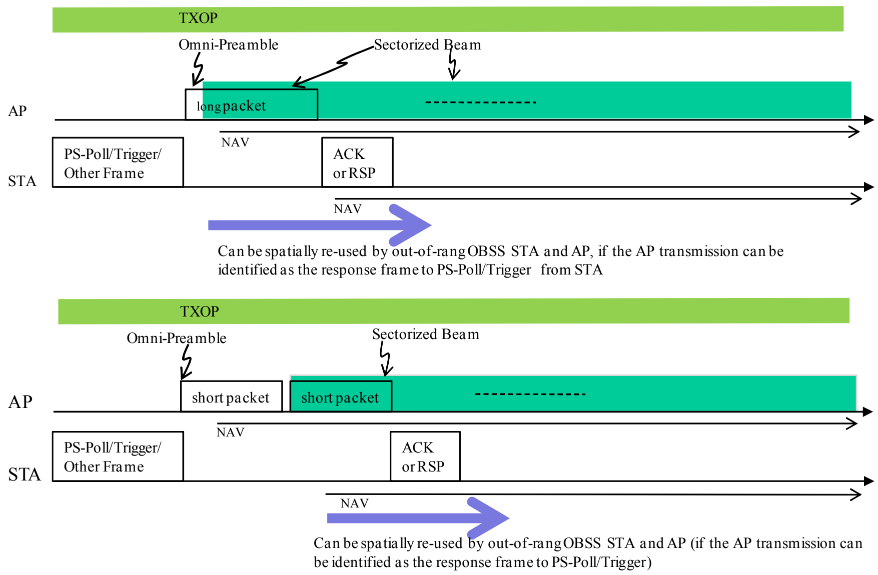

Figure 9-44i—SO frame exchange sequence 4

To facilitate the detection of the spatially orthogonal conditions by OBSS stations or OBSS APs, the short CTS NDP may be transmitted preceding the SO frame exchange. If the Early Sector Indicator in the CTS frame is set to 1, it indicates that the NDP CTS frame is followed by the sectorized beam frame exchange. Setting the early sector indicator to 1 also indicates to the OBSS STAs that it can cancel its NAV setting if the Spatially Orthogonal conditions are subsequently met. Hence, if the early sector indicator is set to 0, OBSS STA need not check for spatially orthogonal conditions. Figure 9-44j (CTS-to-self preceding SO frame exchange sequence) illustrates the frame exchange preceded by CTS-to-self using CTS NDP.

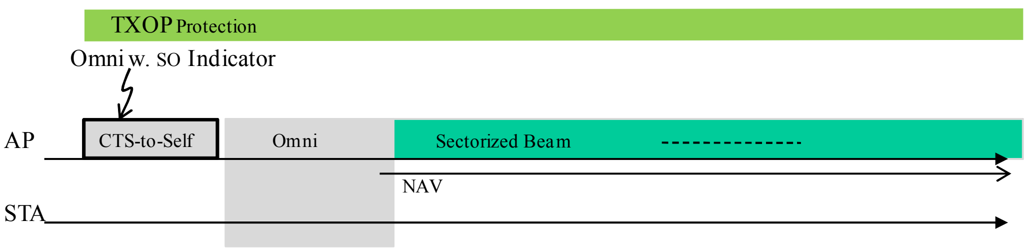

Figure 9-44j—CTS-to-self preceding SO frame exchange sequence

9.32m.4 Sector training operation

9.32m.4.1 Introduction

The sector training is one way to help the stations to determine the best sectors to communicate with the AP. Sector training requires the AP to transmit training NDPs over all sectors. The best sector might be chosen by a station based on instantaneous or averaged CSI. The specific method of choosing the sector is beyond the scope of this standard. The results of the sector training may be fed-back by the stations to the AP using Sector ID feedback frame. These training NDPs shall be transmitted consecutively and should be sent within a single TXOP. The training information is exchanged using the HT variant Control field. The sector training supports up to eight sectors. The AP may use other methods to determine the station's best sector.

9.32m.4.2 Procedure

In the sector training, the AP sends a sector training announcement followed by a series of NDP sector training frames separated by SIFS.

In Type 1 Sectorization, the sector training may occur periodically with the training period and the beacon interval in which the training occurs as indicated in Sector Operation element (Type 1), in response to a request from a STA, or initiated by the AP. The stations may perform the sector training by receiving the training NDPs from AP. In the case that the AP receives the sector training request from a station, the AP shall initiate a sector training. AP supporting Type 1 Sectorization shall support sector training and sector training request. In the Sector Operation element (Type 1) (see 8.4.2.170l), which is transmitted in beacon, probe response, or association response, the AP indicates in which beacon interval and in how many beacon intervals a sector training occurs. The total number of sectors is signalled during the AP capability exchange.

In Type 0 Sectorization, a STA can basically find its best sector ID by listening to all the sectorized beacons. The Sector Operation element (Type 0) carried in the sectorized beacon provides the sectorized beacons rotation period, sector ID, the sub-period of the current sector and the group IDs of the groups of STAs which are allowed to transmit within the current beacon interval. The sector training may be used for STAs which support Sector Training Capable to reduce time for sector discovery and allow STAs which don't listen to all the sectorized beacons for its power saving.

When a station joins a BSS with sectorization, it shall indicate whether it supports Sector ID Feedback Capable and Sector Training Capable during the Sector Capabilities exchange (see 8.4.2.170l (Sector Capabilities element)). The station may use the Sector ID feedback frame (see 8.5.23.4a (VHT Sector ID Feedback frame format)) to signal to the AP which sector is the best sector found.

The station may request Sector Training from AP by using the HT Variant Control field if it is capable of sector training request. By setting the MAI=14 in the Link Adaptation Control subfield of the HT Variant Control field, the station indicates HT variant control field is used for signaling Sector Training (or Antenna Selection) information. The Sector training (or sector training resumption) is requested by a station when the ASELC subfield is set to 1 and the ASEL Data subfield with values in the range of 1 to 15, being the number of the first NDP training frames to be transmitted when the command is Sector Training Resumption, where 0 corresponds to the first training frame in the Sector Training Request. When the NDP Announcement field is also set to 1, it indicates training NDP frames to follow with two consecutive training NDP frames separated by SIFS.

The frame exchange sequence for sector training is shown in Figure 9-44k (Sector training), where the AP transmits training NDP frames, and the STA provides Sector ID feedback. The frame exchange comprises the following steps:

a) (Optional) A station may initiate the sector training by sending a +HTC frame with the ASELC set to 1 for sector training request.

b) The AP sends out consecutive training NDPs separated by SIFS in a TXOP of which it is the TXOP holder with no ACK over different sectorized beams. NDP CTS frames (8.3.4a.1.1), with NDP MAC Frame Type=3, are used in sector training. Each training NDP is transmitted over one sector beam. The first training NDP frame shall be preceded by a +HTC frame with NDP announcement subfield set to 1. The positions of the training NDP frames correspond to the sector IDs of the sectorized beams, in ascending order starting with Sector ID =0.

c) The station(s) may perform training by estimating the received signal quality corresponding to each training NDP.

d) The station(s) engages in the training by receiving the sector training frames may respond with a selected sector ID using the sector ID feedback frame in a subsequent TXOP or during Sector Report RAW which may be indicated by beacon for fast sector discovery of multiple STAs (see 9.32m.4.4 (Fast Sector Discovery)).

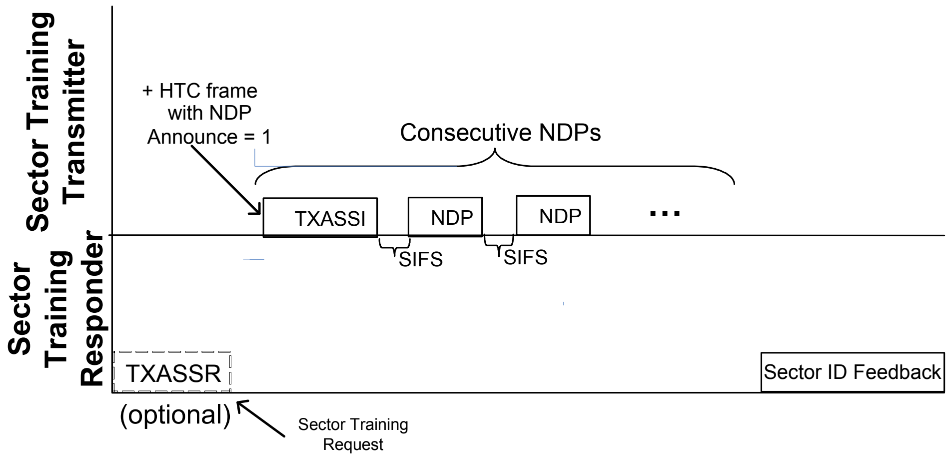

Figure 9-44k—Sector training

If the AP receives a +HTC MPDU with the MAI subfield equal to 14, the ASEL Command subfield equal to Sector Training Request (=1), and the ASEL Data subfield equal to a zero to correspond to the command Sector Training, the station shall assume a total number of training NDPs that corresponds to the total number of sectors. If the AP receives a +HTC MPDU with the MAI subfield equal to 14, the ASEL Command subfield equal to Sector Training Request (=1), and the ASEL Data subfield equal nonzero value to correspond to the command Sector Training Resumption (a Resumption MPDU), the station shall assume the number of training frames that follow the Resumption MPDU is equal to the number of training NDPs from the total number of sectors minus the order number transmitted in the ASEL Data subfield of the Resumption MPDU.

AP may schedule sector sounding for multiple STAs by RAW in a beacon interval using the RAW Parameter Set element with the Sounding RAW Indication set to 1 (see 8.4.2.170b (RPS element)). During the Sounding RAW, non-AP STAs are prohibited to transmit but can elect to listen to the sector training for the entire RAW. This Sounding RAW may be scheduled in a periodic or impromptu way.

The sector training within the Sounding RAW starts with a frame with NDP announcement indicator set to 1 in the HT control field and is followed in SIFS by a number of NDP CTS frames, each transmitted through different antenna sector starting with Sector ID equal to 0, and separated by SIFS. The Sounding RAW indication sub-field set to 0 indicates no sector sounding is performed within the RAW.

9.32m.4.3 Sector ID feedback

A station may optionally use a VHT action frame (see 8.5.23.4a) for (solicited and unsolicited) Sector ID feedback.

9.32m.4.4 Fast Sector Discovery

When multiple STAs report their Sector ID feedback frames to AP, Sector ID feedback frames may be protected by Sector Report RAW indicated in the beacon (signaling TBD) to avoid contentions with others. The Sector Report RAW may be assigned after the Sounding RAW for fast sector discovery of multiple STAs.

9.32n Relay operation

In this subclause, STA means non-AP STA.

An AP shall act as a Relay AP with dot11RelayAPActivated is true.

A STA with dot11RelaySTACapable set to true shall include the Relay element in Association or Probe Requests.A Relay AP shall include a Relay element in transmitted Beacon and Probe Response frames.

A Relay is an entity that logically consists of a Relay AP and Relay STA.

A STA with dot11RelaySTACapable set to true is a Relay STA if it receives an Association Respond with a Relay element included.

A Relay AP shall not set the Relay Control field of transmitted Relay elements to 0 if a co-located Relay STA is associated with a Relay AP.

A Root AP is defined as a Relay AP that sets the Relay Control field of transmitted Relay elements to 0.

A Relay AP that is not a Root AP shall use same SSID as the Relay AP to which it is associated.

A Relay AP that is not a Root AP shall set the Relay Control field of transmitted Relay elements to 1.

A Relay STA shall send a Reachable Address Update frame to the AP to which it is associated the current list of reachable addresses when one of the following conditions occurs:

1) A new STA associates with the Relay AP
2) A STA is disassociated or deautheticated from the Relay AP

A Relay STA may send a Reachable Address element to the Relay AP to which it is associated indicating the current list of reachable addresses when associating.

9.32n.1 Addressing and forwarding of individually addressed relay frames

MSDUs received at the MAC SAP of a Relay STA which are not destined for the Relay STA are forwarded via the air interface to the Relay AP to which it is associated, using either a 4-address frame format or an A-MSDU format.

The addressing of the 4-address frame shall be as follows in this case:

— A1 is the MAC address of the AP (the receiver of the MPDU)
— A2 is the MAC address of the Relay STA (the transmitter of the MPDU)

- A3 is the DA of the MSDU (the destination address of the MSDU).
- A4 is the SA of the MSDU (the source address of the MSDU)

The addressing of the A-MSDU frame shall be as follows in this case:

- A1 is the MAC address of the AP (the receiver of the MPDU)
- A2 is the MAC address of the Relay STA (the transmitter of the MPDU)
- A3 is the MAC address of the AP (the BSSID)
- DA in A-MSDU subframe header is the DA of the MSDU (the destination address of the MSDU)
- SA in A-MSDU subframe header is the SA of the MSDU (the source address of the MSDU)

MSDUs received at the MAC SAP of a Relay AP which are not destined for the Relay AP or one of its associated STAs are forwarded via the air interface to an appropriate Relay STA, using either a 4-address frame format or an A-MSDU format.

The addressing of a 4-address frame shall be as follows in this case:

- A1 is the MAC address of the Relay STA (the receiver of the MPDU)
- A2 is the MAC address of the Relay AP (the transmitter of the MPDU)
- A3 is the DA of the MSDU (the destination address of the MSDU)
- A4 is the SA of the MSDU (the source address of the MSDU)

The addressing of an A-MSDU frame shall be as follows in this case:

- A1 is the MAC address of the Relay STA (the receiver of the MPDU)
- A2 is the MAC address of the Relay AP (the transmitter of the MPDU)
- A3 is the MAC address of the AP (the BSSID)
- DA in A-MSDU subframe header is the DA of the MSDU (the destination address of the MSDU)
- SA in A-MSDU subframe header is the SA of the MSDU (the source address of the MSDU)

9.32n.2 Addressing and forwarding of group addressed relay frames

Group addressed MSDUs received at the MAC SAP of a Relay STA are forwarded via the air interface to the Relay AP to which it is associated, using either a 4-address frame format or an A-MSDU format.

The addressing of the 4-address frame shall be as follows in this case:

- A1 is the MAC address of the AP (the receiver of the MPDU)
- A2 is the MAC address of the Relay STA (the transmitter of the MPDU)
- A3 is the DA of the MSDU (the group address).
- A4 is the SA of the MSDU (the source address of the MSDU)

The addressing of the A-MSDU frame shall be as follows in this case:

- A1 is the MAC address of the AP (the receiver of the MPDU)
- A2 is the MAC address of the Relay STA (the transmitter of the MPDU)
- A3 is the MAC address of the AP (the BSSID)
- DA in A-MSDU subframe header is the DA of the MSDU (the group address)
- SA in A-MSDU subframe header is the SA of the MSDU (the source address of the MSDU)

Group addressed MSDUs received at the MAC SAP of a Relay AP are forwarded via the air interface to an appropriate Relay STA and its associated STAs, using a 3-address frame format.

The addressing of a 3-address frame shall be as follows in this case:

- A1 is the DA of the MSDU (the group address)
- A2 is the SA of the MSDU (the source address of the MSDU)
- A3 is the MAC address of the AP (the BSSID)

9.32n.3 Procedures TXOP sharing

The sequence of frames exchanged over the first hop and second hop depends on the acknowledgement procedure used at the Relay STA. Frames can use either:

- Explicit ACK procedure
- Implicit ACK procedure

When Relay STA receives a valid frame with Relayed Frame field set to 1, Relay STA may acknowledge the received frame using the Implicit ACK procedure.

When Relay STA receives a valid frame with Relayed Frame field set to 0, Relay STA shall not acknowledge the received frame using the Implicit ACK procedure.

When Relay STA uses the Explicit ACK procedure to acknowledge the reception of a valid frame, the Relay STA shall set the Relayed Frame field to 1 in the immediate ACK frame. A Relay STA may set Relayed Frame field to 1 only if the More Data field was set to 0 in the frame most recently received from the non-AP STA.

A non-AP STA that receives the ACK frame that matches its address shall not initiate any further frame transmissions within the current TXOP.

The choice of acknowledgement procedure is optional to the Relay STA.

The operation of TXOP sharing is supported only for S1G frames.

NOTE- The frames transmitted over the first hop and second hop can be sent at two different MCSs.

9.32n.3.1 Explicit ACK procedure

A non-AP STA is the source of the frame to be relayed when the direction of the frame is from the non-AP STA to the AP.

An AP is the final destination of the frame to be relayed when the direction of the frame is from the non-AP STA to the AP.

A non-AP STA starts a frame exchange by sending a frame addressed to the relay STA with ACK Indication field set to ACK. The relay STA shall set the ACK Indication field of the response frame that is transmitted to the non-AP STA to Not ACK, BlockAck or CTS and shall set the Relayed Frame field of the response frame that is transmitted to the non-AP STA to 1.

The Relay STA shall transmit the received frame addressed to the AP SIFS after sending the response frame transmission that included an ACK Indication field value of ACK. Upon the successful receipt of the relayed frame, the AP shall set the ACK Indication field of the response frame to No ACK.

The non-AP STA uses a new TXOP for a new frame transmission.

When the direction of the frame is from the AP to the non-AP the AP STA starts a frame exchange by sending a frame addressed to the relay STA with ACK Indication field set to ACK. The relay STA shall set the ACK Indication field of the response frame that is transmitted to the AP STA to Not ACK, BlockAck or CTS, and shall set the Relayed Frame field of the response frame that is transmitted to the non-AP STA to 1.

The Relay STA shall transmit the received frame addressed to the non-AP STA SIFS after sending the response frame transmission that included an ACK Indication field value of ACK. Upon the successful receipt of the relayed frame, the non-AP STA shall set the ACK Indication field of the response frame to No ACK.

The AP uses a new TXOP for a new frame transmission.

9.32n.3.2 Implicit ACK procedure

When a relay station receives an MPDU for forwarding in TXOP sharing relay operation, the relay station may directly forward the received MPDU without sending back acknowledgement frame to the transmitter of the MPDU. This implicit ACK mechanism is available only when PAID information is included in the PLCP header (≥2MHz PHY frame format).

If an MPDU is transmitted by a STA associated with a relay station to the relay station, the relay station forwards the received MPDU to the AP that it is associated with in SIFS time. After transmitting the MPDU, the STA shall wait for an ACKTimeout interval, with a value of aSIFSTime + aSlotTime + aPHY-RX-START-Delay, starting at the PHY-TXEND.confirm primitive. If the STA receives a valid PLCP header within the ACKTimeout interval and PAID in the received PLCP header is identical to PAID corresponding to BSSID of the AP, the STA recognize it as successful acknowledgement, permitting the frame sequence to continue, or to end without retries, as appropriate for the particular frame sequence in progress.

If an MPDU is transmitted by a AP to a relay station, the relay station forward the received MPDU to the STA that is associated with in SIFS time. After transmitting the MPDU, the AP shall wait for an ACKTimeout interval, with a value of aSIFSTime + aSlotTime + aPHY-RX-START-Delay, starting at the PHY-TXEND.confirm primitive. If the AP receives a valid PLCP header within the ACKTimeout interval and PAID in the received PLCP header is identical to PAID corresponding to DA of the transmitted MPDU, the AP recognizes it as successful acknowledgement, permitting the frame sequence to continue, or to end without retries, as appropriate for the particular frame sequence in progress. If the RA of the forwarded MPDU is different from DA of MPDU transmitted by the AP, the relay station shall use explicit ACK procedure.

For downlink implicit ACK procedure, an AP that the relay is associated with shall know PAID of STAs associated with a relay station that is associated with the AP. For this purpose, a relay station may indicate an associated STA's AID to the AP by sending an STA Information Announcement frame including an AID Announcement element when the STA becomes associated or the STA's AID is changed.

For uplink implicit ACK procedure, STAs associated with a relay station shall know BSSID of the AP that serving relay station is associated with. For this purpose, a relay station may indicate the BSSID of the AP to newly associated STAs by using RootAP BSSID information in Beacon frame or Probe Response frame.

9.32n.3.3 Flow control for relay

A relay STA may serve as a relay to more than one non-AP STAs at any one time. Depending on channel conditions, a relay STA might not be able to access the channel due to medium busy condition and/or frames that are transmitted unsuccessfully.

As a result, frames can become buffered at the relay STA. To avoid a buffer overflow condition, a relay STA may signal to non-AP STAs to stop sending frames addressed to the relay STA until adequate space exists in its buffer to accept additional frames.

Signaling for flow control is TBD.

9.32n.3.4 Relay discovery procedure

A single-hop direct path is a one-hop path between a non-AP STA performing an active scan for relay STAs, and the root AP.

A relay path is a two-hop path between a non-AP STA performing an active scan for relay STAs, and the root AP through the relay STA.

A non-AP STA that performs active scanning shall use the Probe Request frame for relay STA discovery. The Probe Request frame may optionally include link budget information for the single-hop direct path and additional QoS requirements for the relay path. This information shall be conveyed using the Relay Discovery element if present. The formula for calculating link budget and QoS requirements are implementation specific.

The contents of link budget information and QoS requirement fields in the Relay Discovery element are TBD.

A relay STA receiving a Probe Request frame becomes eligible to be a relay STA for this non-AP STA if the link budget and QoS requirements are met and the SSID matches. If these requirements are met, a relay STA may respond to the non-AP STA with a Probe Response frame and offer to be a relay STA candidate for this non-AP STA. A relay STA may optionally include link budget information between the relay STA and AP. The principle for this operation is to reduce the number of Probe Responses sent from relay STAs.

Based on the number of Probe Responses received, the non-AP STA selects a designated relay STA among the relay STA candidates.

9.32o Sensor Only BSS

An AP may indicate that the AP only supports a Sensor type STA by transmitting the S1G Capabilities element in Beacon frames or Probe Response frames in which the STA Type Support subfield is set to 1. When the STA Type Support subfield is set to 1, only Sensor type STAs are allowed to associate and operate with that AP.

An AP may indicate that the AP only supports non-Sensor type STAs by transmitting the S1G Capabilities element in Beacon frames or Probe Response frames in which the STA Type Support subfield is set to 2. When the STA Type Support subfield is set to 2, only non-Sensor STAs are allowed to associate and operate with the AP.

An AP may indicate that the AP supports both Sensor type and non-Sensor type STAs by transmitting the S1G Capabilities element in a Beacon or a Probe Response frame, in which the STA Type Support subfield is set to 0, in which case any type of STA is allowed to associate and operate with the AP.

An AP may change its support for the Sensor or non-Sensor type STAs by changing its S1G Capabilities indication. When a STA notices that its type is not supported anymore by its AP, the STA shall initiate the de-association from that AP. Then the STA may associate with another AP that supports its type.

9.32p Support for energy limited STAs

A STA powered by a small energy supply can be limited in terms of its ability to transmit or receive in certain intervals of time. The indications described in this clause allow a STA to indicate such limitations to another STA that intends to communicate with it, so that operations can be performed successfully.

A S1G STA may include an Activity Specification element in Probe Request, Association Request and Activity Specification frames.

A transmitter S1G STA receiving an Activity Specification Element from an associated or peer receiver S1G STA shall not transmit to the receiver STA, or cause the receiver STA to transmit, a PPDU that would exceed a time of Max Awake Interval following the most recent transition of the STA from Doze to Awake state as known at the transmitter.

Note: the most recent transition of the STA from Doze to Awake state is known by the transmitter because indicated by one of the following events:

— the time a PS-Poll or trigger frame is received by the transmitter STA, from the AP or Peer STA
— the start of a TWT for the receiver STA, as setup with the transmitter STA
— the start time of a slot in a RAW defined by the transmitter STA for the receiver STA.
— a (S)TBTT at which the STA shall receive a beacon

A transmitter S1G STA receiving an Activity Specification Element from an associated or peer receiver S1G STA shall not start the transmission of a PPDU intended for the receiver STA, or cause the receiver STA to transmit a PPDU, before a Recovery Time interval has expired since the STA last transitioned to Doze state, as known at the transmitter.

Note: the time the STA transitioned to Doze state is known at the transmitter as indicated by one of the following events

— the reception of an acknowledgment for a transmission to the receiver STA of a Buffered Unit sent in response to a PS-Poll
— the reception of an acknowledgment for the transmission to the receiver STA of a frame with EOSP field set to 1
— the end of Adjusted Wake Time for a TWT for the receiver STA, as setup with the transmitter STA
— the end time of a slot in a RAW for that STA defined by the transmitter STA for the receiver STA
— the end of transmission of a beacon that the STA is supposed to receive
— the end of transmission of group addressed BUs the STA is supposed to receive following a DTIM.

When the transmitter cannot complete frames exchanges within Max Awake Interval, a new back-off procedure is invoked after stopping the current transmission.

9.32q Flexible Multicast

MID is the AID that represents a group of S1G STAs. A MID corresponds to a bit in the traffic-indication virtual bitmap which corresponds to multicast traffic buffered for a group of S1G STAs in the BSS.

For example, if S1G AP has multicast data buffered for a group of SIG STAs, S1G AP may indicate it in segment count element (8.4.2.170c) in DTIM beacon first. The group of S1G STAs listen to the DTIM beacon to check whether S1G AP may have their buffered multicast data to deliver within current DTIM interval. If so, the group of S1G STAs will wake up later at the TIM interval assigned by S1G AP to check the TIM segment for their buffered multicast data. If S1G AP has multicast data to deliver for the group of S1G STAs, the group of S1G STAs will receive the multicast data at the assigned time slots.

The S1G STA with group MAC address can request MID from S1G AP through AID Switch Request frame. The S1G STAs with same group MAC address may prefer different multicast listen intervals (8.4.2.170d) due to different power constraints. Therefore, S1G AP should assign MID to a STA through AID Switch Response frame based on both group MAC address and multicast listen interval of the S1G STA. S1G AP may use different MIDs to represent one multicast group for different S1G STAs, and S1G STA should link the assigned MID to its group MAC address and multicast listen interval.

13 bits MID can be used in short MAC header (8.7.3.2) and as partial MID (9.17b (Group ID and partial AID in S1G PPDUs)).

9.32r OBSS Mitigation Procedure

To mitigate the interference between a 1MHz BSS, which has longer range and covers larger area, and one or more 2/4/8/16 MHz BSSs, which have shorter range and cover non-overlapping smaller areas, an STA in a 2/4/8/16 MHz BSSs may send a NDP ACK in response to a frame carried in an S1G PPDU in a narrower bandwidth. ie, the TXVECTOR parameter CH_BANDWIDTH of the STA is set to indicate a channel width that is less than the channel width indicated by the RXVECTOR parameter CH_BANDWIDTH of the frame eliciting the response.

10. MLME

Editor's Note: modifications based on 802.11REVmc 0.4

10.1 Synchronization

10.1.3 Maintaining synchronization

10.1.3.2 Beacon generation in infrastructure networks

Modify the first sentence and insert two sentences at the end of the first paragraph of 10.1.3.2 as follows:

A non-S1G AP or a S1G AP with do11ShortBeacon set to false ~~The AP~~ shall define the timing for the entire BSS by transmitting Beacon frames according to dot11BeaconPeriod. This defines a series of TBTTs exactly dot11BeaconPeriod TUs apart. Time 0 is defined to be a TBTT with the Beacon frame being a DTIM. At each TBTT, the AP shall schedule a Beacon frame as the next frame for transmission according to the medium access rules specified in Clause 9. The beacon period is included in Beacon and Probe Response frames, and a STA shall adopt that beacon period when joining the BSS, i.e., the STA sets its dot11BeaconPeriod variable to that beacon period.

A non-S1G AP shall not transmit Short Beacon frames.

The operation of an S1G AP with do11ShortBeacon set to true is defined in section 10.1.3.7a.1 (General)

Add a new subclause after clause 10.1.3.7:

10.1.3.7a Maintaining Synchronization with Short Beacon

10.1.3.7a.1 General

A S1G AP with do11ShortBeacon set to true shall send a Short Beacon frame at intervals given by the dot11ShortBeaconPeriod with the following exception: a Beacon may be sent instead of a Short Beacon in a Short Beacon Interval of a TSBTT that coincides with a TBTT. The timestamp of the Short Beacon is set to the 4 LSBs of the TSF timer at the time that the data symbol containing the first bit of the timestamp is transmitted. Note that an AP that has do11ShortBeacon set to true may use the procedures of clause 10.1.3.2 when transmitting a Short Beacon.

In a TBTT (that coincides with a TSBTT), where a Short Beacon is sent instead of a Beacon, the Short Beacon shall include a Short Beacon compatibility element and may include other elements that would have been included in a Beacon sent at a TBTT. An STA can reconstruct the 8 octet TSF at the AP by concatenating the 4 octet TSF completion field in the Short Beacon compatibility element with the Timestamp field in the Short Beacon.

10.1.3.7a.2 Generation of Short Beacon

Short Beacon may be transmitted in a BSS only. The use of a Short Beacon frame in an IBSS or MBSS is beyond scope. An AP may define the timing for the BSS by sending Short Beacon frames according to the dott11ShortBeaconPeriod. The value for the dot11ShortBeaconPeriod shall be such that dot11BeaconPeriod = n*dot11ShortBeaconPeriod, where n is an integer. This defines a series of TSBTTs exactly dot11ShortBeaconPeriod TUs apart. If n is larger than 1, the Time of Next TBTT Present field shall be set to

1 and the Next TBTT field shall be present in Short Beacon frames. Time 0 is defined to be a TBTT or TSBTT with the Beacon frame or Short Beacon frame being a DTIM.

10.1.3.7a.3 TSF timer accuracy with Short Beacon

Upon receiving a Short Beacon frame with a valid FCS and BSSID , a S1G STA shall update its TSF timer according to the following algorithm: the received timestamp value shall be adjusted by adding an amount equal to the receiving STA's delay through its local PHY components plus the time since the first bit of the timestamp was received at the MAC/PHY interface. The last 4 bytes of STA's TSF timer shall then be set to the adjusted value of the timestamp. The STA's TSF timer shall be set to the adjusted value of the received timestamp. The higher 4 bytes of the TSF shall be adjusted to account for roll over. The accuracy of the TSF timer shall be no worse than ±0.01%. with respect to the last 4 bytes of the TSF.

10.1.3.7a.4 Passive scanning with Short Beacon

If the ScanType parameter indicates a passive scan, the S1G STA shall listen to each channel scanned for no longer than a maximum duration defined by the MaxChannelTime parameter.

10.1.3.7a.5 Initializing a BSS using Short Beacon

In addition to the procedures described in Clause 10.1.4.4, upon receipt of an MLME-START request primitive, the STA shall select a short beacon period and send the Short Beacon.

10.1.3.7a.6 Terminating a BSS

An infrastructure BSS may be terminated at any time. In addition to procedures described in Clause 10.1.7, upon receipt of an MLME-STOP.request primitive, a S1G STA shall stop transmitting Short Beacon frames.

10.1.4 Acquiring synchronization, scanning

10.1.4.1 General

Insert the following paragraph after the 2nd paragraph of the sub-clause 10.1.4.1:

An S1G STA may use Short Probe Response frames as defined in 8.3.4.15c (Short Probe Response frame format) instead of Probe Response frames as defined in 8.3.3.10 (Probe Response frame format). Short Probe Response frame is used for reducing overhead of using long Probe Response frame in active scanning by optimizing the frame format and by allowing STA to request minimum information that is required for association with the responding STA to be included in the Short Probe Response frame.

Probe Response Option element defined in 8.4.2.170v (Probe Response Option element) is used by the requesting STA for indicating which optional information is requested to be included in the Short Probe Response frame that is transmitted by the responding STAs. A STA may include ProbeResponseOption in the MLME-SCAN.request primitive to include the Probe Response Option element in the Probe Request frame The requesting STA indicates the optional information to the responding STA by setting one or more bits in the Probe Response Option bitmaps in the Probe Response Option element transmitted in Probe Request frame as defined in Clause 8.4.2.170v (Probe Response Option element).

10.1.4.2 Passive scanning

10.1.4.3 Active scanning

10.1.4.3.1 Introduction

Modify the following paragraph of the sub-clause 10.1.4.3.1 as follows:

Active scanning involves the generation of Probe request frames and the subsequent processing of received probe responses. ~~Probe Response frames.~~ S1G STA may include Probe Response Option element in the Probe Request frame to indicate which optional information is requested to be included in the Short Probe Response frame. If the responding STA is an S1G STA and if it receives a Probe Request frame with Probe Response Option element, then Short Probe Response frame may be transmitted by the responding STA as a probe response. Otherwise, a Probe Response frame shall be transmitted by the responding STA as a probe response. The details of the active scanning procedures are as specified in the following subclauses.

10.1.4.3.2 Sending a probe response

Insert the following paragraph after the 4th paragraph of the sub-clause 10.1.4.3.2:

If the requesting STA is an S1G STA and a Probe Response Option element (see Clause 8.4.2.170v (Probe Response Option element)) is included in the Probe Request frame, and if the responding STA is an S1G STA and supports Short Probe Response, then the responding STA shall respond with Short Probe Response frame. If a bit in a Probe Response Option bitmap in the Probe Response Option element is set to 1, it means that corresponding optional information is requested by the requesting STA, and the responding STA shall include the corresponding information in the Short Probe Response frame if the STA supports it. If the Request full SSID bit in the Probe Response Option element is set to 1, then the responding STA shall include its full SSID in the Short Probe Response frame. If it is set to 0, then it shall include its compressed SSID instead of the full SSID.

Modify the following paragraph of the sub-clause 10.1.4.3.2 as follows:

Probe Response frames and Short Probe Response frames shall be sent as directed frames to the address of the STA that generated the probe request. The SSID List element shall not be included in a Probe Request frame in an IBSS.

TGah editor: Insert the following new sub-clause 10.1.4.3.4 after 10.1.4.3 as the following:

10.1.4.3.3 Active scanning for relay discovery

S1G STAs that are performing an active scan to discover an operating APs, or Relay APs may include the Relay Discovery element (see 8.4.2.170s (Relay Discovery element)) in the Probe Request frame. This element provides information on the single-hop direct path, and QoS criteria on the relay path.

The active scanning procedure for Relay AP is similar to the Active scanning procedure outlined in 10.1.4.3.3.

A Relay AP receiving Probe Request frames may respond with a Probe Response if the criteria outlined in 10.1.4.3.2 are met. A Relay AP also may not respond with a Probe Response if the QoS criteria on the relay path specified in the Relay Discovery element cannot be satisfied.

A Relay AP sending Probe Response frames may include the Relay Discovery element to carry link budget information between the Relay AP and root AP.

A S1G STA may use the information received from different Relay APs to determine a suitable Relay AP for association. The Relay AP selection is made by the S1G STA, and the specific selection procedure is up to the implementation.

TGah editor: Insert the following new sub-clause after 10.1.4.3 as the following:

10.1.4.3.4 NDP Probing

The NDP Probing is used to reduce the energy consumption during the scanning. Upon receipt of the MLME-SCAN.request primitive with ScanType indicating a NDP Probing, a STA for which dot11NDPProbingActivated is true shall transmit a NDP Probe Request frame that has either a compressed SSID or an access network option.

APs receiving a NDP Probe Request frames shall respond with a (short) Probe Response frame only if:

a) The compressed SSID in the NDP Probe Request frame is the specific compressed SSID of the AP.
b) The access network option in the NDP Probe Request frame is the access network option of the AP.

When an AP responses a (short) Probe Response frame, it shall perform the Basic Access procedure as defined in 9.3.4.2. Because a NDP Probe Request frame does not have a MAC Address of STA requesting a NDP Probing, a (short) Probe Response frame shall be broadcasted.

If PHY-CCA.indication (busy) primitive has not been detected before the ProbeTimer reaches MinChannelTime, then set NAV to 0 and scan the next channel. Else, if it receives (short) Probe Response frame, STA may transmit a Probe Request frame/Association Request frame or listen to full Beacon frame for obtaining the more information.

An illustration of the NDP probing procedure is shown in Figure 10-3a (NDP Probing Procedure).

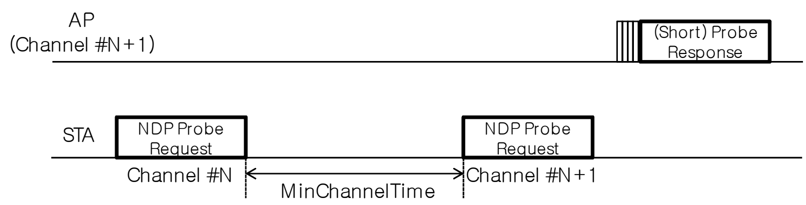

Figure 10-3a—NDP Probing Procedure

10.2 Power management

10.2.1 Power management in an infrastructure network

10.2.1.1 General

Modify the 3rd paragraph of subsection 10.2.1.1 as follows:

If any STA in its BSS is in PS mode, the AP shall buffer all group addressed BUs and deliver them to all STAs immediately following the next Beacon frame or Short Beacon frame containing a DTIM transmission.

Insert the following after the 4th paragraph of subsection 10.2.1.1:

When dot11S1GOptionImplemented is false, the traffic-indication virtual bitmap, maintained by the AP, shall be transmitted in a TIM element. When dot11S1GOptionImplemented is true, the traffic-indication virtual bitmap may be divided into more than one segment and each segment shall be transmitted in a TIM element.

Modify the 5th paragraph of subclause 10.2.1.1 as follows:

STAs operating in PS modes shall periodically listen for Beacon frames or Short Beacon frames, as determined by the STA's ListenInterval and the ReceiveDTIMs parameter in the MLME-POWERMGT.request primitive.

Add the following paragraphs after the last paragraph of subclause 10.2.1.1 as follows:

In a BSS with AP that has dot11ShortBeacon set to true, a Short Beacon may be sent or instead of a Beacon during at a TBTT that coincides with a TSBTT. All operations for power management at STAs in such a BSS shall use the information in the Short Beacon during a TBTT that has a Short Beacon only.

An S1G AP may change its Power Management mode as described in clause 10.2.1.19.

10.2.1.2 STA Power Management modes

Modify line 2 of Table 10-1 as follows:

PS	STA with dot11NonTIMModeActivated set to false listens to selected Beacon frames (based upon the ListenInterval parameter of the MLME-ASSOCIATE.request or MLME-REASSOCIATE.request primitive) and sends PS-Poll frames to the AP if the TIM element in the most recent Beacon frame or Short Beacon Frame indicates an individually addressed BU is buffered for that STA. STA with dot11NonTIMModeActivated set to true shall transmit at least one PS-Poll or trigger frame to the AP every listen interval without receiving a beacon frame (based upon the ListenInterval parameter of the MLME-ASSOCIATE.request or MLME-REASSOCIATE.request primitive). An S1G STA may send PS-Poll frames to an S1G AP regardless of whether individually addressed buffered BUs have been indicated by the S1G AP. The S1G STA is not required to listen to selected Beacons in this case. The AP shall transmit buffered individually addressed BUs to a PS STA only in response to a PS-Poll from that STA, during the CFP in the case of a CF-Pollable PS STA, or during a scheduled or unscheduled APSD service period for the STA. In PS mode, a STA shall be in the Doze state and shall enter the Awake state to receive selected Beacon or Short Beacon frames, to receive group addressed transmissions following certain received Beacon or Short Beacon frames, to transmit, and to await responses to transmitted PS-Poll frames or (for CF-Pollable STAs) to receive CF transmissions of buffered BUs.

Add the following paragraphs at the end of this sub-clause:

An S1G STA uses AC_VO to send PS-Poll frame as the default setting. The S1G AP shall inform the S1G STA of the access category specified in the PS-Poll AC subfield in the Control field in the EDCA Parameter Set element for sending PS-Poll frames at Beacon and Probe Response frames, over-writing the default value.

Upon receiving a PS-Poll, the S1G AP may use RTS/CTS protection scheme to send buffered data until no more data or TXOP limit which comes first. The RTS shall be regarded as the immediate acknowledgement to PS-Poll.

If dot11NonTIMOperationEnabled is true for S1G AP and a non-AP S1G STA, the AP and the STA shall inform each other their capability of supporting Non-TIM mode in association procedure with a non-TIM support field in Extended Capabilities element. The STA carries an Extended Capabilities element with the Non-TIM Support field in Association Request frame to inform the AP whether it supports Non-TIM mode or not. An AP operating as Sensor-Only BSS shall always allow the STA to enter non-TIM mode if it requests to. If the AP is not operating as Sensor-Only BSS, upon receiving the STA's Association Request frame with the Non-TIM Support field set to 1, the AP confirms the STA whether it allows the STA entering Non-TIM mode in Association Response frame using the Non-TIM support field. If the STA is not allowed to be in Non-TIM mode through negotiating by association procedure, the STA shall not work in Non-TIM mode. The AP may recommend a value of listen interval different from that in Association Request frame based on its buffer management consideration in Association Response frame.

10.2.1.3 AP TIM transmissions

10.2.1.4 TIM types

Modify the 3rd paragraph of subclause 10.2.1.4 as follows:

The AP shall transmit a TIM with every Beacon frame. Every dot11DTIMPeriod, a TIM of type DTIM is transmitted within a Beacon frame, rather than an ordinary TIM. In an AP with do11ShortBeaconInterval set to true, Short Beacon frames may include a TIM. Every dot11ShortBeaconDTIMPeriod, the AP shall transmit a TIM of type DTIM in the Short Beacon frame.

Add a sentence to the end of the 4th paragraph of 10.2.1.4 as follows:

…… some of which are DTIMs. Note that the second STA with ReceiveDTIMs equal to false does not power-on its receiver for all DTIMs. The details of Figure 10.4 also apply to the case of a Short Beacon Frame with TIM .

10.2.1.5 Power management with APSD

10.2.1.5.1 Power Management with APSD procedures

10.2.1.6 AP operation during the CP

Modify the paragraph c) as follows:

c) At every beacon interval, the AP shall assemble the partial virtual bitmap containing the buffer status per destination for STAs in the PS mode and shall send this out in the TIM field of the Beacon frame. At every beacon interval, the APSD-capable AP shall assemble the partial virtual bitmap containing the buffer status of nondelivery-enabled ACs (if there exists at least one nondeliveryenabled AC) per destination for STAs in PS mode and shall send this out in the TIM field of the Beacon frame. When all ACs are delivery-enabled, the APSD-capable AP shall assemble the partial virtual bitmap containing the buffer status for all ACs per destination. If FMS is enabled, the AP shall include the FMS Descriptor element in every Beacon frame. The FMS Descriptor element shall indicate all FMS group addressed frames that the AP buffers. The operation described in this paragraph shall also be performed for every short beacon interval where a TIM is received.

Modify the paragraph g) as follows:

g) A single buffered BU for a STA in the PS mode shall be forwarded to the STA after a PS-Poll has been received from that STA. For a STA using U-APSD, the AP transmits one BU destined for the STA from any AC that is not delivery-enabled in response to PS-Poll from the STA. When all ACs associated with the STA are delivery-enabled, AP transmits one BU from the highest priority AC. The AP can respond with either an immediate data or (#100)Management frame or with an (#190)ACK frame, while delaying the responding data or (#100)Management frame.

An S1G AP that sends an (NDP) ACK frame in response to a PS-Poll or NDP PS-Poll frame received from an S1G STA shall set the More Data subfield of the (NDP) ACK frame to 0 when no BU is buffered for the S1G STA and to 1 otherwise.

A More Data subfield equal to 0 in an (NDP) ACK frame that is sent by an S1G AP in response to a PS-Poll or NDP PS-Poll frame received from an S1G STA indicates to the S1G STA that no service period starts, which implies that the S1G STA may enter the doze state.

A More Data subfield equal to 1 in an (NDP) ACK frame that is sent by an S1G AP in response to a PS-Poll or NDP PS-Poll frame received from an S1G STA indicates to the S1G STA that a service period starts, after which the S1G STA shall remain in the wake state until a frame is received from the S1G AP with the EOSP subfield equal to 1. If the ACK with the More Data subfield equal to 1 is an NDP ACK with a Duration

Indication subfield equal to 1, the service period starts at a time T after the end of the NDP ACK frame, where T is the time value indicated in the Duration field of the NDP ACK; if the Duration Indication subfield is 0, the service period starts immediately after the end of the NDP ACK frame.

Modify the paragraph i) as follows:

i) If the AP does not receive an acknowledgment to an individually addressed data or bufferable management frame sent to a STA in PS mode following receipt of a PS-Poll from that STA, it may retransmit the frame for at most the lesser of the maximum retry limit and dot11QAPMissingAckRetryLimit times before the next Beacon frame or Short Beacon frame, but it shall retransmit that frame at least once before the next Beacon frame, time permitting and subject to its appropriate lifetime limit. If an acknowledgment to the retransmission is not received, it may wait until after the next Beacon frame or Short Beacon frame to further retransmit that frame subject to its appropriate lifetime limit.

10.2.1.7 AP operation during the CFP

10.2.1.8 Receive operation for STAs in PS mode during the CP

Change the first paragraph a) in subclause 10.2.1.8 as following:

a) The STA with dot11NonTIMModeActivated set to false shall wake up early enough to be able to receive the first Beacon frame scheduled for transmission at the time corresponding to the last TBTT plus the ListenInterval. The STA with dot11NonTIMModeActivated set to true is not required to wake up to receive a beacon frame and shall transmit at least one PS-Poll or trigger frame every listen interval.

10.2.1.9 Receive operation for STAs in PS mode during the CFP

Add a new item e) after the item d):

e) A S1G STA may enter the sleep state after receiving from an S1G AP, and in response to a PS-Poll frame sent to the S1G AP, an (NDP) ACK frame with the More Data subfield equal to 0.

Add a subclause 10.2.1.19 after 10.2.1.18 WNM-Sleep mode based on REVmc D1.1 as the following:

10.2.1.19 AP Power management

An S1G AP may operate in the following Power Management modes:

- Active
- Power save

An AP in Active mode shall be in Awake state and may receive frames at any time.

An AP in Power Save mode may be in any of the following two power states:

- Awake
- Doze

The AP may indicate it is operating in Power Save mode by:

- including an AP Power Management element in Beacon or Short Beacon frame with the PM Mode subfield set to 1;

— or including one or more RPS elements in Beacon or Short Beacon frame, with the AP PM field set to 1.

The AP shall operate in Active mode during a Beacon or short Beacon interval if the AP Power Management element is either absent in the Beacon or Short Beacon or the PM Mode subfield is set to 0. Similarly, the AP shall operate in Active mode during one or more RAWs defined by an RPS element with the AP PM field set to 0.

An AP including an AP Power Management element with the PM Mode subfield set to 1 in Beacon or Short Beacon frame may be in Doze state at any time, except that it shall be in Awake state during any of the following intervals of time:

— any RAW intervals that are setup according to 9.19.4a (Restricted Access Window (RAW) Operation), except for RAWs that are defined by any RPS element with AP PM field set to 1;
— any PRAW as defined in 9.19.4a.6 (Periodic RAW (PRAW) operation);
— starting at any TWT start time, and for the following Adjusted Minimum Awake Duration as described in 9.32f (Target Wake Time).

An AP may be in Doze state during the interval of time defined by any RPS element sent by the AP with AP PM field set to 1.

For operating in Doze state, AP shall indicate a RAW for other types of traffic (e.g., association and authentication frames).

Irrespective of the Power Management mode and Power States, an AP shall maintain the synchronization of the network by generating beacons as described in clause 10.1.3 (Maintaining synchronization).

10.3 STA authentication and association

10.3.5 Association, reassociation, and disassociation

Insert the new sub-clause after sub-clause 10.3.5.9 as follows:

10.3.5.9aService type indication during association

Different STAs may support different types of services, for example sensor services and offloading services. Different service types may have different requirements on QoS, packet size, duty circle etc. An AP can optimize the system operating parameters with the knowledge of service type of each STA.

A STA may indicate the AP its service type information during association by adding a service type field in the AID Request element in an Association Request frame or a Reassociation Request frame as described in 8.3.3.5 and 8.3.3.7.

10.3.6 Additional mechanisms for an AP collocated with a mesh STA

10.3.7 Authentication Control

In infrastructure mode, when dot11S1GOptionImplemented is true, AP and STA may use the Authentication Control element to alleviate media contention when a large number of STAs are trying or expected to send Authentication Request to the AP at the same time.

When dot11S1GAuthenticationControlActivated is true, AP is allowed to limit the number of STAs that can transmit Authentication Request to it by broadcasting the Authentication Control element in a beacon. AP can adjust the value of Authentication Control Threshold within the element from beacon to beacon.

A STA for which supports authentication control sets dot11S1GAuthenticationControlActivated to true and set dot11S1GAuthenticationControlPause to false when it is initialized.

When a STA for which dot11S1GAuthenticationControlActivated is true receives a beacon from the AP that the STA intends to join including an Authentication Control element, the behavior is TBD.

When a STA for which dot11AuthenticationControlActivated is true receives a beacon from an AP that it is intended to join does not include an Authentication Control element, it shall set dot11AuthenticationPause to false.

10.14 SA Query procedures

Insert the following paragraph at the end of the sub-clause 10.14 as the following:

If a S1G STA in a power save mode wakes up with an interval longer than dot11AssociationSAQueryMaximumTimeout, an existing SA can be destroyed. So, for maintaining its valid SA status, the S1G STA shall wake to listen to SA Query Request frame with the interval of dot11AssociationSAQueryMaximumTimeout. For this purpose, a S1G AP provides the Timeout Interval (Association Comeback time, which is set to dot11AssociationSAQueryMaximumTimeout) in an Association Response frame and Reassociation Response frame with a status code 0 to the S1G STA.

10.25 Quality-of-service management frame (QMF)

Editor's Note: 802.11af D3.0 ends at sub-clause 10.43.

Add the following new sub-clauses after subclause 10.43 as the following:

10.43a S1G 1/2/4/8/16 MHz Operation

When establishing a 2/4/8/16MHz BSS, the AP determines and announces the location of 1MHz primary channel located at either upper or lower side of the 2MHz primary channel.

A S1G STA that does not participate in the subchannel selective transmission protocol shall neither transmit nor be transmitted to, a 1 MHz non-duplicated PPDU on 1MHz subchannels other than the primary 1Mhz channel of a 2/4/8/16 MHz BSSs.

A non-duplicated 1MHz transmission from a STA that participates in the subchannel selective transmission protocol in a 4/8/16MHz BSS, shall use the same upper or lower 1MHz subchannel in any of the allowed 2MHz channel(s).

10.43b Dynamic AID assignment operation

Implementation of Dynamic AID assignment is optional for a STA. A STA that has a value of true for dot11DynamicAIDActivated is defined as a STA that supports Dynamic AID assignment. A STA for which dot11DynamicAIDActivated is true shall set the Dynamic AID field of the S1G Capabilities Info field in the S1G Capabilities element to 1.

When a traffic pattern or a remaining battery life is changed, a STA may change its wakeup interval. If a wakeup interval of a STA is changed, an AID of the STA should be updated to belong to AID segment of the new wakeup interval. When a STA has buffered frames for a peer non-AP STA, it may want to belong to the group of AIDs having the same TIM interval with the peer non-AP STA.

When dot11DynamicAIDActivated is true, a STA requesting a new wakeup interval transmits an AID Switch Request frame to an AP. After receiving the AID Switch Request frame, the AP responds with an AID Switch Response frame to the STA.

Also, AP can change the group of STA for load/traffic distribution of each group. For this or other unspecified purpose, an AP with dot11DynamicAIDActivated set to true can transmit an unsolicited AID Switch Response frame to STA.

When a STA dot11DynamicAIDActivated set to true switches TIM mode and non-TIM mode, the STA's AID is also changed. The STA transmits AID Switch Request frame to an AP to inform the switch between TIM and non-TIM mode. After receiving AID Switch Request frame, the AP shall transmit an AID Switch Response frame to the STA.

An illustration of the dynamic AID assignment is shown in Figure 10-39b (Illustration of dynamic AID assignment)

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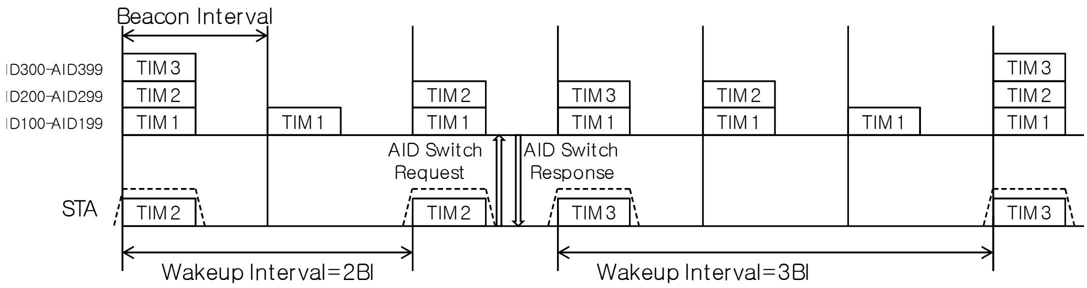


Figure 10-39b—Illustration of dynamic AID assignment

A STA may switch between a TIM mode and a non-TIM mode during operation.

If the mode switching is initiated by STA, when the STA switches between TIM mode and non-TIM mode, the STA should inform AP of its switching through AID Switch Request frame with B3 or B4 of AID Request IE set to 1.

Upon receiving AID Switch Request frame with B3 or B4 of AID Request IE set to 1, AP may reassign a new AID to the STA through AID Switch Response frame. The new AID is included in AID Response IE.

If the AID included in AID Response IE of AID Switch Response frame is the same as the STA's AID, the STA shall not change its AID. Otherwise, the STA shall use the AID included in AID Response IE as its AID.

When an AID of a non-AP STA is changed to another AID, if the STA has the direct connections with other STAs (e.g., TDLS/DLS), the STA shall send the STA Information Announcement frame (see8.5.23a.5) including an AID Announcement element to the peer STAs in order to inform the peer STAs of the updated AID information.

If a non-AP STA with direct connections receives the STA Information Announcement frame including an AID Announcement element from a peer STA, the non-AP STA updates the peer STA's AID to the received AID and sends the ACK frame after SIFS.

10.43c Short Beacon

10.43c.1 System information update procedure

The S1G AP with dot11ShortBeaconOptionImplemented set to true shall increase the value (modulo 256) of the Change Sequence field in the next transmitted Short Beacon frame(s) when a critical update occurs to any of the elements inside the Beacon frame. The following events shall classify as a critical update:

a) Inclusion of a Channel Switch Announcement

b) Inclusion of an Extended Channel Switch Announcement

c) Modification of the EDCA parameters

d) Modification of the S1G Operation element

An S1G AP may classify other changes in the Beacon frame as critical updates.

The S1G STA shall attempt to either receive the next Beacon frame or transmit a Probe Request frame when it receives a Change Sequence field that contains a value that is different from the previously received Change Sequence field. When a S1G STA transmits a Probe Request frame for obtaining the updated system information, it may include the Change Sequence field in the Probe Request frame for asking the optimized Probe Response frame.

When an S1G AP receives a probe request frame with a Change Sequence from a S1G STA associated with the S1G AP, it compares the value of received Change Sequence with the value of its current Change Sequence. If the value of the received Change Sequence is different from the value of the current Change Sequence, the S1G AP should send a compressed Probe Response frame which is a Probe Response frame including the Change Sequence element and only the elements that need be updated by the STA. If the S1G AP receives a Probe Request frame including a Change Sequence element with an invalid value which the AP does not store, the AP shall send a Probe Response frame as defined in 10.1.4.3.2 (Sending a probe response).

10.43d Non-TIM operation

If dot11S1GNonTIMOperationImplemented is true for a non-AP STA and if the STA does not need a TIM entry for the downlink signaling, then the STA shall indicate it in Association Request frames or Reassociation Request frames.

10.43e S1G BSS operation

10.43e.1 Basic S1G BSS functionality

Among all Sub 1GHz available channels, the new S1G BSS should select an idle channel which can help keep maximum number of available wider bandwidth channels after it is selected.

(Others TBD)

11. Security

Editor's Note: modifications based on 802.11REVmc D1.1

11.4.3.3.3 Construct AAD

Insert the following at the end of the sub-clause 11.4.3.3.3 as the following:

When dot11ShortMACHeaderImplemented is set to true, the format of the AAD of Short MAC Header is shown in Figure 11-18c (AAD construction of Short MAC Header).

	FC	A1	A2	A3	A4	SC
Octets:	2	6 or 2	6 or 2	6	6	2

Figure 11-18c—AAD construction of Short MAC Header

When dot11ShortMACHeaderImplemented is set to true, the length of the AAD of the AAD of Short MAC Header varies depending on the presence or absence of the A3 and A4 fields and is shown in Table 11-1 (AAD length of Short MAC Header).

Table 11-1—AAD length of Short MAC Header

A3 field	A4 field	AAD length (octets)
Absent	Absent	12
Present	Absent	18
Absent	Present	18
Present	Present	24

When dot11ShortMACHeaderImplemented is set to true, AAD construction of the AAD of Short MAC Header is performed as follows:

a) FC – MPDU Frame Control field, with
   1) Type bits (bits 2 3 4 5) in a Data MPDU masked to 0
   2) Power Management bit (bit 8) masked to 0
   3) More Data bit (bit 9) masked to 0
   4) Protected Frame bit (bit 10) always set to 1
   5) EOSP bit (bit 11) masked to 0
   6) Reserved bit (bit 12) masked to 0

b) A1 –MPDU Address 1 field.
   1) When the SID is present in A1 field and either the STA or its peer has the SPP A-MSDU Capable field equal to 0, bit 15 of SID is masked to 0 for the AAD calculation

c) A2 –MPDU Address 2 field.

1) When the SID is present in A2 field and either the STA or its peer has the SPP A-MSDU Capable field equal to 0, bit 15 of SID is masked to 0 for the AAD calculation

d) A3 –MPDU Address 3 field, if present.

e) A4 –MPDU Address 4 field, if present.

f) SC – MPDU Sequence Control field, with the Sequence Number subfield (bits 4–15 of the Sequence Control field) masked to 0. The Fragment Number subfield is not modified.

11.4.3.3.4 Construct CCM nonce

Modify Figure 11-19 and 2nd paragraph in the sub-clause 11.4.3.3.4 as the following:

	Nonce Flags	STA MAC Address identified by A2	PN
Octets:	1	6	6

Figure 11-19—Nonce construction

The Nonce field has an internal structure of Nonce Flags || STA MAC Address identified by A2 || PN ("||" is concatenation), where

— If the Type field of the Frame Control field is 10 (Data frame) and there is a QC field present in the MPDU header, bits 0 to 3 of the Priority subfield of the Nonce Flags field shall be set to the value of the QC TID (bits 0 to 3 of the QC field). If the Type field of the Frame Control field is 00 (Management frame), and the frame is a QMF, the Priority subfield of the Nonce Flags field shall be set to the value in the ACI subfield of the Sequence Number field. Otherwise, the Priority subfield of the Nonce Flags field shall be set to the fixed value 0.(11ae) If the Protocol Version field of the Frame Control field is 1, bits 1 to 3 of the Priority subfield shall be set to the value of the FC TID (bits 13-15 of the Frame Control field).

— When management frame protection is negotiated, the Management field of the Nonce Flags field shall be set to 1 if the Type field of the Frame Control field is 00 (Management frame); otherwise it is set to 0.

— Bits 5 to 7 of the Nonce Flags field are reserved and shall be set to 0 on transmission.

— STA MAC Address identified by ~~MPDU address~~ A2 field occupies octets 1–6. This shall be encoded with the octets ordered with STA MAC Address identified by A2 octet 0 at octet index 1 and STA MAC Address identified by A2 octet 5 at octet index 6.

— The PN field occupies octets 7–12. The octets of PN shall be ordered so that PN0 is at octet index 12 and PN5 is at octet index 7.

24. Sub 1 GHz (S1G) PHY specification

24.1 Introduction

24.1.1 Introduction to the S1G PHY

Clause 24 specifies the PHY entity for a S1G orthogonal frequency division multiplexing (OFDM) system.

The S1G PHY is based on the VHT PHY defined in Clause 22, which in turn are based on HT PHY defined in Clause 20 and the OFDM PHY defined in Clause 18. The S1G PHY defines MIMO-OFDM PHY in the sub-1GHz bands using narrower bandwidths than those in 2.4GHz and 5GHz bands, with maximum number of space-time streams supported being four, and with support for multi-user (MU) transmissions. An MU transmission supports up to four users with up to three space-time streams per user with the total number of space-time streams not exceeding four.

NOTE—A S1G SU PPDU includes individually addressed and group addressed transmissions.

The S1G PHY provides support for 1MHz, 2MHz, 4MHz, 8MHz and 16MHz contiguous channel widths. A tone spacing of 31.25 kHz is used in all the bandwidths.

Except 1MHz, the PPDUs with bandwidth 2MHz, 4MHz, 8MHz and 16MHz are in general modulated the same way as 20MHz, 40MHz, 80MHz and 160MHz contiguous mode as specified in clause 22, respectively, except with a 1/10 clock rate, referring to Clause 24-4 (Timing-related constants).

The S1G PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), 64-QAM and 256-QAM. Forward error correction (FEC) coding (convolutional or LDPC coding) is used with coding rates of 1/2, 2/3, 3/4 and 5/6.

A S1G Non-AP STA shall support the following Clause 24 features:

- 1MHz and 2MHz channel width
- 1MHz PPDU, 2MHz PPDU with short preamble
- Greater than or equal to 2MHz long format PPDU, if >2MHz channel width is supported
- Detect and decode SIG-A field of the greater than or equal to 2MHz long preamble.
- Single spatial stream MCS0 to 2, and MCS10 (for 1MHz PPDU only)
- Binary convolutional coding
- Normal Guard Interval
- Fixed Pilots

A S1G AP STA shall support the following Clause 24 features:

- 1MHz and 2MHz channel width
- 1MHz PPDU, 2MHz PPDU with short preamble
- Greater than or equal to 2MHz long format PPDU, if >2MHz channel width is supported

- Detect and decode SIG-A field of the greater than or equal to 2MHz long preamble.
- Single spatial stream MCS0 to 7, and MCS10 (for 1MHz PPDU only)
- Binary convolutional coding
- Normal Guard Interval
- Fixed Pilots

A S1G STA may support the following Clause 24 features:

- 2 or more spatial streams (transmit and receive)
- 2MHz, 4MHz, 8MHz and 16MHz PPDU with long preamble
- Beamforming sounding (by sending a S1G NDP)
- Respond to transmit beamforming sounding (provide compressed beamforming feedback)
- STBC (transmit and receive)
- LDPC (transmit and receive)
- S1G MU PPDUs (transmit and receive)
- Support for 4 MHz channel width
- Support for 8 MHz channel width
- Support for 16 MHz channel width
- S1G-MCSs 8 and 9 (transmit and receive)
- Short Guard Interval
- Travelling Pilots

24.1.2 Scope

24.1.3 S1G PHY functions

24.1.3.1 General

24.1.3.2 PHY management entity (PLME)

24.1.3.3 Service specification method

24.1.4 PPDU formats

The structure of the PPDU transmitted by an S1G STA is determined by the TXVECTOR parameters as defined in Table 24-1 (TXVECTOR and RXVECTOR parameters).

The FORMAT parameter determines the overall structure of the PPDU, and includes:

- S1G, defined for S1G non-duplicate PPDU
- S1G_DUP_2M, defined for S1G 2MHz Duplicated PPDU
- S1G_DUP_1M, defined for S1G 1MHz Duplicated PPDU

The CH_BANDWIDTH parameter and PREAMBLE_TYPE parameter determines the PPDU bandwidth and the preamble type (long preamble or short preamble), respectively.

- 1MHz format is used for 1MHz PPDU or 1MHz Duplicated PPDU, if (FORMAT=S1G and CH_BANDWIDTH=CBW1) or FORMAT=S1G_DUP_1M. Support for the 1MHz format is mandatory.
- Greater than or equal to 2MHz short format is used for 2MHz, 4MHz, 8MHz or 16MHz PPDU with short preamble format, if ((FORMAT=S1G and (CH_BANDWIDTH=CBW2 or CBW4 or CBW8 or CBW16)) or FORMAT=S1G_DUP_2M) and PREAMBLE_TYPE=S1G_SHORT_PREAMBLE. It is similar to the HT-greenfield format as in clause 20, which does not contain an omni-portion in the preamble. Support for the greater than or equal to 2MHz short format is mandatory.
- Greater than or equal to 2MHz long format is used for 2MHz, 4MHz, 8MHz or 16MHz PPDU with long preamble format, if ((FORMAT=S1G and (CH_BANDWIDTH=CBW2 or CBW4 or CBW8 or CBW16)) or FORMAT=S1G_DUP_2M) and PREAMBLE_TYPE=S1G_LONG_PREAMBLE. It is similar to the HT-mixed format as in clause 20, which contains an omni-portion in the preamble. Support for the greater than or equal to 2MHz long format is optional if a STA supports only 1MHz and 2MHz PPDUs, it is mandatory if a STA supports wider than 2MHz PPDUs. Any S1G STA shall support detecting and decoding up to the SIG-A field in the greater than or equal to 2MHz long format PPDUs.

A greater than or equal to 2MHz long format PPDU can be further categorized as an S1G SU PPDU or an S1G MU PPDU. A greater than or equal to 2MHz long format PPDU with MU_SU = MU is an S1G MU PPDU, otherwise it is an S1G SU PPDU. An S1G MU PPDU carries one or more PSDUs to one or more STAs. An 1MHz format PPDU or a greater than or equal to 2MHz short format PPDU is only used as an S1G SU PPDU.

24.2 S1G PHY service interface

24.2.1 Introduction

The PHY provides an interface to the MAC through an extension of the generic PHY service interface defined in 7.3.4 (Basic service and options). The interface includes TXVECTOR, RXVECTOR, and PHYCONFIG_VECTOR.

The TXVECTOR supplies the PHY with per-PPDU transmit parameters. Using the RXVECTOR, the PHY informs the MAC of the received PPDU parameters. Using the PHYCONFIG_VECTOR, the MAC configures the PHY for operation, independent of frame transmission or reception.

24.2.2 TXVECTOR and RXVECTOR parameters

The parameters in Table 24-1 (TXVECTOR and RXVECTOR parameters) are defined as part of the TXVECTOR parameter list in the PHY-TXSTART.request primitive and/or as part of the RXVECTOR parameter list in the PHY-RXSTART.indication primitive.

Table 24-1—TXVECTOR and RXVECTOR parameters

Parameter	Condition	Value	TXVECTOR	RXVECTOR
FORMAT		Determines the format of the PPDU. Enumerated type: S1G indicates S1G PPDU format. S1G_DUP_1M indicates S1G 1MHz Duplicate PPDU format S1G_DUP_2M indicates S1G 2MHz Duplicate PPDU format	Y	Y
PREAMBLE_TYPE	FORMAT is S1G and (CH_BANDWIDTH is CBW2 or CBW4 or CBW8 or CBW16)	Determine the type of preamble of the S1G PPDU. Enumerated type: S1G_SHORT_PREAMBLE indicates the short preamble defined in 24.3.8.2.1 (Short preamble). S1G_LONG_PREAMBLE indicates the long preamble defined in 24.3.8.2.2 (Long preamble).	Y	Y
	FORMAT is S1G_DUP_2M	Determine the type of preamble of the S1G 2MHz Duplicate mode PPDU. Enumerated type: S1G_SHORT_PREAMBLE indicates the short preamble defined in 24.3.8.2.1 (Short preamble). S1G_LONG_PREAMBLE indicates the long preamble defined in 24.3.8.2.2 (Long preamble).	Y	Y
	FORMAT is S1G and CH_BANDWIDTH equals CBW1	Not present	N	N
	FORMAT is S1G_DUP_1M	Not present	N	N
	Otherwise	See corresponding entry in Table 20-1.		
MU_SU	FORMAT is S1G and (CH_BANDWIDTH is CBW2 or CBW4 or CBW8 or CBW16)	Determine whether MU or SU of the S1G PPDU Enumerated type: Set to MU if NUM_USERS is 2 to 4. Set to SU if NUM_USERS is 1.	Y	Y
	FORMAT is S1G_DUP_2M	Determine whether MU or SU of the S1G PPDU Enumerated type: Set to MU if NUM_USERS is 2 to 4. Set to SU if NUM_USERS is 1.	Y	Y
	FORMAT is S1G and CH_BANDWIDTH equals CBW1	Set to SU.	Y	Y
	FORMAT is S1G_DUP_1M	Set to SU.	Y	Y
	Otherwise	Not present		

Table 24-1—TXVECTOR and RXVECTOR parameters

NDP_FRAME	FORMAT is S1G	Determine the type of S1G Frame. Set to 1 if this packet is one of NDP frames not for channel sounding as defined in 8.3.4a (NDP MAC frames). Set to 0 otherwise.	Y	Y
	FORMAT is S1G_DUP_1M	Determine the type of S1G 1MHz Duplicate Frame. Set to 1 if this packet is one of NDP duplicate frames not for channel sounding as defined in 8.3.4a (NDP MAC frames). Set to 0 otherwise.	Y	Y
	Otherwise	Not present Note) NDP Frame of the type of 2MHz Duplicate Frame is not allowed in the S1G PHY specification as described in 24.3.9.12.2 (2MHz duplicate transmission).	N	N
NDP_FRAME_CONTENTS	NDP_FRAME is 1	Determine the contents of S1G NDP MAC Frame. Set to concatenated bit fields for the SIG of the corresponding NDP MAC Frame as defined in 8.3.4a (NDP MAC frames).	Y	Y
	Otherwise	Not present		

Table 24-1—TXVECTOR and RXVECTOR parameters

SMOOTHING	FORMAT is S1G and (CH_BANDWIDTH equals CBW2 or CBW4 or CBW8 or CBW16) and PREAMBLE_TYPE equals S1G_SHORT_PREAMBLE	Indicates whether frequency-domain smoothing is recommended as part of channel estimation. Enumerated type: SMOOTHING_REC indicates that smoothing is recommended. SMOOTHING_NOT_REC indicates that smoothing is not recommended.	Y	Y
	FORMAT is S1G_DUP_2M and PREAMBLE_TYPE equals S1G_SHORT_PREAMBLE	Indicates whether frequency-domain smoothing is recommended as part of channel estimation. Enumerated type: SMOOTHING_REC indicates that smoothing is recommended. SMOOTHING_NOT_REC indicates that smoothing is not recommended.	Y	Y
	FORMAT is S1G_DUP_1M	Indicates whether frequency-domain smoothing is recommended as part of channel estimation. Enumerated type: SMOOTHING_REC indicates that smoothing is recommended. SMOOTHING_NOT_REC indicates that smoothing is not recommended.	Y	Y
	FORMAT is S1G and CH_BANDWIDTH equals CBW1	Indicates whether frequency-domain smoothing is recommended as part of channel estimation. Enumerated type: SMOOTHING_REC indicates that smoothing is recommended. SMOOTHING_NOT_REC indicates that smoothing is not recommended.	Y	N
	FORMAT is S1G and (CH_BANDWIDTH equals CBW2 or CBW4 or CBW8 or CBW16) and PREAMBLE_TYPE equals S1G_LONG_PREAMBLE	Not present	N	N
	FORMAT is S1G_DUP_2M and PREAMBLE_TYPE equals S1G_LONG_PREAMBLE	Not present	N	N
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		

Table 24-1—TXVECTOR and RXVECTOR parameters

AGGREGATION	FORMAT is S1G	Indicates whether the PSDU contains an A-MPDU. Enumerated type: AGGREGATED indicates this packet has A-MPDU aggregation. NOT_AGGREGATED indicates this packet does not have A-MPDU aggregation.	Y	Y
	FORMAT is S1G_DUP_2M	Indicates whether the PSDU contains an A-MPDU. Enumerated type: AGGREGATED indicates this packet has A-MPDU aggregation. NOT_AGGREGATED indicates this packet does not have A-MPDU aggregation.	Y	Y
	FORMAT is S1G_DUP_1M	Indicates whether the PSDU contains an A-MPDU. Enumerated type: AGGREGATED indicates this packet has A-MPDU aggregation. NOT_AGGREGATED indicates this packet does not have A-MPDU aggregation.	Y	Y
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		
N_TX	FORMAT is S1G	Indicates the number of transmit chains.	Y	N
	FORMAT is S1G_DUP_2M	Indicates the number of transmit chains.	Y	N
	FORMAT is S1G_DUP_1M	Indicates the number of transmit chains.	Y	N
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		
EXPANSION_MAT_TYPE	FORMAT is S1G and EXPANSION_MAT is present	Set to COMPRESSED_SV	Y	N
	FORMAT is S1G_DUP_2M and EXPANSION_MAT is present	Set to COMPRESSED_SV	Y	N
	FORMAT is S1G_DUP_1M and EXPANSION_MAT is present	Set to COMPRESSED_SV	Y	N
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		

Table 24-1—TXVECTOR and RXVECTOR parameters

EXPANSION_MAT	FORMAT is S1G	Contains a vector in the number of selected subcarriers containing feedback matrices as defined in 24.3.10.2 (Beamforming Feedback Matrix V) based on the channel measured during the training symbols of a previous S1G NDP PPDU.	MU	N
	FORMAT is S1G_DUP_2M	Contains a vector in the number of selected subcarriers containing feedback matrices as defined in 24.3.10.2 (Beamforming Feedback Matrix V) based on the channel measured during the training symbols of a previous S1G NDP PPDU.	MU	N
	FORMAT is S1G_DUP_1M	Contains a vector in the number of selected subcarriers containing feedback matrices as defined in 24.3.10.2 (Beamforming Feedback Matrix V) based on the channel measured during the training symbols of a previous S1G NDP PPDU.	Y	N
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		

Table 24-1—TXVECTOR and RXVECTOR parameters

CHAN_MAT_TYPE	FORMAT is S1G and LENGTH equals 0 and NDP_FRAME equals 0	Set to COMPRESSED_SV	N	Y
	FORMAT is S1G_DUP_2M and LENGTH equals 0 and NDP_FRAME equals 0	Set to COMPRESSED_SV	N	Y
	FORMAT is S1G_DUP_1M and LENGTH equals 0 and NDP_FRAME equals 0	Set to COMPRESSED_SV	N	Y
	FORMAT is S1G and LENGTH equals 0 and NDP_FRAME equals 1	Not present	N	N
	FORMAT is S1G_DUP_2M and LENGTH equals 0 and NDP_FRAME equals 1	Not present	N	N
	FORMAT is S1G_DUP_1M and LENGTH equals 0 and NDP_FRAME equals 1	Not present	N	N
	FORMAT is S1G and LENGTH is greater than 0	Not present	N	N
	FORMAT is S1G_DUP_2M and LENGTH is greater than 0	Not present	N	N
	FORMAT is S1G_DUP_1M and LENGTH is greater than 0	Not present	N	N
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		

Table 24-1—TXVECTOR and RXVECTOR parameters

CHAN_MAT	FORMAT is S1G and LENGTH equals 0 and NDP_FRAME equals 0	Contains a set of compressed beamforming feedback matrices as defined in 24.3.10.2 (Beamforming Feedback Matrix V) based on the channel measured during the training symbols of the received S1G NDP PPDU.	N	Y
	FORMAT is S1G_DUP_2M and LENGTH equals 0 and NDP_FRAME equals 0	Contains a set of compressed beamforming feedback matrices as defined in 24.3.10.2 (Beamforming Feedback Matrix V) based on the channel measured during the training symbols of the received S1G NDP PPDU.	N	Y
	FORMAT is S1G_DUP_1M and LENGTH equals 0 and NDP_FRAME equals 0	Contains a set of compressed beamforming feedback matrices as defined in 24.3.10.2 (Beamforming Feedback Matrix V) based on the channel measured during the training symbols of the received S1G NDP PPDU.	N	Y
	FORMAT is S1G and LENGTH equals 0 and NDP_FRAME equals 1	Not present	N	N
	FORMAT is S1G_DUP_2M and LENGTH equals 0 and NDP_FRAME equals 1	Not present	N	N
	FORMAT is S1G_DUP_1M and LENGTH equals 0 and NDP_FRAME equals 1	Not present	N	N
	FORMAT is S1G and LENGTH is greater than 0	Not present	N	N
	FORMAT is S1G_DUP_2M and LENGTH is greater than 0	Not present	N	N
	FORMAT is S1G_DUP_1M and LENGTH is greater than 0	Not present	N	N
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		

Table 24-1—TXVECTOR and RXVECTOR parameters

DELTA_SNR	FORMAT is S1G and MU_SU equals MU	Contains an array of delta SNR values as defined in 8.4.x.x (MU Exclusive Beamforming Report field) based on the channel measured during the training symbols of the received S1G NDP PPDU. NOTE—In the RXVECTOR this parameter is present only for S1G NDP PPDUs for MU sounding.	MU	Y
	FORMAT is S1G_DUP_2M and MU_SU equals MU	Contains an array of delta SNR values as defined in 8.4.x.x (MU Exclusive Beamforming Report field) based on the channel measured during the training symbols of the received S1G NDP PPDU. NOTE—In the RXVECTOR this parameter is present only for S1G NDP PPDUs for MU sounding.	MU	Y
	FORMAT is S1G and MU_SU equals SU	Not present	N	N
	FORMAT is S1G_DUP_2M and MU_SU equals SU	Not present	N	N
	FORMAT is S1G_DUP_1M	Not present	N	N
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		
RCPI		Is a measure of the received RF power averaged over all the receive chains in the Data field of a received PPDU. Refer to 20.3.21.6 (Received channel power indicator (RCPI) measurement) for the definition of RCPI.	N	Y
SNR	FORMAT is S1G	Contains an array of measures of the received SNR for each spatial stream. SNR indications of 8 bits are supported. SNR shall be the sum of the decibel values of SNR per tone divided by the number of tones represented in each stream as described in 8.4.1.48 (VHT Compressed Beamforming Report field)	N	Y
	FORMAT is S1G_DUP_2M	Contains an array of measures of the received SNR for each spatial stream. SNR indications of 8 bits are supported. SNR shall be the sum of the decibel values of SNR per tone divided by the number of tones represented in each stream as described in 8.4.1.48 (VHT Compressed Beamforming Report field)	N	Y
	FORMAT is S1G_DUP_1M	Contains an array of measures of the received SNR for each spatial stream. SNR indications of 8 bits are supported. SNR shall be the sum of the decibel values of SNR per tone divided by the number of tones represented in each stream as described in 8.4.1.48 (VHT Compressed Beamforming Report field)	N	Y
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		

Table 24-1—TXVECTOR and RXVECTOR parameters

FEC_CODING	FORMAT is S1G	Indicates which FEC encoding is used. Enumerated type: BCC_CODING indicates binary convolutional code. LDPC_CODING indicates low-density parity check code.	MU	Y
	FORMAT is S1G_DUP_2M	Indicates which FEC encoding is used. Enumerated type: BCC_CODING indicates binary convolutional code. LDPC_CODING indicates low-density parity check code.	MU	Y
	FORMAT is S1G_DUP_1M	Indicates which FEC encoding is used. Enumerated type: BCC_CODING indicates binary convolutional code. LDPC_CODING indicates low-density parity check code.	Y	Y
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		
STBC	FORMAT is S1G	Indicates whether or not STBC is used. 0 indicates no STBC (N_{STS}=N_{SS} in the Data field). 1 indicates STBC is used (N_{STS}=$2N_{SS}$ in the Data field).	Y	Y
	FORMAT is S1G_DUP_2M	Indicates whether or not STBC is used. 0 indicates no STBC (N_{STS}=N_{SS} in the Data field). 1 indicates STBC is used (N_{STS}=$2N_{SS}$ in the Data field).	Y	Y
	FORMAT is S1G_DUP_1M	Indicates whether or not STBC is used. 0 indicates no STBC (N_{STS}=N_{SS} in the Data field). 1 indicates STBC is used (N_{STS}=$2N_{SS}$ in the Data field).	Y	Y
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		
GI_TYPE	FORMAT is S1G	Indicates whether a short guard interval is used in the transmission of the Data field of the PPDU. Enumerated type: LONG_GI indicates short GI is not used in the Data field of the PPDU. SHORT_GI indicates short GI is used in the Data field of the PPDU.	Y	Y
	FORMAT is S1G_DUP_2M	Indicates whether a short guard interval is used in the transmission of the Data field of the PPDU. Enumerated type: LONG_GI indicates short GI is not used in the Data field of the PPDU. SHORT_GI indicates short GI is used in the Data field of the PPDU.	Y	Y
	FORMAT is S1G_DUP_1M	Indicates whether a short guard interval is used in the transmission of the Data field of the PPDU. Enumerated type: LONG_GI indicates short GI is not used in the Data field of the PPDU. SHORT_GI indicates short GI is used in the Data field of the PPDU.	Y	Y
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.	N	N

Table 24-1—TXVECTOR and RXVECTOR parameters

TXPWR_LEVEL	FORMAT is S1G	The allowed values for the TXPWR_LEVEL parameter are in the range from 1 to numberOfO-ctets(dot11TxPowerLevelExtended)/2. This parameter is used to indicate which of the available transmit output power levels defined in dot11TxPowerLevelExtended shall be used for the current transmission.	Y	N
	FORMAT is S1G_DUP_2M	The allowed values for the TXPWR_LEVEL parameter are in the range from 1 to numberOfOctets(dot11TxPowerLevelExtended)/2. This parameter is used to indicate which of the available transmit output power levels defined in dot11TxPowerLevelExtended shall be used for the current transmission.	Y	N
	FORMAT is S1G_DUP_1M	The allowed values for the TXPWR_LEVEL parameter are in the range from 1 to numberOfOctets(dot11TxPowerLevelExtended)/2. This parameter is used to indicate which of the available transmit output power levels defined in dot11TxPowerLevelExtended shall be used for the current transmission.	Y	N
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		
RSSI	FORMAT is S1G	The allowed values for the RSSI parameter are in the range 0 to 255 inclusive. This parameter is a measure by the PHY of the power observed at the antennas used to receive the current PPDU measured during the reception of the S1G-LTF field. RSSI is intended to be used in a relative manner, and it is a monotonically increasing function of the received power.	N	Y
	FORMAT is S1G_DUP_2M	The allowed values for the RSSI parameter are in the range 0 to 255 inclusive. This parameter is a measure by the PHY of the power observed at the antennas used to receive the current PPDU measured during the reception of the S1G-LTF field. RSSI is intended to be used in a relative manner, and it is a monotonically increasing function of the received power.	N	Y
	FORMAT is S1G_DUP_1M	The allowed values for the RSSI parameter are in the range 0 to 255 inclusive. This parameter is a measure by the PHY of the power observed at the antennas used to receive the current PPDU measured during the reception of the S1G-LTF field. RSSI is intended to be used in a relative manner, and it is a monotonically increasing function of the received power.	N	Y
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		

Table 24-1—TXVECTOR and RXVECTOR parameters

MCS	FORMAT is S1G and (CH_BANDWIDTH equals CBW2 or CBW4 or CBW8 or CBW16)	Indicates the modulation and coding scheme used in the transmission of the PPDU. Integer: range 0 to 9	MU	Y
	FORMAT is S1G_DUP_2M	Indicates the modulation and coding scheme used in the transmission of the PPDU. Integer: range 0 to 9	MU	Y
	FORMAT is S1G and CH_BANDWIDTH equals CBW1	Indicates the modulation and coding scheme used in the transmission of the PPDU. Integer: range 0 to 10	Y	Y
	FORMAT is S1G_DUP_1M	Indicates the modulation and coding scheme used in the transmission of the PPDU. Integer: range 0 to 10	Y	Y
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		
REC_MCS	FORMAT is S1G and (CH_BANDWIDTH equals CBW2 or CBW4 or CBW8 or CBW16)	Indicates the MCS that the STA's receiver recommends. Integer: range 0 to 9	N	O
	FORMAT is S1G_DUP_2M	Indicates the MCS that the STA's receiver recommends. Integer: range 0 to 9	N	O
	FORMAT is S1G and CH_BANDWIDTH equals CBW1	Indicates the MCS that the STA's receiver recommends. Integer: range 0 to 10	N	O
	FORMAT is S1G_DUP_1M	Indicates the MCS that the STA's receiver recommends. Integer: range 0 to 10	N	O
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		

Table 24-1—TXVECTOR and RXVECTOR parameters

CH_BANDWIDTH	FORMAT is S1G	Indicates the channel width of the transmitted PPDU: Enumerated type: CBW1 for 1 MHz CBW2 for 2 MHz CBW4 for 4 MHz CBW8 for 8 MHz CBW16 for 16 MHz	Y	Y
	FORMAT is S1G_DUP_2M	In TXVECTOR, indicates the channel width of the transmitted 2MHz Duplicate PPDU. In RXVECTOR, indicates the estimated channel width of the 2MHz Duplicate received PPDU. Enumerated type: CBW2 for 2 MHz CBW4 for 4 MHz CBW8 for 8 MHz CBW16 for 16 MHz	Y	Y
	FORMAT is S1G_DUP_1M	In TXVECTOR, indicates the channel width of the transmitted 1MHz Duplicate PPDU. In RXVECTOR, indicates the estimated channel width of the 1MHz Duplicate received PPDU. Enumerated type: CBW1 for 1MHz CBW2 for 2 MHz CBW4 for 4 MHz CBW8 for 8 MHz CBW16 for 16 MHz	Y	Y
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		

Table 24-1—TXVECTOR and RXVECTOR parameters

LENGTH	FORMAT is S1G and AGGREGATION is AGGREGATED	Indicates the packet duration in number of symbols in the S1G PSDU.	Y	Y
	FORMAT is S1G_DUP_2M and AGGREGATION is AGGREGATED	Indicates the packet duration in number of symbols in the S1G 2MHz Duplicate PSDU.	Y	Y
	FORMAT is S1G_DUP_1M and AGGREGATION is AGGREGATED	Indicates the packet duration in number of symbols in the S1G 1MHz Duplicate PSDU.	Y	Y
	FORMAT is S1G and AGGREGATION is NOT_AGGREGATED	Indicates the packet duration in number of octets in the S1G PSDU.	Y	Y
	FORMAT is S1G_DUP_2M and AGGREGATION is AGGREGATED	Indicates the packet duration in number of symbols in the S1G 2MHz Duplicate PSDU.	Y	Y
	FORMAT is S1G_DUP_1M and AGGREGATION is AGGREGATED	Indicates the packet duration in number of symbols in the S1G 1MHz Duplicate PSDU.	Y	Y
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		
PSDU_LENGTH	FORMAT is S1G	Indicates the number of octets in the S1G PSDU. A value of 0 indicates an S1G NDP PPDU	Y	Y
	FORMAT is S1G_DUP_2M	Indicates the number of octets in the S1G 2MHz Duplicate PSDU. A value of 0 indicates an S1G NDP PPDU.	Y	Y
	FORMAT is S1G_DUP_1M	Indicates the number of octets in the S1G 1MHz Duplicate PSDU. A value of 0 indicates an S1G NDP PPDU.	Y	Y
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		

Table 24-1—TXVECTOR and RXVECTOR parameters

NUM_STS	FORMAT is S1G	Indicates the number of space-time streams. Integer: range 1-4 per user in the TXVECTOR and 0-4 in the RXVECTOR. NUM_STS summed over all users is in the range 1 to 4 for MU-MIMO.	MU	Y
	FORMAT is S1G_DUP_2M	Indicates the number of space-time streams. Integer: range 1-4 per user in the TXVECTOR and 0-4 in the RXVECTOR. NUM_STS summed over all users is in the range 1 to 4 for MU-MIMO.	MU	Y
	FORMAT is S1G_DUP_1M	Indicates the number of space-time streams. Integer: range 1-4 per user in the TXVECTOR and 0-4 in the RXVECTOR.	Y	Y
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		
GROUP_ID	FORMAT is S1G and MU_SU equals MU	Indicates the group ID. Integer: range 0-63 (see Table 24-15 (Fields in the SIG-A field of long preamble MU PPDU)))	Y	Y
	FORMAT is S1G_DUP_2M and MU_SU equals MU	Indicates the group ID. Integer: range 0-63 (see Table 24-15 (Fields in the SIG-A field of long preamble MU PPDU)))	Y	Y
	FORMAT is S1G and MU_SU equals SU	Not present	N	N
	FORMAT is S1G_DUP_2M and MU_SU equals SU	Not present	N	N
	FORMAT is S1G and CH_BANDWIDTH equals CBW1	Not present	N	N
	FORMAT is S1G_DUP_1M	Not present	N	N
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		

Table 24-1—TXVECTOR and RXVECTOR parameters

PARTIAL_AID	FORMAT is S1G and MU_SU equals SU	Provides an abbreviated indication of the intended recipient(s) of the PSDU (see 9.17b (Group ID and partial AID in S1G PPDUs)). Integer: range 0-511.	Y	Y
	FORMAT is S1G_DUP_2M and MU_SU equals SU	Provides an abbreviated indication of the intended recipient(s) of the PSDU (see 9.17b (Group ID and partial AID in S1G PPDUs)). Integer: range 0-511.	Y	Y
	FORMAT is S1G and MU_SU equals MU	Not present	N	N
	FORMAT is S1G_DUP_2M and MU_SU equals MU	Not present	N	N
	FORMAT is S1G and CH_BANDWIDTH equals CBW1	Not present	N	N
	FORMAT is S1G_DUP_1M	Not present	N	N
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		
NUM_USERS	FORMAT is S1G and MU_SU equals MU	Indicates the number of users with non-zero space-time streams. Integer: range 2 to 4.	Y	N
	FORMAT is S1G and MU_SU equals SU	Set to 1	Y	N
	FORMAT is S1G_DUP_2M and MU_SU equals MU	Indicates the number of users with non-zero space-time streams. Integer: range 2 to 4.	Y	N
	FORMAT is S1G_DUP_2M and MU_SU equals SU	Set to 1	Y	N
	FORMAT is SIG and CH_BANDWIDTH equals CBW1	Set to 1	Y	N
	FORMAT is S1G_DUP_1M	Set to 1	Y	N
	Otherwise	See corresponding entry in Table 20-1 and Table 22-1.		

Table 24-1—TXVECTOR and RXVECTOR parameters

BEAM_CHANGE	FORMAT is S1G and MU_SU equals SU and (CH_BANDWIDTH equals CBW2 or CBW4 or CBW8 or CBW16) and PREAMBLE_TYPE equals S1G_LONG_PREAMBL	Set to 1 if Q matrix is changed as described in 24.3.8.2.2.1.4 (SIG-A definition). Set to 0 otherwise. NOTE—If BEAM_CHANGE is 0 and PREAMBLE_TYPE is S1G_LONG_PREAMBLE, the receiver may do channel smoothing. Otherwise, smoothing is not recommended.	Y	O
	FORMAT is S1G_DUP_2M and MU_SU equals SU and PREAMBLE_TYPE equals S1G_LONG_PREAMBL E	Set to 1 if Q matrix is changed as described in 24.x.x. Set to 0 otherwise. NOTE—If BEAM_CHANGE is 0 and PREAMBLE_TYPE is S1G_LONG_PREAMBLE, the receiver may do channel smoothing. Otherwise, smoothing is not recommended.	Y	O
	Otherwise	Not present	N	N
ACK_INDICATION	FORMAT is S1G	Set to 0 if ACK. Set to 1 if Block ACK. Set to 2 if No ACK. Set to 3 otherwise.	Y	Y
	FORMAT is S1G_DUP_2M	Set to 0 if ACK. Set to 1 if Block ACK. Set to 2 if No ACK. Set to 3 otherwise.	Y	Y
	FORMAT is S1G_DUP_1M	Set to 0 if ACK. Set to 1 if Block ACK. Set to 2 if No ACK. Set to 3 otherwise.	Y	Y
	Otherwise	Not present	N	N
DOPPLER	FORMAT is S1G	Set to 1 if traveling pilots are used in the packet. Set to 0 otherwise.	Y	O
	FORMAT is S1G_DUP_2M	Set to 1 if traveling pilots are used in the packet. Set to 0 otherwise.	Y	O
	FORMAT is S1G_DUP_1M	Set to 1 if traveling pilots are used in the packet. Set to 0 otherwise.	Y	O
	Otherwise	Not present	N	N
TIME_OF_DEPARTU RE_REQUESTED		Boolean value: True indicates that the MAC entity requests that the PHY entity measures and reports time of departure parameters corresponding to the time when the first PPDU energy is sent by the transmitting port. False indicates that the MAC entity requests that the PHY entity neither measures nor reports time of departure parameters.	O	N

Table 24-1—TXVECTOR and RXVECTOR parameters

RX_START_OF_FRAME_OFFSET	dot11MgmtOptionTimingMsmtActivated is true	0 to 2^{32}– 1. An estimate of the offset (in 10 ns units) from the point in time at which the start of the preamble corresponding to the incoming frame arrived at the receive antenna port to the point in time at which this primitive is issued to the MAC.	N	Y
	Otherwise	Not present		

NOTE 1—In the "TXVECTOR" and "RXVECTOR" columns, the following apply:
Y = Present;
N = Not present;
O = Optional;
MU indicates that the parameter is present once for an S1G SU PPDU and present per user for an S1G MU PPDU. Parameters specified to be present per user are conceptually supplied as an array of values indexed by *u*, where *u* takes values 0 to NUM_USERS-1.

24.2.3 Effect of CH_BANDWIDTH parameter on PPDU format

Table 24-2 (PPDU format as a function of CH_BANDWIDTH parameter) shows the PPDU format as a function of the CH_BANDWIDTH parameter.

Table 24-2—PPDU format as a function of CH_BANDWIDTH parameter

FORMAT	CH_BANDWIDTH	PPDU format
S1G	CBW1	The STA transmits an S1G PPDU of 1 MHz bandwidth. If the operating channel width is wider than 1 MHz, then the transmission shall use the primary 1 MHz channel.
S1G	CBW2	The STA transmits an S1G PPDU of 2 MHz bandwidth. If the operating channel width is wider than 2 MHz, then the transmission shall use the primary 2 MHz channel.
S1G	CBW4	The STA transmits an S1G PPDU of 4 MHz bandwidth. If the operating channel width is wider than 4 MHz, then the transmission shall use the primary 4 MHz channel.

Table 24-2—PPDU format as a function of CH_BANDWIDTH parameter

S1G	CBW8	The STA transmits an S1G PPDU of 8 MHz bandwidth. If the operating channel width is wider than 8 MHz, then the transmission shall use the primary 8 MHz channel.
S1G	CBW16	The STA transmits an S1G PPDU of 16 MHz bandwidth.
S1G_DUP_2M	CBW2	The STA transmits a S1G 2 MHz Duplicate PPDU using the primary 2 MHz channel as defined in 24.3.9.12.2 (2MHz duplicate transmission).
S1G_DUP_2M	CBW4	The STA transmits an S1G 2 MHz Duplicate PPDU using two adjacent 2 MHz channels as defined in 24.3.9.12.2 (2MHz duplicate transmission). If the operating channel width is wider than 4 MHz, then the transmission shall use the primary 4 MHz channel. The one 2 MHz channel higher in frequency is rotated +90º relative to the 2 MHz channel lowest in frequency as defined in Equation (24-6).
S1G_DUP_2M	CBW8	The STA transmits an S1G 2 MHz Duplicate PPDU using four adjacent 2 MHz channels as defined in 24.3.9.12.2 (2MHz duplicate transmission). If the BSS operating channel width is 16 MHz, then the transmission shall use the primary 8 MHz channel. The three 2 MHz channels higher in frequency are rotated +180º relative to the 2 MHz channel lowest in frequency as defined in Equation (24-7).
S1G_DUP_2M	CBW16	The STA transmits an S1G 2 MHz Duplicate PPDU using eight adjacent 2 MHz channels as defined in 24.3.9.12.2 (2MHz duplicate transmission). The second, third, fourth, sixth, seventh and eighth 2 MHz channels in the order of increasing frequency are rotated +180º relative to the 2 MHz channel lowest in frequency as defined in Equation (24-8).
S1G_DUP_1M	CBW1	The STA transmits a S1G 1 MHz Duplicate PPDU using the primary 1 MHz channel as defined in 24.3.9.12.1 (1MHz duplicate transmission).
S1G_DUP_1M	CBW2	The STA transmits an S1G 1 MHz Duplicate PPDU using two adjacent 1 MHz channels as defined in 24.3.9.12.1 (1MHz duplicate transmission). If the operating channel width is wider than 2 MHz, then the transmission shall use the primary 2 MHz channel. Phase rotation per each 1MHz channel is TBD as defined in Equation (24-9).

Table 24-2—PPDU format as a function of CH_BANDWIDTH parameter

S1G_DUP_1M	CBW4	The STA transmits an S1G 1 MHz Duplicate PPDU using four adjacent 1 MHz channels as defined in 24.3.9.12.1 (1MHz duplicate transmission). If the operating channel width is wider than 4 MHz, then the transmission shall use the primary 4 MHz channel. Phase rotation per each 1MHz channel is TBD as defined in Equation (24-10).
S1G_DUP_1M	CBW8	The STA transmits an S1G 1 MHz Duplicate PPDU using eight adjacent 1 MHz channels as defined in 24.3.9.12.1 (1MHz duplicate transmission). If the BSS operating channel width is 16 MHz, then the transmission shall use the primary 8 MHz channel. Phase rotation per each 1MHz channel is TBD as defined in Equation (24-11).
S1G_DUP_1M	CBW16	The STA transmits an S1G 1 MHz Duplicate PPDU using sixteen adjacent 1 MHz channels as defined in 24.3.9.12.1 (1MHz duplicate transmission). Phase rotation per each 1MHz channel is TBD as defined in Equation (24-12).

24.3 S1G PLCP sublayer

24.3.1 Introduction

24.3.2 S1G PPDU format

Three formats are defined for the S1G PLCP: greater than or equal to 2MHz short format, greater than or equal to 2MHz long format, and 1MHz format.

The general structure for greater than or equal to 2MHz short format is defined as in Figure 24-20 (S1G greater than or equal to 2 MHz short format). This format is used for SU transmission using 2MHz, 4MHz, 8MHz and 16MHz PPDUs.

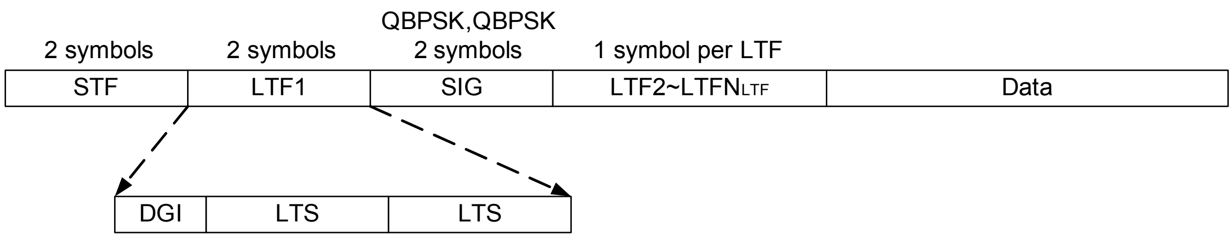


Figure 24-20—S1G greater than or equal to 2 MHz short format

The general structure for greater than or equal to 2MHz long format is defined as in Figure 24-21 (S1G greater than or equal to 2MHz long format). This frame format can be used for MU and SU beamformed transmissions using 2MHz, 4MHz, 8MHz and 16MHz PPDUs.

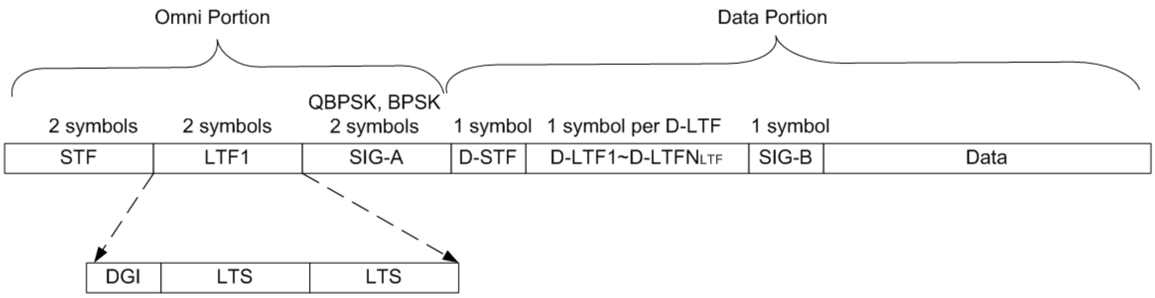


Figure 24-21—S1G greater than or equal to 2MHz long format

The general structure for 1MHz format is defined as in Figure 24-22 (S1G 1MHz format). This frame format is used for 1MHz PPDU SU transmission.

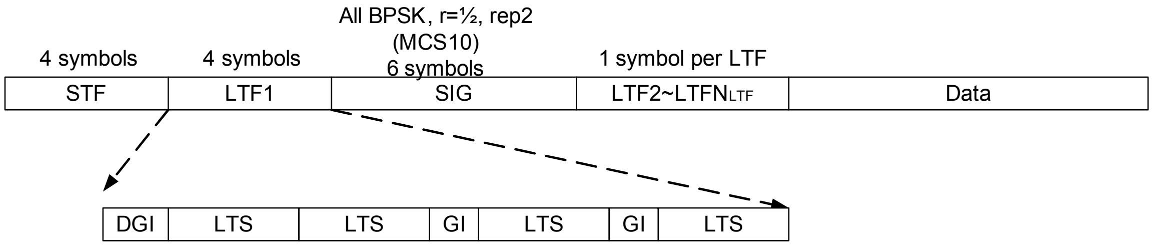


Figure 24-22—S1G 1MHz format

The fields of the S1G PPDU formats are summarized in Table 24-3 (Fields of the S1G PPDU).

Table 24-3—Fields of the S1G PPDU

Field	Description
STF	Short Training field
LTF	Long Training field
SIG	SIGNAL field
SIG-A	Signal A field
D-STF	Short Training field for data
D-LTF	Long Training field for data
SIG-B	Signal B field
Data	The Data field carries the PSDU(s)

The SIG-A, D-STF, D-LTF, and SIG-B fields exist only in S1G greater than or equal to 2MHz long format. In a S1G NDP, the Data field is not present. The number of symbols in the LTF field of 1MHz format and greater than or equal to 2MHz short format, or in the D-LTF field of greater than or equal to 2MHz long format, N_{VHTLTF}, can be either 1, 2, or 4 and is determined by the total number of space-time streams across all users being transmitted in the S1G PPDU (see Table 24-10 (Number of LTFs required for different numbers of space time streams)).

24.3.3 Transmitter block diagram

Each field in a S1G PPDU can be generated using a subset of the following blocks (only select blocks are listed below):

a) PHY Padding
b) Scrambler
c) BCC encoder parser
d) FEC (BCC or LDPC) encoders
e) Stream parser
f) Segment parser (for 16 MHz)
g) BCC Interleaver
h) Replicate the encoded bits (for 1MHz MCS10)
i) Constellation mapper
j) Pilot insertion
k) Replicate over multiple 1 MHz or 2MHz
l) Multiply by 1st column of P_{HTLTF}
m) LDPC tone mapper
n) Segment deparser
o) Space time block code (STBC) encoder
p) Cyclic shift diversity (CSD) per STS insertion
q) Spatial mapper
r) Inverse discrete Fourier transform (IDFT)
s) Cyclic shift diversity (CSD) per chain insertion
t) Guard interval (GI) insertion
u) Windowing

The general transmission flow for S1G 1MHz non-repetition MCSs, and all the MCSs for greater than or equal to 2MHz short and long formats are the same as the corresponding portions in clause 22.3 (VHT PHY layer).

Specifically, Figure 22-5, with “20MHz” replaced by “2MHz”, shows the transmit process for the SIG-A field of a S1G PPDU in greater than or equal to 2MHz long format. These transmit blocks are also used to generate the omni portion of the S1G greater than or equal to 2MHz long format PPDU, except that the BCC encoder and interleaver are not used when generating the STF and LTF1 fields.

Figure 22-6 and Figure 22-7, with “20MHz” replaced by “2MHz”, show the transmit process for generating the SIG-B field of a S1G PPDU in greater than or equal to 2MHz long format, for S1G SU PPDU and S1G MU PPDU, respectively.

Figure 22-8 shows the transmitter blocks used to generate the BCC encoded Data field of a 2MHz, 4MHz and 8MHz SU PPDU in short or long format, and of a 1MHz PPDU except MCS10. A subset of these transmitter blocks consisting of the constellation mapper and CSD blocks, as well as the blocks to the right of, and including, the spatial mapping block, are also used to generate the STF and LTF fields in 1MHz format and greater than or equal to 2MHz short format, or the D-STF and D-LTF fields in greater than or equal to 2MHz long format. This is illustrated in Figure 24-25 (Generation of LTF symbols) in subclause 24.3.8.2.1.3 (LTF definition) for the mentioned LTF fields. A similar set of transmit blocks is used to generate the mentioned STF fields.

Figure 22-9 shows the transmitter blocks used to generate the LDPC encoded Data field of a 2MHz, 4MHz and 8MHz SU PPDU in short or long format, and of a 1MHz PPDU except MCS10.

Figure 22-10 shows the transmit process for generating the Data field of a 2MHz, 4MHz and 8MHz MU PPDU in long format with BCC and/or LDPC encoding.

Figure 22-11 and Figure 22-12 show the transmit process for generating the Data field of a 16 MHz SU PPDU in short or long format, with BCC and LDPC encoding, respectively.

Figure 24-23 (Transmitter block diagram for the Data field of a 1MHz S1G PPDU with BCC or LDPC encoding and MCS10) below shows the transmit process for generating the Data field of a 1MHz PPDU with MCS10, either BCC or LDPC encoded.

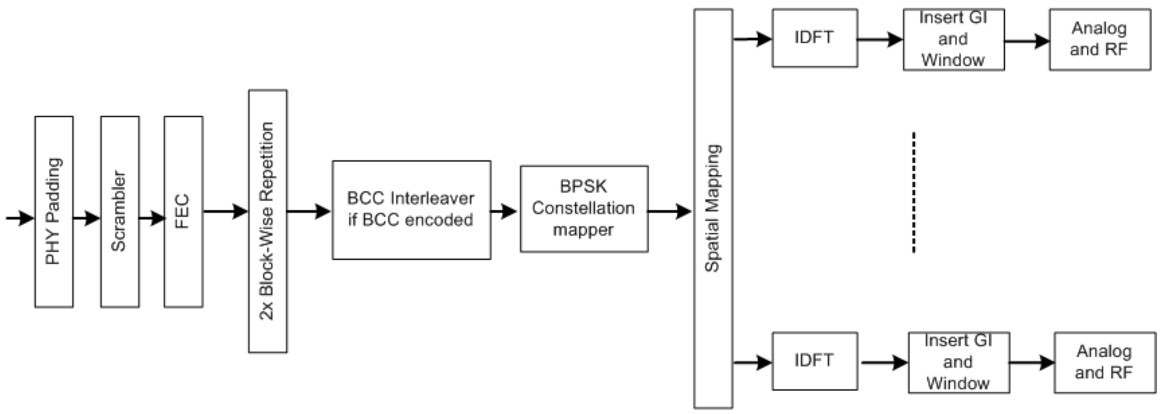


Figure 24-23—Transmitter block diagram for the Data field of a 1MHz S1G PPDU with BCC or LDPC encoding and MCS10

24.3.4 Overview of the PPDU encoding process

24.3.4.1 General

This subclause provides an overview of the S1G PPDU encoding process.

24.3.4.2 Construction of the Preamble part in an S1G PPDU (greater than or equal to 2MHz, long preamble)

24.3.4.2.1 Construction of STF

Construct the STF field as defined in 24.3.8.2.1.2 (STF definition) with the following highlights:

a) Determine the CH_BANDWIDTH from the TXVECTOR.

b) Sequence generation: Generate the STF sequence over the CH_BANDWIDTH as described in 24.3.8.2.2.1.2 (STF definition).

c) Phase rotation: Apply appropriate phase rotation for each 2 MHz subchannel as described in 24.3.9.11 (OFDM modulation), 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

d) IDFT: Compute the inverse discrete Fourier transform.

e) CSD: Apply CSD for each transmit chain and frequency segment as described in 24.3.8.2.2.1.1 (Cyclic shift for S1G modulated fields).

f) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 24.3.7 (Mathematical description of signals).

g) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.2.2 Construction of the LTF1

Construct the LTF1 field as defined in 24.3.8.2.1.3 (LTF definition) with the following highlights:

a) Determine the CH_BANDWIDTH from the TXVECTOR.

b) Sequence generation: Generate the LTF1 sequence over the CH_BANDWIDTH as described in 24.3.8.2.1.3 (LTF definition).

c) Phase rotation: Apply appropriate phase rotation for each 2 MHz subchannel as described in 24.3.9.11 (OFDM modulation), 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

d) IDFT: Compute the inverse discrete Fourier transform.

e) CSD: Apply CSD for each transmit chain and frequency segment as described in 24.3.8.2.2.1.1 (Cyclic shift for S1G modulated fields).

f) Insert GI and apply windowing: Prepend a GI (2 x LONG_GI) and apply windowing as described in 24.3.7 (Mathematical description of signals).

g) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.2.3 Construction of SIG-A

The SIG-A field consists of two symbols, SIG-A1 and SIG-A2, as defined in 24.3.8.2.2.1.4 (SIG-A definition) and is constructed as follows:

a) Obtain the CH_BANDWIDTH, STBC, MU_SU, GROUP_ID (MU only), PARTIAL_AID (SU only), NUM_STS, GI_TYPE, FEC_CODING, MCS (SU only), NUM_USERS, LENGTH, AGGREGATION (SU only), ACK_INDICATION, BEAM_CHANGE (SU only) and DOPPLER from the TXVECTOR. Add the reserved bits, append the calculated 4 bit CRC, then append the N_{tail} tail bits as shown in 24.3.8.2.2.1.4 (SIG-A definition). This results in 48 uncoded bits.

b) BCC encoder: Encode the data by a convolutional encoder at the rate of R=1/2 as described in 18.3.5.6 (Convolutional encoder).

c) BCC interleaver: Interleave as described in 18.3.5.7 (Data interleaving).

d) Constellation mapper: QBPSK modulate the first 48 interleaved bits by rotating by 90° counter-clockwise relative to the original BPSK as described in 24.3.8.2.2.1.4 (SIG-A definition) to form the first symbol of SIG-A. BPSK modulate the second 48 interleaved bits to form the second symbol of SIG-A.

e) Pilot insertion: Insert pilots as described in 18.3.5.10 (OFDM modulation).

f) Duplication and phase rotation: Duplicate SIG-A1 and SIG-A2 over each 2 MHz of the CH_BANDWIDTH. Apply the appropriate phase rotation for each 2 MHz subchannel as described in 24.3.9.11 (OFDM modulation), 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

g) IDFT: Compute the inverse discrete Fourier transform.

h) CSD: Apply CSD for each transmit chain as described in 24.3.8.2.2.1.1 (Cyclic shift for S1G modulated fields).

i) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions).

j) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.2.4 Construction of D-STF

The D-STF field is defined in 24.3.8.2.2.2.2 (D-STF definition) and constructed as follows:

a) Sequence generation: Generate the D-STF in the frequency-domain over the bandwidth indicated by CH_BANDWIDTH as described in 24.3.8.2.2.2.2 (D-STF definition).

b) Phase rotation: Apply appropriate phase rotation for each 2 MHz subchannel as described in 24.3.9.11 (OFDM modulation), 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

c) CSD: Apply CSD for each space-time stream and frequency segment as described in 24.3.8.2.2.1.1 (Cyclic shift for S1G modulated fields).

d) Spatial mapping: Apply the *Q* matrix as described in 24.3.10 (SU-MIMO and DL-MU-MIMO Beamforming).

e) IDFT: Compute the inverse discrete Fourier transform.

f) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions).

g) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.2.5 Construction of D-LTF

The D-LTF field is defined in 24.3.8.2.2.2.3 (D-LTF definition) and constructed as follows:

a) Sequence generation: Generate the D-LTF sequence in the frequency-domain over the bandwidth indicated by CH_BANDWIDTH as described in 24.3.8.2.2.2.3 (D-LTF definition).

b) Phase rotation: Apply appropriate phase rotation for each 2 MHz subchannel as described in 24.3.9.11 (OFDM modulation), 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

c) $A_{D\text{-}LTF}$ matrix mapping: Apply the $P_{D\text{-}LTF}$ matrix to the D-LTF sequence and apply the $R_{D\text{-}LTF}$ matrix to the pilot tones as described in 24.3.8.2.2.2.3 (D-LTF definition).

d) CSD: Apply CSD for each space-time stream and frequency segment as described in 24.3.8.2.2.1.1 (Cyclic shift for S1G modulated fields).

e) Spatial mapping: Apply the Q matrix as described in 24.3.10 (SU-MIMO and DL-MU-MIMO Beamforming).

f) IDFT: Compute the inverse discrete Fourier transform.

g) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions).

h) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.2.6 Construction of SIG-B

The SIG-B field is constructed per-user as follows:

a) Obtain the MCS (for MU only) from the TXVECTOR.

b) SIG-B bits: Set the MCS (for MU only) as described in 24.3.8.2.2.2.4 (SIG-B definition). Add the reserved bits and N_{tail} bits of tail.

c) SIG-B Bit Repetition: Repeat the SIG-B bits as a function of CH_BANDWIDTH as defined in 24.3.8.2.2.2.4 (SIG-B definition).

d) BCC encoder: Encode the SIG-B field using BCC at rate R=1/2 as described in 18.3.5.6 (Convolutional encoder).

e) BCC interleaver: Interleave as described in 24.3.9.8 (BCC interleaver).

f) Constellation mapper: Map to a BPSK constellation as defined in 18.3.5.8 (Subcarrier modulation mapping).

g) Pilot insertion: Insert pilots following the steps described in 24.3.9.10 (Pilot subcarriers).

h) $P_{D\text{-}LTF}$ matrix mapping: Apply the mapping of the 1st column of the $P_{D\text{-}LTF}$ matrix to the data subcarriers as described in 24.3.8.2.2.2.4 (SIG-B definition). The total number of data and pilot subcarriers is the same as in the Data field.

i) CSD: Apply CSD for each space-time stream and frequency segment as described in 24.3.8.2.2.1.1 (Cyclic shift for S1G modulated fields).

j) Spatial mapping: Apply the Q matrix as described in 24.3.10 (SU-MIMO and DL-MU-MIMO Beamforming).

k) Phase rotation: Apply the appropriate phase rotations for each 2 MHz subchannel as described in 24.3.9.11 (OFDM modulation), 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

l) IDFT: Compute the inverse discrete Fourier transform.

m) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions).

n) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.3 Construction of the Preamble part in an S1G PPDU (greater than or equal to 2MHz, short preamble)

24.3.4.3.1 Construction of STF

The STF field is defined in 24.3.8.2.1.2 (STF definition) and constructed as follows:

a) Determine the CH_BANDWIDTH from the TXVECTOR.

b) Sequence generation: Generate the STF in the frequency-domain over the bandwidth indicated by CH_BANDWIDTH as described in 24.3.8.2.1.2 (STF definition).

c) Phase rotation: Apply appropriate phase rotation for each 2 MHz subchannel as described in 24.3.9.11 (OFDM modulation), 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

d) P_{LTF} matrix mapping: Apply the mapping of the first column of the P_{LTF} matrix to the STF sequence as described in 24.3.8.2.1.3 (LTF definition).

e) CSD: Apply CSD for each space-time stream and frequency segment as described in 24.3.8.2.1.1 (Cyclic shift for S1G modulated fields).

f) Spatial mapping: Apply the Q matrix as described in 24.3.10 (SU-MIMO and DL-MU-MIMO Beamforming).

g) IDFT: Compute the inverse discrete Fourier transform.

h) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions).

i) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.3.2 Construction of LTF1

The LTF1 field is defined in 24.3.8.2.1.3 (LTF definition) and constructed as follows:

a) Sequence generation: Generate the LTF1 sequence in the frequency-domain over the bandwidth indicated by CH_BANDWIDTH as described in 24.3.8.2.1.3 (LTF definition).

b) Phase rotation: Apply appropriate phase rotation for each 2 MHz subchannel as described in 24.3.9.11 (OFDM modulation), 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

c) A_{LTF} matrix mapping: Apply the mapping of the first column of the P_{LTF} matrix to the LTF1 sequence and apply the first column of R_{LTF} matrix to the pilot tones as described in 24.3.8.2.1.3 (LTF definition).

d) CSD: Apply CSD for each space-time stream and frequency segment as described in 24.3.8.2.1.1 (Cyclic shift for S1G modulated fields).

e) Spatial mapping: Apply the Q matrix as described in 24.3.10 (SU-MIMO and DL-MU-MIMO Beamforming).

f) IDFT: Compute the inverse discrete Fourier transform.

g) Insert GI and apply windowing: Prepend a GI (2 x LONG_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions).

h) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.3.3 Construction of SIG

The SIG field is constructed per-user as follows:

a) Obtain the CH_BANDWIDTH, STBC, PARTIAL_AID, NUM_STS, GI_TYPE, FEC_CODING, MCS, SMOOTHONG, NUM_USERS, LENGTH, AGGREGATION, ACK_INDICATION, NDP_FRAME and DOPPLER from the TXVECTOR. Add the reserved bits, append the calculated 4 bit CRC, then append the N_{tail} tail bits as shown in 24.3.8.2.1.4 (SIG definition). This results in 48 uncoded bits.

b) BCC encoder: Encode the data by a convolutional encoder at the rate of R=1/2 as described in 18.3.5.6 (Convolutional encoder).

c) BCC interleaver: Interleave as described in 18.3.5.7 (Data interleaving).

d) Constellation mapper: QBPSK modulate the first 48 interleaved bits as described in 18.3.5.8 (Subcarrier modulation mapping) to form the first symbol of SIG. QBPSK modulate the second 48 interleaved bits to form the second symbol of SIG.

e) Pilot insertion: Insert pilots as described in 18.3.5.10 (OFDM modulation).

f) P_{LTF} matrix mapping: Apply the mapping of the 1st column of the P_{LTF} matrix to the data subcarriers as described in 24.3.8.2.1.4 (SIG definition).

g) CSD: Apply CSD for each space-time stream and frequency segment as described in 24.3.8.2.1.1 (Cyclic shift for S1G modulated fields).

h) Spatial mapping: Apply the Q matrix as described in 24.3.10 (SU-MIMO and DL-MU-MIMO Beamforming).

i) Duplication and phase rotation: Duplicate two symbols of SIG over each 2 MHz of the CH_BANDWIDTH. Apply the appropriate phase rotation for each 2 MHz subchannel as described in 24.3.9.11 (OFDM modulation), 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

j) IDFT: Compute the inverse discrete Fourier transform.

k) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in

l) 18.3.2.5 (Mathematical conventions in the signal descriptions).

m) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.3.4 Construction of LTF2-LTFNLTF

The LTF2-LTFNLTF field is defined in 24.3.8.2.1.3 (LTF definition) and constructed as follows:

a) Sequence generation: Generate the LTF2-LTFNLTF sequence in the frequency-domain over the bandwidth indicated by CH_BANDWIDTH as described in 24.3.8.2.1.3 (LTF definition).

b) Phase rotation: Apply appropriate phase rotation for each 2 MHz subchannel as described in 24.3.9.11 (OFDM modulation), 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

c) A_{LTF} matrix mapping: Apply the mapping of the P_{LTF} matrix (from the 2nd column to the last column) to the LTF2-LTFNLTF sequence and apply the mapping of the R_{LTF} matrix (from the 2nd column to the last column) to the pilot tones as described in 24.3.8.2.1.3 (LTF definition).

d) CSD: Apply CSD for each space-time stream and frequency segment as described in 24.3.8.2.1.1 (Cyclic shift for S1G modulated fields).

e) Spatial mapping: Apply the Q matrix as described in 24.3.10 (SU-MIMO and DL-MU-MIMO Beamforming).

f) IDFT: Compute the inverse discrete Fourier transform.

g) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions).

h) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.4 Construction of the Preamble part in an S1G PPDU (1MHz)

24.3.4.4.1 Construction of 1MHz STF

The 1MHz STF field is defined in 24.3.8.3.2 (STF definition) and constructed as follows:

a) Determine the CH_BANDWIDTH from the TXVECTOR if 1MHz Duplicate PPDU.

b) Sequence generation: Generate the 1MHz STF in the frequency-domain over the bandwidth indicated by CH_BANDWIDTH as described in 24.3.8.3.2 (STF definition). Apply the 3dB power boosting if the MCS from the TXVECTOR equals MCS10.

c) Phase rotation: Apply appropriate phase rotation for each 1 MHz subchannel if 1MHz Duplicate PPDU as described in 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

d) $P_{1MHz\text{-}LTF}$ matrix mapping: Apply the mapping of the first column of the $P_{1MHz\text{-}LTF}$ matrix to the 1MHz STF sequence as described in 24.3.8.3.3 (LTF definition).

e) CSD: Apply CSD for each space-time stream and frequency segment as described in 24.3.8.3.1 (Cyclic shift for S1G modulated fields).

f) Spatial mapping: Apply the Q matrix as described in 24.3.10 (SU-MIMO and DL-MU-MIMO Beamforming).

g) IDFT: Compute the inverse discrete Fourier transform.

h) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions).

i) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.4.2 Construction of 1MHz LTF1

The 1MHz LTF1 field is defined in 24.3.8.3.3 (LTF definition) and constructed as follows:

a) Sequence generation: Generate the 1MHz LTF1 sequence in the frequency-domain over the bandwidth indicated by CH_BANDWIDTH as described in 24.3.8.3.3 (LTF definition).

b) Phase rotation: Apply appropriate phase rotation for each 1 MHz subchannel if 1MHz Duplicate PPDU as described in 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

c) $A_{1MHz\text{-}LTF}$ matrix mapping: Apply the mapping of the first column of the $P_{1MHz\text{-}LTF}$ matrix to the 1MHz LTF1 sequence and apply the first column of $R_{1MHz\text{-}LTF}$ matrix to the pilot tones as described in 24.3.8.3.3 (LTF definition).

d) CSD: Apply CSD for each space-time stream and frequency segment as described in 24.3.8.3.1 (Cyclic shift for S1G modulated fields).

e) Spatial mapping: Apply the Q matrix as described in 24.3.10 (SU-MIMO and DL-MU-MIMO Beamforming).

f) IDFT: Compute the inverse discrete Fourier transform.

g) Insert GI and apply windowing: Prepend a GI (2 x LONG_GI) for the first two symbols and insert a GI (LONG_GI) per each subsequent symbol. Apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions).

h) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.4.3 Construction of 1MHz SIG

The SIG field is constructed per-user as follows:

a) Obtain the STBC, NUM_STS, GI_TYPE, FEC_CODING, MCS, SMOOTHONG, LENGTH, AGGREGATION, ACK_INDICATION, NDP_FRAME and DOPPLER from the TXVECTOR. Add the reserved bits, append the calculated 4 bit CRC, then append the N_{tail} tail bits as shown in 24.3.8.3.4 (SIG definition). This results in 36 uncoded bits.

b) BCC encoder: Encode the data by a convolutional encoder at the rate of R=1/2 as described in 18.3.5.6 (Convolutional encoder) and apply the block-wise 2 times repetition on a per-OFDM symbol basis.

c) BCC interleaver: Interleave as described in 18.3.5.7 (Data interleaving).

d) Constellation mapper: BPSK modulate the interleaved bits as described in 18.3.5.8 (Subcarrier modulation mapping) to form the 6 symbols of SIG.

e) Pilot insertion: Insert pilots as described in 18.3.5.10 (OFDM modulation).

f) $P_{1MHz\text{-}LTF}$ matrix mapping: Apply the mapping of the 1st column of the $P_{1MHz\text{-}LTF}$ matrix to the data subcarriers as described in 24.3.8.3.4 (SIG definition).

g) CSD: Apply CSD for each space-time stream and frequency segment as described in 24.3.8.3.1 (Cyclic shift for S1G modulated fields).

h) Spatial mapping: Apply the Q matrix as described in 24.3.10 (SU-MIMO and DL-MU-MIMO Beamforming).

i) Duplication and phase rotation: Duplicate 6 symbols of SIG over each 1 MHz of the CH_BANDWIDTH if 1MHz Duplicate PPDU. Apply the appropriate phase rotation for each 1 MHz subchannel as described in if 1MHz Duplicate PPDU as described in 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

j) IDFT: Compute the inverse discrete Fourier transform.

k) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in

l) 18.3.2.5 (Mathematical conventions in the signal descriptions).

m) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.4.4 Construction of 1MHz LTF2-LTFNLTF

The 1MHz LTF2-LTFNLTF field is defined in 24.3.8.3.3 (LTF definition) and constructed as follows:

a) Sequence generation: Generate the 1MHz LTF2-LTFNLTF sequence in the frequency-domain over the bandwidth indicated by CH_BANDWIDTH as described in 24.3.8.3.3 (LTF definition).

b) Phase rotation: Apply appropriate phase rotation for each 1 MHz subchannel as described in 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals) if 1MHz Duplicate PPDU.

c) $A_{1MHz\text{-}LTF}$ matrix mapping: Apply the mapping of the $P_{1MHz\text{-}LTF}$ matrix (from the 2nd column to the last column) to the 1MHz LTF2-LTFN_{LTF} sequence and apply the mapping of the $R_{1MHz\text{-}LTF}$ matrix (from the 2nd column to the last column) to the pilot tones as described in 24.3.8.3.3 (LTF definition).

d) CSD: Apply CSD for each space-time stream and frequency segment as described in 24.3.8.3.1 (Cyclic shift for S1G modulated fields).

e) Spatial mapping: Apply the *Q* matrix as described in 24.3.10 (SU-MIMO and DL-MU-MIMO Beamforming).

f) IDFT: Compute the inverse discrete Fourier transform.

g) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions).

h) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.5 Construction of the Data field in an S1G SU PPDU

24.3.4.5.1 Using BCC

The construction of the Data field in an S1G SU PPDU with BCC encoding proceeds as follows:

a) SERVICE field: Generate the SERVICE field as described in 24.3.9.2 (SERVICE field) and append the PSDU to the SERVICE field.

b) PHY padding: Append the PHY pad bits to the PSDU.

c) Scrambler: Scramble the PHY padded data.

d) BCC encoder: Divide the scrambled bits between the encoders by sending bits to different encoders in a round robin manner. The number of encoders is determined by rate-dependent parameters described in 24.5 (Parameters for S1G-MCSs). BCC encode as described in 24.3.9.4.2 (BCC encoder parsing operation) and 24.3.9.4.3 (Binary convolutional coding and puncturing).

e) Stream parser: Rearrange the output of the BCC encoders into blocks as described in 24.3.9.6 (Stream parser).

f) Segment parser (if needed): For a contiguous 16 MHz transmission, divide the output bits of each stream parser into two frequency subblocks as described in 24.3.9.7 (Segment parser). This block is bypassed for 1 MHz, 2 MHz, 4 MHz and 8 MHz S1G PPDU transmissions.

g) BCC interleaver: Interleave as described in 24.3.9.8 (BCC interleaver).

h) Constellation mapper: Map to BPSK, QPSK, 16-QAM, 64-QAM or 256-QAM constellation points as described in 24.3.9.9 (Constellation mapping).

i) Segment deparser (if needed): For a contiguous 16 MHz transmission, merge the two frequency subblocks into one frequency segment as described in 24.3.9.9.3 (Segment deparser). This block is bypassed for 1 MHz, 2 MHz, 4 MHz, 8 MHz S1G PPDU transmissions.

j) STBC: Apply STBC as described in 24.3.9.9.4 (Space-time block coding).

k) Pilot insertion: Insert pilots following the steps described in 24.3.9.10 (Pilot subcarriers).

l) CSD: Apply CSD for each space-time stream and frequency segment as described in 24.3.8.2.1.1 (Cyclic shift for S1G modulated fields) if 2MHz short preamble is used, 24.3.8.2.2.2.1 (Cyclic shift for S1G modulated fields) if 2MHz long preamble is used and 24.3.8.3.1 (Cyclic shift for S1G modulated fields) if 1MHz preamble is used.

m) Spatial mapping: Apply the *Q* matrix as described in 24.3.10 (SU-MIMO and DL-MU-MIMO Beamforming).

n) Phase rotation: Apply the appropriate phase rotations for each 2 MHz subchannel if 2 MHz preamble is used or for each 1 MHz subchannel if 1 MHz Duplicate PPDU as described in 24.3.9.11 (OFDM modulation), 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

o) IDFT: Compute the inverse discrete Fourier transform.

p) Insert GI and apply windowing: Prepend a GI (SHORT_GI or LONG_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions). Note that SHORT_GI can be applied since the 2nd symbol of data field.

q) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.5.2 Using LDPC

The construction of the Data field in an S1G SU PPDU with LDPC encoding proceeds as follows:

a) SERVICE field: Generate the SERVICE field as described in 24.3.9.2 (SERVICE field) and append the PSDU to the SERVICE field.

b) PHY padding: Append the PHY pad bits to the PSDU.

c) Scrambler: Scramble the PHY padded data.

d) LDPC encoder: The scrambled bits are encoded using the LDPC code with the LENGTH from the TXVECTOR as described in 24.3.9.4.4 (LDPC coding).

e) Stream parser: The output of the LDPC encoder is rearranged into blocks as described in 24.3.9.6 (Stream parser).

f) Segment parser (if needed): For a contiguous 16 MHz transmission, divide the output bits of each stream parser into two frequency subblocks as described in 24.3.9.7 (Segment parser). This block is bypassed for 1 MHz, 2 MHz, 4 MHz and 8 MHz S1G PPDU transmissions.

g) Constellation mapper: Map to BPSK, QPSK, 16-QAM, 64-QAM or 256-QAM constellation points as described in.24.3.9.9 (Constellation mapping).

h) LDPC tone mapper: The LDPC tone mapping shall be performed on all LDPC encoded streams as described in 24.3.9.9.2 (LDPC tone mapping). LDPC tone mapper is bypassed for 1MHz transmission.

i) Segment deparser (if needed): For a contiguous 16 MHz transmission, merge the two frequency subblocks into one frequency segment as described in 24.3.9.9.3 (Segment deparser). This block is bypassed for 1 MHz, 2 MHz, 4 MHz and 8 MHz S1G PPDU transmissions.

j) STBC: Apply STBC as described in 24.3.9.9.4 (Space-time block coding).

k) Pilot insertion: Insert pilots following the steps described in 24.3.9.10 (Pilot subcarriers).

l) CSD: Apply CSD for each space-time stream and frequency segment as described in 24.3.8.2.1.1 (Cyclic shift for S1G modulated fields) if 2MHz short preamble is used, 24.3.8.2.2.2.1 (Cyclic shift for S1G modulated fields) if 2 MHz long preamble is used and 24.3.8.3.1 (Cyclic shift for S1G modulated fields) if 1 MHz preamble is used.

m) Spatial mapping: Apply the Q matrix as described in 24.3.10 (SU-MIMO and DL-MU-MIMO Beamforming).

n) Phase rotation: Apply the appropriate phase rotations for each 2 MHz subchannel if 2 MHz preamble is used or for each 1 MHz subchannel if 1 MHz Duplicate PPDU as described in 24.3.9.11 (OFDM modulation), 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

o) IDFT: Compute the inverse discrete Fourier transform.

p) Insert GI and apply windowing: Prepend a GI (SHORT_GI or LONG_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions). Note that SHORT_GI can be applied since the 2nd symbol of data field.

q) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.6 Construction of the Data field in an S1G SU PPDU (1MHz MCS0 rep2 mode)

24.3.4.6.1 Using BCC

The construction of the Data field in an S1G SU PPDU (1MHz MCS0 rep2 mode) with BCC encoding proceeds as follows:

a) SERVICE field: Generate the SERVICE field as described in 24.3.9.2 (SERVICE field) and append the PSDU to the SERVICE field.

b) PHY padding: Append the PHY pad bits to the PSDU.

c) Scrambler: Scramble the PHY padded data.

d) BCC encoder: BCC encode as described in 24.3.9.4.2 (BCC encoder parsing operation) and 24.3.9.4.3 (Binary convolutional coding and puncturing).

e) Block repetition: Apply the block-wise 2 times repetition on a per-OFDM symbol basis as described in 24.3.9.5 (Repetition for 1MHz MCS10).

f) Segment parser (if needed): For a contiguous 16 MHz transmission, divide the output bits of each stream parser into two frequency subblocks as described in 24.3.9.7 (Segment parser). This block is bypassed for 1 MHz, 2 MHz, 4 MHz and 8 MHz S1G PPDU transmissions.

g) BCC interleaver: Interleave as described in 24.3.9.8 (BCC interleaver).

h) Constellation mapper: Map to BPSK constellation points as described in 24.3.9.9 (Constellation mapping).

i) Segment deparser (if needed): For a contiguous 16 MHz transmission, merge the two frequency subblocks into one frequency segment as described in 24.3.9.9.3 (Segment deparser). This block is bypassed for 1 MHz, 2 MHz, 4 MHz and 8 MHz S1G PPDU transmissions.

j) Pilot insertion: Insert pilots following the steps described in 24.3.9.10 (Pilot subcarriers).

k) CSD: Apply CSD for each space-time stream and frequency segment as described in 24.3.8.3.1 (Cyclic shift for S1G modulated fields).

l) Spatial mapping: Apply the Q matrix as described in 24.3.10 (SU-MIMO and DL-MU-MIMO Beamforming).

m) Phase rotation: Apply the appropriate phase rotations for each 1 MHz subchannel if 1 MHz Duplicate PPDU as described in 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

n) IDFT: Compute the inverse discrete Fourier transform.

o) Insert GI and apply windowing: Prepend a GI (SHORT_GI or LONG_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions). Note that SHORT_GI can be applied since the 2nd symbol of data field.

p) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.6.2 Using LDPC

The construction of the Data field in an S1G SU PPDU (1MHz MCS0 rep2 mode) with LDPC encoding proceeds as follows:

a) SERVICE field: Generate the SERVICE field as described in 24.3.9.2 (SERVICE field) and append the PSDU to the SERVICE field.

b) PHY padding: Append the PHY pad bits to the PSDU.

c) Scrambler: Scramble the PHY padded data.

d) LDPC encoder: The scrambled bits are encoded using the LDPC code with the LENGTH from the TXVECTOR as described in 24.3.9.4.4 (LDPC coding).

e) Block repetition: Apply the block-wise 2 times repetition on a per-OFDM symbol basis as described in 24.3.9.5 (Repetition for 1MHz MCS10).

f) Segment parser (if needed): For a contiguous 16 MHz transmission, divide the output bits of each stream parser into two frequency subblocks as described in 24.3.9.7 (Segment parser). This block is bypassed for 1 MHz, 2 MHz, 4 MHz and 8 MHz S1G PPDU transmissions.

g) Constellation mapper: Map to BPSK constellation points as described in 24.3.9.9 (Constellation mapping).

h) Segment deparser (if needed): For a contiguous 16 MHz transmission, merge the two frequency subblocks into one frequency segment as described in 24.3.9.9.3 (Segment deparser). This block is bypassed for 1 MHz, 2 MHz, 4 MHz and 8 MHz S1G PPDU transmissions.

i) Pilot insertion: Insert pilots following the steps described in 24.3.9.10 (Pilot subcarriers).

j) CSD: Apply CSD for each space-time stream and frequency segment as described in 24.3.8.3.1 (Cyclic shift for S1G modulated fields).

k) Spatial mapping: Apply the *Q* matrix as described in 24.3.10 (SU-MIMO and DL-MU-MIMO Beamforming).

l) Phase rotation: Apply the appropriate phase rotations for each 1 MHz subchannel if 1 MHz Duplicate PPDU as described in 24.3.9.12 (1MHz and 2MHz duplicate transmission) and 24.3.7 (Mathematical description of signals).

m) IDFT: Compute the inverse discrete Fourier transform.

n) Insert GI and apply windowing: Prepend a GI (SHORT_GI or LONG_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions). Note that SHORT_GI can be applied since the 2nd symbol of data field.

o) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.4.7 Construction of the Data field in an S1G MU PPDU

24.3.4.7.1 General

For an MU transmission, the PPDU encoding process is performed on a per-user basis up to the input of the Spatial Mapping block except CSD (as described in 24.3.8.2.1.1 (Cyclic shift for S1G modulated fields) if 2 MHz short preamble is used, 24.3.8.2.2.2.1 (Cyclic shift for S1G modulated fields) if 2 MHz long preamble is used and 24.3.8.3.1 (Cyclic shift for S1G modulated fields) if 1 MHz preamble is used). All user data is combined and mapped to the transmit chains in the Spatial Mapping block. Note that 1MHz PPDU cannot be used for an MU transmission.

24.3.4.7.2 Using BCC

A Data field with BCC encoding is constructed using the process described in 24.3.4.5.1 (Using BCC) and 24.3.4.6.1 (Using BCC) before the spatial mapping block and repeated for each user that uses BCC encoding.

24.3.4.7.3 Using LDPC

A Data field with LDPC encoding is constructed using the process described in 24.3.4.5.2 (Using LDPC) and 24.3.4.6.2 (Using LDPC) before the spatial mapping block and repeated for each user that uses LDPC encoding.

24.3.4.7.4 Combining to form an S1G MU PPDU

The per-user data is combined as follows:

a) Spatial Mapping: The *Q* matrix is applied as described in 24.3.10 (SU-MIMO and DL-MU-MIMO Beamforming). The combining of all user data is done in this block.

b) Phase rotation: Apply the appropriate phase rotations for each 1MHz subchannel if 1MHz Duplicate PPDU or for each 2 MHz subchannel if 2 MHz preamble is used as described in 24.3.9.11 (OFDM modulation), 24.3.9.12 (1MHz and 2MHz duplicate transmission), and 24.3.7 (Mathematical description of signals).

c) IDFT: Compute the inverse discrete Fourier transform.

d) Insert GI and apply windowing: Prepend a GI (SHORT_GI or LONG_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions). Note that SHORT_GI can be applied since the 2^{nd} symbol of data field.

e) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 24.3.7 (Mathematical description of signals) and 24.3.8 (S1G preamble) for details.

24.3.5 Modulation and coding scheme (MCS)

The S1G-MCS is a value that determines the modulation and coding used in the Data field of the PPDU. It is a compact representation that is carried in the SIG or SIG-A field for S1G SU PPDUs and in the SIG-B field for S1G MU PPDUs using greater than or equal to 2MHz long format. Rate-dependent parameters for the full set of S1G-MCSs are shown in Table 24-36 (S1G MCSs for 1MHz, Nss = 1) to Table 24-55 (S1G MCSs for 16MHz, Nss = 4) (in 24.5 (Parameters for S1G-MCSs)).

These tables give rate-dependent parameters for S1G-MCSs with indices 0 to 9 (and index 10 solely for 1MHz, NSS = 1), with number of spatial streams from 1 to 4 and bandwidth options of 1 MHz, 2 MHz, 4 MHz, 8 MHz and 16 MHz. Equal modulation (EQM) is applied to all streams for a particular user.

24.3.6 Timing-related parameters

Table 24-4 (Timing-related constants) defines the timing-related parameters for all S1G PPDU formats, except the SIG field in greater than or equal to 2MHz short format, and the SIG-A field in greater than or equal to 2MHz long format. Note that the timing-related parameters for the SIG field in 1MHz PPDU and the SIG-B field in greater than or equal to 2MHz long format are the same as those defined for the Data field as shown in Table 24-4 (Timing-related constants).

Table 24-4— Timing-related constants

Parameter	CBW1	CBW2	CBW4	CBW8	CBW16	Description
N_{SD}	24	52	108	234	468	Number of data subcarriers per OFDM symbol
N_{SP}	2	4	6	8	16	Number of pilot subcarrier per OFDM symbol
N_{ST}	26	56	114	242	484	Total number of useful subcarriers per OFDM symbol
N_{SR}	13	28	58	122	250	Highest data subcarrier index per OFDM symbol
Δ_F	31.25 kHz					Subcarrier frequency spacing
T_{DFT}	32 μs = $1/\Delta_F$					IDFT/DFT period
T_{GI}	8 μs = $T_{DFT}/4$					Guard interval duration
T_{GI2}	16 μs					Double guard interval
T_{GIS}	4 μs = $T_{DFT}/8$					Short guard interval duration
T_{SYML}	40 μs = $T_{DFT} + T_{GI}$ = 1.25 × T_{DFT}					Duration of OFDM symbol with normal guard interval
T_{SYMS}	36 μs = $T_{DFT} + T_{GIS}$ = 1.125 × T_{DFT}					Duration of OFDM symbol with short guard interval
T_{SYM}	T_{SYML} or T_{SYMS} depending on the GI used					OFDM symbol duration
T_{STF}	160 μs = 4 × T_{SYML}	80 μs = 2 × T_{SYML}				STF field duration

Table 24-4— Timing-related constants

T_{DSTF}	n.a.	40 µs = T_{SYML}	≥2 MHz long preamble D-STF field duration
T_{LTF1}	160 µs = 4 × T_{DFT} + 2 × T_{GI} + T_{GI2}	80 µs = 2 × T_{DFT} + T_{GI2}	First LTF field duration
T_{LTF}	40 µs = T_{SYML}		Second and subsequent LTF field duration
T_{DLTF}	n.a.	40 µs = T_{SYML}	≥2 MHz long preamble D-LTF field duration
T_{SIG}	240 µs = 6 × T_{SYML}	80 µs = 2 × T_{SYML}	SIG field duration
$T_{SIG\text{-}A}$	n.a.	80 µs = 2 × T_{SYML}	≥2 MHz long preamble SIG-A field duration
$T_{SIG\text{-}B}$	n.a.	40 µs = T_{SYML}	≥2 MHz long preamble SIG-B field duration
$N_{service}$	8		Number of bits in the SERVICE field
N_{tail}	6		Number of tail bits per BCC encoder
NOTE 1— $N_{ST} = N_{SD} + N_{SP}$			

Table 24-5 (Timing-related constants for SIG/SIG-A field in ≥2MHz PPDUs) defines the timing-related parameters for the SIG field in greater than or equal to 2MHz short format, or the SIG-A field in greater than or equal to 2MHz long format. Note that short/double guard interval is not used for SIG/SIG-A field in ≥2MHz PPDUs.

Table 24-5—Timing-related constants for SIG/SIG-A field in ≥2MHz PPDUs

Parameter	CBW1	CBW2	CBW4	CBW8	CBW16	Description
N_{SD}	n.a.	48	48	48	48	Number of data subcarriers per OFDM symbol per 2MHz sub-channel
N_{SP}	n.a.	4	4	4	4	Number of pilot subcarrier per OFDM symbol per 2MHz sub-channel
N_{ST}	n.a.	52	52	52	52	Total number of useful subcarriers per OFDM symbol per 2MHz sub-channel
N_{SR}	n.a.	26	56	120	248	Highest data subcarrier index per OFDM symbol
Δ_F	31.25 kHz					Subcarrier frequency spacing
T_{DFT}	32 μs = $1/\Delta_F$					IDFT/DFT period
T_{GI}	8 μs = $T_{DFT}/4$					Guard interval duration
T_{SYM}	40 μs = $T_{DFT} + T_{GI}$ = $1.25 \times T_{DFT}$					OFDM symbol duration
T_{SIG}	n.a.	80 μs = $2 \times T_{SYM}$				SIG field duration
$T_{SIG\text{-}A}$	n.a.	80 μs = $2 \times T_{SYM}$				≥2 MHz long preamble SIG-A field duration

Table 24-6 (Frequently used parameters) defines parameters used frequently in 24 (Sub 1 GHz (S1G) PHY specification).

Table 24-6—Frequently used parameters

Symbol	Explanation
N_{CBPS}, $N_{CBPS,u}$	Number of coded bits per symbol for user u, u = 0, ..., N_u-1. For a S1G SU PPDU, $N_{CBPS} = N_{CBPS,0}$ For a S1G MU PPDU, N_{CBPS} is undefined
N_{CBPSS}, $N_{CBPSS,u}$	Number of coded bits per symbol per spatial stream. For the SIG-B field in greater than or equal to 2MHz long format, $N_{CBPSS} = N_{SD}$ for all users. For the Data field, $N_{CBPSS,u}$ equals the number of coded bits per symbol per spatial stream for user u, u = 0, ..., N_u-1. For the Data field of a S1G SU PPDU, $N_{CBPSS} = N_{CBPSS,0}$ For the Data field of a S1G MU PPDU, N_{CBPSS} is undefined
N_{CBPSSI}, $N_{CBPSSI,u}$	Number of coded bits per symbol per spatial stream per BCC interleaver block. For a S1G SU PPDU, $N_{CBPSSI} = \begin{cases} N_{CBPSS}, \text{ for a 1 MHz, 2 MHz, 4 MHz or 8 MHz PPDU} \\ \frac{N_{CBPSS}}{2}, \text{ for a 16 MHz PPDU} \end{cases}$ For a S1G MU PPDU for user u, u = 0, ..., N_u-1 $N_{CBPSSI,u} = \begin{cases} N_{CBPSS,u}, \text{ for a 1 MHz, 2 MHz, 4 MHz or 8 MHz PPDU} \\ \frac{N_{CBPSS,u}}{2}, \text{ for a 16 MHz PPDU} \end{cases}$
N_{DBPS}, $N_{DBPS,u}$	Number of data bits per symbol for user u, u = 0, ..., N_u-1. For a S1G SU PPDU, $N_{DBPS} = N_{DBPS,0}$ For a S1G MU PPDU, N_{DBPS} is undefined
N_{BPSCS}, $N_{BPSCS,u}$	Number of coded bits per subcarrier per spatial stream for user u, u = 0, ..., N_u-1. For a S1G SU PPDU, $N_{BPSCS} = N_{BPSCS,0}$ For a S1G MU PPDU, N_{BPSCS} is undefined
N_{RX}	Number of receive chains
N_u	For greater than or equal to 2MHz long format, the Omni-portion always has N_u = 1, and in the Data portion, N_u represents the number of users in the transmission (equal to the TXVECTOR parameter NUM_USERS). For 1MHz format and greater than or equal to 2MHz short format, N_u = 1.
N_{STS}, $N_{STS,u}$	Number of space-time streams. For greater than or equal to 2MHz long format, the Omni-portion always has $N_{STS,u}=1$ (see Note 1); and for the Data portion $N_{STS,u}$ is the number of space-time streams for user u, u = $0, \ldots, N_u-1$. For 1MHz format and greater than or equal to 2MHz short format, $N_{STS,u}=1$. . For a S1G SU PPDU,$N_{STS} = N_{STS,0}$; for a S1G MU PPDU,N_{STS} is undefined.

Table 24-6—Frequently used parameters

$N_{STS,total}$	For 1MHz format, greater than or equal to 2MHz short format, and the Data portion of greater than or equal to 2MHz long format, $N_{STS,total}$ is the total number of space-time streams in a PPDU. $N_{STS,total} = \sum_{u=0}^{N_u-1} N_{STS,u}$ For the Omni-portion of greater than or equal to 2MHz long format, $N_{STS,total}$ is undefined. Note that $N_{STS,total} = N_{STS}$ for a S1G SU PPDU.
N_{SS}, $N_{SS,u}$	Number of spatial streams. For greater than or equal to 2MHz long format, the Omni-portion always has $N_{SS,u}=1$ (see Note 2); and for the Data portion $N_{SS,u}$ is the number of space-time streams for user u, $u = 0,..., N_u-1$. For 1MHz format and greater than or equal to 2MHz short format, $N_{SS,u} = 1$. . For a S1G SU PPDU,$N_{SS} = N_{SS,0}$; for a S1G MU PPDU,N_{SS} is undefined.
N_{TX}	Number of transmit chains
N_{ES}, $N_{ES,u}$	The number of BCC encoders. For the SIG-B field of great than or equal to 2MHz long format, $N_{ES}=1$ for each user. For the Data portion of great than or equal to 2MHz long format, $N_{ES,u}$ is the number of BCC encoders for the Data field for user u, $u = 0,....Nu-1$. . For the Data field of a S1G SU PPDU, $N_{ES} = N_{ES,0}$. For the Data field of a S1G MU PPDU, N_{ES} is undefined. For the Data field encoded using LDPC, $N_{ES} = 1$ for a S1G SU PPDU and $N_{ES,u} = 1$ for a S1G MU PPDU for user u, $u = 0, ...N_u-1$
N_{LTF}	Number of long training fields in 1MHz format or greater than or equal to 2MHz short format; or the number of data long training fields in greater than or equal to 2MHz long format (see 24.3.8.2.1.3, 24.3.8.2.2.2.3, and 24.3.8.3.3)
R, R_u	R_u is the coding rate for user u, $u = 0, ..., N_u-1$. For a S1G SU PPDU, $R = R_0$ For a S1G MU PPDU, R is undefined
M_u	For the Omni portion of greater than or equal to 2MHz long format, $M_u = 0$. Otherwise $M_u = \sum_{u'=0}^{u-1} N_{STS,u'}$ with $M_0 = 0$.
NOTE 1—For the Omni portion of greater than or equal to 2MHz long format, u is 0 only since $N_u = 1$	

24.3.7 Mathematical description of signals

For a description of the conventions used for the mathematical description of the signals, see 18.3.2.5 (Mathematical conventions in the signal descriptions).

For a 1 MHz S1G PPDU transmission, the 1 MHz is divided into 32 subcarriers. The signal is transmitted on subcarriers -13 to -1 and 1 to 13, with 0 being the center (DC) subcarrier.

For a 2 MHz S1G PPDU transmission, the 2 MHz is divided into 64 subcarriers. The signal is transmitted on subcarriers -28 to -1 and 1 to 28, with 0 being the center (DC) subcarrier.

For a 4 MHz S1G PPDU transmission, the 4 MHz is divided into 128 subcarriers. The signal is transmitted on subcarriers -58 to -2 and 2 to 58.

For an 8 MHz S1G PPDU transmission, the 8 MHz is divided into 256 subcarriers. The signal is transmitted on subcarriers -122 to -2 and 2 to 122.

For a 16 MHz S1G PPDU transmission, the 16 MHz is divided into 512 subcarriers. The signal is transmitted on subcarriers -250 to -130, -126 to -6, 6 to 126, and 130 to 250.

The transmitted signal is described in complex baseband signal notation. The actual transmitted signal is related to the complex baseband signal by the relation shown in Equation (24-1).

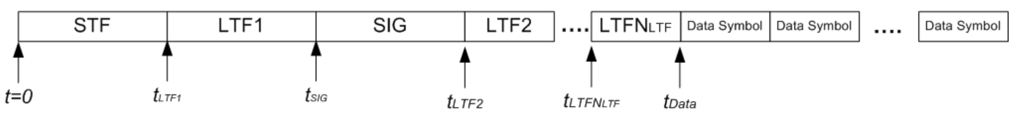
$$r_{RF}(t) = \mathrm{Re}\{r(t)\exp(j2\pi f_c t)\} \tag{24-1}$$

where

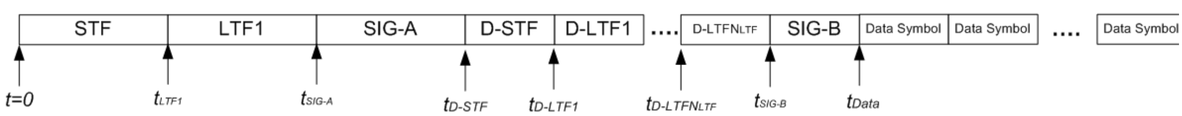
$\mathrm{Re}\{.\}$ represents the real part of a complex variable;

f_c represents the center frequency of the carrier.

The transmitted RF signal is derived by up-converting the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure 24-24 (Timing boundaries for S1G PPDU fields) where N_{LTF} is the number of LTF or D-LTF symbols and is defined in Table 24-10 (Number of LTFs required for different numbers of space time streams), up to $N_{STS,Total} = 4$.



a. Greater than or equal to 2MHz Short Format, or 1MHz Format



b. Greater than or equal to 2MHz Long Format

Figure 24-24—Timing boundaries for S1G PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

For 1MHz PPDU format, and greater than or equal to 2MHz short PPDU format, the signal transmitted on transmit chain i_{TX} shall be as shown in Equation (24-2)

$$r_{\text{PPDU}}^{(i_{\text{TX}})}(t) = r_{\text{STF}}^{(i_{\text{TX}})}(t) + r_{\text{LTF1}}^{(i_{\text{TX}})}(t - t_{\text{LTF1}}) + r_{\text{SIG}}^{(i_{\text{TX}})}(t - t_{\text{SIG}}) + \sum_{i_{\text{LTF}}=2}^{N_{\text{LTF}}} r_{\text{LTF}}^{(i_{\text{TX}}, i_{\text{LTF}})}\left(t - t_{\text{LTF2}} - (i_{\text{LTF}} - 2)T_{\text{LTFs}}\right) + r_{\text{Data}}^{(i_{\text{TX}})}(t - t_{\text{Data}}) \quad (24\text{-}2)$$

Where

$$\begin{aligned} t_{\text{LTF1}} &= T_{\text{STF}} \\ t_{\text{SIG}} &= t_{\text{LTF1}} + T_{\text{LTF1}} \\ t_{LTF2} &= t_{\text{SIG}} + T_{\text{SIG}} \\ t_{\text{Data}} &= t_{LTF2} + (N_{LTF} - 1)T_{LTFs}. \end{aligned}$$

Each field, $r_{Field}^{(i_{\text{TX}})}(t)$, is defined as the summation of one or more subfields, where each subfield is defined to be an inverse discrete Fourier transform as specified in Equation (24-3).

$$r_{\text{Field}}^{(i_{\text{TX}})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} N_{\text{Norm}}}} w_{T_{\text{Field}}}(t) \sum_{k=-N_{SR}}^{N_{SR}} \sum_{u=0}^{N_u - 1} \sum_{m=1}^{N_{STS,u}} \left[Q_k\right]_{i_{TX},(M_u+m)} \Upsilon_{k,\text{BW}} X_{k,u}^{(m)} \exp\left(j2\pi k \Delta_F (t - T_{GI,Field} - T_{CS}(M_u + m))\right) \quad (24\text{-}3)$$

This general representation holds for all subfields. In the case of greater than or equal to 2MHz long format, the total power of the time domain S1G modulated field signals summed over all transmit chains should not exceed the total power of the time domain Omni-portion signals summed over all transmit chains. For notational simplicity, the parameter BW is omitted from some bandwidth dependent terms.

Table 24-7 (Tone scaling factor and guard interval duration values for PHY fields) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$ as a function of bandwidth per frequency segment.

Table 24-7—Tone scaling factor and guard interval duration values for PHY fields

Field	$N_{\text{Field}}^{\text{Tone}}$ as a function of bandwidth per frequency segment					Guard interval duration
	1 MHz	2 MHz	4 MHz	8 MHz	16 MHz	
STF	6	12	24	48	96	n.a.

Table 24-7—Tone scaling factor and guard interval duration values for PHY fields

LTF1	26	56	112	242	484	T_{GI2} for the first 2 symbols, and T_{GI} for the 3rd and 4th symbols in the case of 1MHz
SIG	26	52	104	208	416	T_{GI}
SIG-A for long format	n.a.	52	104	208	416	T_{GI}
D-STF for long format	n.a.	12	24	48	96	n.a.
LTF2~N_{LTF}	26	56	114	242	484	T_{GI}
D-LTF for long format	n.a.	56	114	242	484	T_{GI}
SIG-B for long format	n.a.	56	114	242	484	T_{GI}
1st Data Symbol	26	56	114	242	484	T_{GI} (See NOTE 2)
From 2nd to the last Data Symbols	26	56	114	242	484	T_{GI} or T_{GIS} (see NOTE 2)
1MHz_DUP_OFDM-Data (see NOTE 1)	n.a.	52	104	208	416	T_{GI} or T_{GIS} (see NOTE 2)
2MHz_DUP_OFDM-Data (see NOTE 1)	n.a.	n.a.	112	224	448	T_{GI} or T_{GIS} (see NOTE 2)

NOTE 1—For notational convenience, 1MHz_HT_DUP_OFDM-Data and 2MHz_HT_DUP_OFDM-Data is used as a label for the Data field of a duplicated PPDU with format type 1MHz_DUP_OFDM or 2MHz_DUP-OFDM.

NOTE2—T_{GI} denotes guard interval duration when TXVECTOR parameter GI_TYPE equals LONG_GI, T_{GIS} denotes short guard interval duration when TXVECTOR parameter GI_TYPE equals SHORT_GI. Regardless of the GI_TYPE value in TXVECTOR, the 1st Data OFDM symbol always uses T_{GI} as its guard interval duration.

N_{Norm} for the Omni portion of the greater than or equal to 2MHz long format, $N_{\text{Norm}} = N_{\text{TX}}$, for all other cases, $N_{\text{Norm}} = N_{STS,total}$, where $N_{STS,total}$ is given in Table 24-6 (Frequently used parameters).

$w_{T_{\text{Field}}}(t)$ is a windowing function. An example function, $w_{T_{\text{Field}}}(t)$, is given in 18.3.2.5 (Mathematical conventions in the signal descriptions).

T_{Subfield} is T_{STF} for STF, T_{LTF1} for LTF1, T_{SIG} for SIG, $T_{SIG\text{-}A}$ for SIG-A, $T_{D\text{-}STF}$ for D-STF, T_{LTF} for LTF2~LTFN_{LTF} in the case of 1MHz format and greater than or equal to 2MHz short format and or for the D-LTFs in the case of greater than or equal to 2MHz long format, and $T_{SIG\text{-}B}$ for SIG-B. T_{Subfield} is T_{SYM} for Data symbols, that is T_{SYML} when not using the short guard interval (Short GI field of SIG or SIG-A is 0), or the first Data symbol regardless of the Short GI field in SIG or SIG-A field, and T_{SYMS} from the 2nd to the last Data symbols when using the short guard interval (Short GI field of SIG or SIG-A is 1).

N_u is defined in Table 24-6 (Frequently used parameters).

N_{SR} is the highest data subcarrier index per frequency segment and has values listed in Table 24-4 (Timing-related constants) and in Table 24-5 (Timing-related constants for SIG/SIG-A field in ≥2MHz PPDUs).

$N_{STS,u}$ is defined in Table 24-6 (Frequently used parameters).

M_u is defined in Table 24-6 (Frequently used parameters).

$[X]_{a,b}$ indicates the element in row a and column b of the matrix X, where $1 \le a \le N_{row}$, and $1 \le b \le N_{col}$. N_{row} and N_{col} are the number of rows and columns, respectively, of the matrix X.

Q_k is the spatial mapping matrix for the subcarrier k. For the Omni-portion of greater than or equal to 2MHz long format, Q_k is a column vector, denoted as $Q_k^{(omni)}$, with N_{TX} elements with element i_{TX} being $\exp(-j2\pi k\Delta_F T_{CS}^{i_{TX}})$, where $T_{CS}^{i_{TX}}$ represents the cyclic shift for transmitter chain i_{TX} whose values are given in Table 24-12 (Per antenna cyclic shift values of S1G long preamble PPDU). For other cases, Q_k is a matrix with N_{TX} rows and $N_{STS,total}$ columns.

Δ_F is the subcarrier frequency spacing given in Table 24-4 (Timing-related constants).

$X_{k,u}^{(m)}$ is the frequency-domain symbol in subcarrier k of user u for of space-time stream m. Some of the $X_{k,u}^{(m)}$ within $-N_{SR} \le k \le N_{SR}$ have a value of zero. Examples of such cases include the DC tones, guard tones on each side of the transmit spectrum, as well as the unmodulated tones of STF and D-STF fields.

$T_{GI,Field}$ is the guard interval duration used for each OFDM symbol in the field. The value for each field is as defined in Table 24-7 (Tone scaling factor and guard interval duration values for PHY fields). T_{GI}, T_{GI2} and T_{GIS} are defined in Table 24-4 (Timing-related constants).

$T_{CS}(l)$, for the Omni-portion of greater than or equal to 2MHz long format, $T_{CS}(l) = 0$. For the other cases, $T_{CS}(l)$ represents the cyclic shift per space-time stream, whose value is defined in Table 24-9 (Cyclic shift values for the S1G short preamble PPDU) for ≥2MHz, and Table 24-17 (Cyclic shift values of S1G 1MHz PPDU).

The function $\Upsilon_{k,BW}$ is used to represent a rotation of the tones. BW in $\Upsilon_{k,BW}$ is determined by the TXVECTOR parameter CH_BANDWIDTH as defined in Table 24-8.

Table 24-8—CH_BANDWIDTH and $\Upsilon_{k,BW}$

CH_BANDWIDTH	$\Upsilon_{k,BW}$
CBW1	$\Upsilon_{k,1}$
CBW2	$\Upsilon_{k,2}$

Table 24-8—CH_BANDWIDTH and $\Upsilon_{k,\mathrm{BW}}$

CBW4	$\Upsilon_{k,4}$
CBW8	$\Upsilon_{k,8}$
CBW16	$\Upsilon_{k,16}$

For a 1 MHz PPDU transmission,

$$\Upsilon_{k,1} = 1 \tag{24-4}$$

For a 2 MHz PPDU transmission,

$$\Upsilon_{k,2} = 1 \tag{24-5}$$

For a 4 MHz PPDU transmission,

$$\Upsilon_{k,4} = \begin{cases} 1, & k < 0 \\ j, & k \ge 0 \end{cases} \tag{24-6}$$

For an 8 MHz PPDU transmission,

$$\Upsilon_{k,8} = \begin{cases} 1, & k < -64 \\ -1, & k \ge 64 \end{cases} \tag{24-7}$$

For a 16 MHz PPDU transmission,

$$\Upsilon_{k,16} = \begin{cases} 1, & k < -192 \\ -1, & \text{-}192 \le k < 0 \\ 1, & 0 \le k < 64 \\ -1, & 64 \le k \end{cases} \tag{24-8}$$

For a 2MHz transmission using 1MHz duplicated mode,

$$\Upsilon_{k,2} = \begin{cases} 1, k < 0 \\ -1, k \ge 0 \end{cases} \tag{24-9}$$

For a 4MHz transmission using 1MHz duplicated mode,

$$\Upsilon_{k,4} = \begin{cases} 1, k < -32 \\ j, -32 \le k < 0 \\ -j, 0 \le k < 32 \\ -1, 32 \le k \end{cases} \quad (24\text{-}10)$$

For a 8MHz transmission using 1MHz duplicated mode,

$$\Upsilon_{k,8} = \begin{cases} 1, k < -96 \\ -1, -96 \le k < -64 \\ 1, -64 \le k < 64 \\ -1, 64 \le k \end{cases} \quad (24\text{-}11)$$

For a 16MHz transmission using 1MHz duplicated mode,

$$\Upsilon_{k,16} = \begin{cases} 1, k < -160 \\ -1, -160 \le k < -128 \\ 1, -128 \le k < -32 \\ -1, -32 \le k < 64 \\ 1, 64 \le k < 96 \\ -1, 96 \le k < 128 \\ 1, 128 \le k < 192 \\ -1, 192 \le k < 224 \\ 1, 224 \le k \end{cases} \quad (24\text{-}12)$$

24.3.8 S1G preamble

24.3.8.1 Introduction

Three preamble formats are defined for S1G PPDUs corresponding to the three PPDU formats: 1MHz preamble, greater than or equal to 2MHz short preamble, and greater than or equal to 2MHz long preamble. The first two preamble formats are defined solely for single user, and the third preamble may be used in either single user or multiuser mode.

24.3.8.2 Greater than or equal to 2MHz PHY

24.3.8.2.1 Short preamble

The greater than or equal to 2MHz short preamble is used only for SU transmissions.

24.3.8.2.1.1 Cyclic shift for S1G modulated fields

The cyclic shift values defined in this subclause apply to the STF, LTF, SIG and Data fields of the S1G short preamble PPDU, for >=2MHz Tx bandwidths. Throughout the S1G short preamble, cyclic shifts are applied to prevent beamforming when similar signals are transmitted in different space-time streams. The same cyclic shift is applied to these streams during the transmission of the Data field of the S1G short preamble

PPDU. The cyclic shift value $T_{CS}(n)$ for space-time stream n out of $N_{STS,total}$ total space-time streams is shown in Table 24-9 (Cyclic shift values for the S1G short preamble PPDU).

Table 24-9—Cyclic shift values for the S1G short preamble PPDU

$T_{CS}(n)$ for >=2MHz, Short Preamble PPDU				
Total number of space-time streams ($N_{STS,total}$)	Cyclic shift for space-time stream n (μs)			
	1	2	3	4
1	0	-	-	-
2	0	-4	-	-
3	0	-4	-2	-
4	0	-4	-2	-6

24.3.8.2.1.2 STF definition

The STF field for a 2 MHz or 4 MHz transmissions is defined by Equation (20-8) and Equation (20-9) respectively in 20.3.9.3.3 (L-STF definition). For a 8 MHz or 16 MHz transmissions, the STF field is defined by Equation (22-14) and Equation (22-15) respectively in 22.3.8.1.2 (L-STF definition). Note that these equations do not include the phase rotation per 2 MHz subchannel.

The time domain representation of the STF signal at transmit chain i_{TX} shall be as specified in Equation (24-13).

$$r_{\mathrm{STF}}^{(i_{\mathrm{TX}})}(t) = \frac{1}{\sqrt{N_{\mathrm{STF}}^{\mathrm{Tone}} N_{\mathrm{STS}}}} w_{T_{\mathrm{STF}}}(t) \sum_{k=-N_{SR}}^{N_{SR}} \sum_{m=1}^{N_{STS}} \left[Q_k\right]_{i_{TX},m} \left[P_{HTLTF}\right]_{m,1} \Upsilon_{k,\mathrm{BW}} S_k \exp\left(j2\pi k\Delta_F(t - T_{CS}(m))\right) \quad (24\text{-}13)$$

where

N_{SR} is defined in

$T_{CS}(m)$ represents the cyclic shift for space-time stream m with a value given in Table 24-9 (Cyclic shift values for the S1G short preamble PPDU)

$\Upsilon_{k,\mathrm{BW}}$ is defined by Equation (24-5)~ Equation (24-8).

Δ_F is defined in Table 24-4 (Timing-related constants)

N_{STS} is defined in Table 24-6 (Frequently used parameters)

P_{HTLTF} is defined in in 20.3.9.4.6. (HT-LTF definition)

$N_{\mathrm{STF}}^{\mathrm{Tone}}$ has the value given in Table 24-7 (Tone scaling factor and guard interval duration values for PHY fields).

24.3.8.2.1.3 LTF definition

The LTF field provides a means for the receiver to estimate the MIMO channel between the set of constellation mapper outputs (or, if STBC is applied, the STBC encoder outputs) and the receive chains. The transmitter provides training for N_{STS} space time streams (spatial mapper inputs) used for the transmission of the PSDU. For each tone, the MIMO channel that can be estimated is an $N_{RX} \times N_{STS}$ matrix. All S1G transmissions have a preamble that contains LTF symbols, where the data tones of each LTF symbol are multiplied by entries belonging to a matrix P_{HTLTF}, to enable channel estimation at the receiver.

The pilot tones of each LTF symbol are multiplied by the first column of the P_{HTLTF} matrix. The multiplication of the pilot tones in the LTF symbols by the first column of the P_{HTLTF} matrix instead of the whole P_{HTLTF} matrix is to allow receivers to track phase and frequency offset during MIMO channel estimation using the LTF. The number of LTF symbols, N_{LTF}, is a function of the total number of space-time streams N_{STS} as shown in Table 24-10 (Number of LTFs required for different numbers of space time streams). As a result, the LTF field consists of one, two, or four symbols that are necessary for the demodulation of the Data field in the PPDU or for channel estimation in an NDP.

Table 24-10— Number of LTFs required for different numbers of space time streams

N_{STS}	N_{TLTF}
1	1
2	2
3	4
4	4

The LTF field for a 2 MHz, 4 MHz, 8 MHz, are 16 MHz transmissions are defined by Equation (22-32), Equation (22-33), Equation (22-34) and Equation (22-35) respectively in 22.3.8.2.5 (VHT-LTF definition). Note that these equations do not include the phase rotation per 2 MHz subchannel.

The generation of the time domain LTF symbols is shown in Figure 24-25 (Generation of LTF symbols) where A_{LTF}^{k} is given in Equation (24-14).

$$A_{LTF}^{k} = \begin{cases} \left[P_{HTLTF}\right]_{*,1} \cdot \left[1 \quad 1 \quad 1 \quad 1\right], & \text{if } k \in K_{\mathrm{Pilot\_Fix}} \\ P_{HTLTF}, & \text{otherwise} \end{cases} \tag{24-14}$$

where

$K_{\mathrm{Pilot\_Fix}}$ is the subcarrier indices for the fixed pilot tones.

For a 2 MHz transmission, $K_{\text{Pilot\_Fix}} = \{\pm 7, \pm 21\}$.

For a 4 MHz transmission, $K_{\text{Pilot\_Fix}} = \{\pm 11, \pm 25, \pm 53\}$.

For an 8 MHz transmission, $K_{\text{Pilot\_Fix}} = \{\pm 11, \pm 39, \pm 75, \pm 103\}$.

For a 16 MHz transmission, $K_{\text{Pilot\_Fix}} = \{\pm 25, \pm 53, \pm 89, \pm 117, \pm 139, \pm 167, \pm 203, \pm 231\}$.

$[P_{HTLTF}]_{*,1}$ is the first column of the P_{HTLTF} matrix.

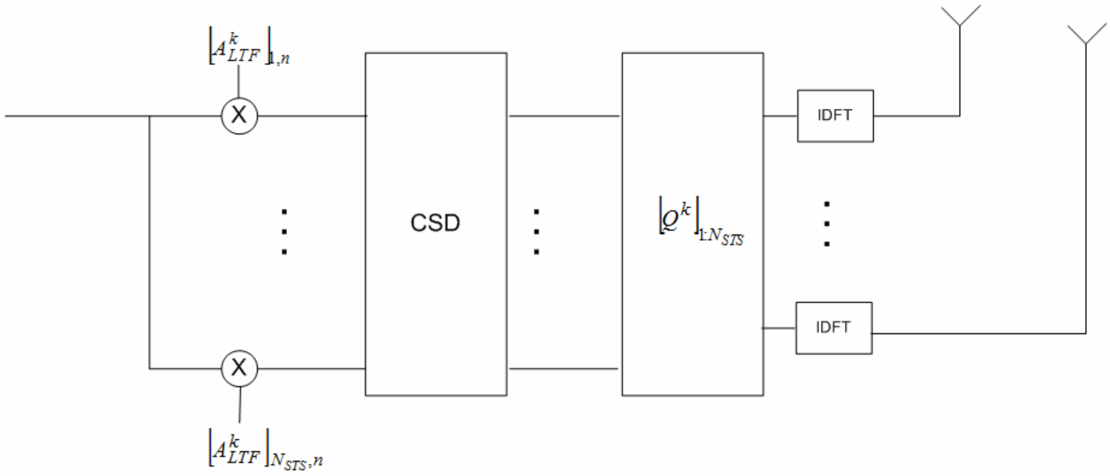


Figure 24-25—Generation of LTF symbols

The time domain representation of the LTF1, and LTF2~LTF$_{\text{NLTF}}$ signals at transmit chain i_{TX} shall be as specified in Equation (24-15) and Equation (24-16), respectively.

$$r_{\text{LTF1}}^{(i_{\text{TX}})}(t) = \frac{1}{\sqrt{N_{\text{LTF}}^{\text{Tone}} N_{\text{STS}}}} w_{T_{\text{LTF1}}}(t) \sum_{k=-N_{SR}}^{N_{SR}} \sum_{m=1}^{N_{STS}} \left(\begin{array}{l} \left[Q_k\right]_{i_{TX},m} \Upsilon_{k,\text{BW}} \left[A_{LTF}^k\right]_{m,1} LTF_k \\ .\exp\left(j2\pi k \Delta_F (t - T_{GI2} - T_{CS}(m))\right) \end{array} \right) \tag{24-15}$$

$$r_{\text{LTF2\sim LTF}_{\text{NLTF}}}^{(i_{\text{TX}})}(t) = \frac{1}{\sqrt{N_{\text{LTF}}^{\text{Tone}} N_{\text{STS}}}} \sum_{n=1}^{N_{LTF}-1} w_{T_{\text{LTF}}}\left(t - (n-1)T_{LTF}\right) \sum_{k=-N_{SR}}^{N_{SR}} \sum_{m=1}^{N_{STS}} \left(\begin{array}{l} \left[Q_k\right]_{i_{TX},m} \Upsilon_{k,\text{BW}} \left[A_{LTF}^k\right]_{m,(n+1)} LTF_k \\ .\exp\left(j2\pi k \Delta_F (t - (n-1)T_{LTF} - T_{GI} - T_{CS}(m))\right) \end{array} \right) \tag{24-16}$$

where

N_{SR} and T_{LTF} are defined in Table 24-4 (Timing-related constants)

$T_{CS}(m)$ represents the cyclic shift for space-time stream *m* with a value given in Table 24-9 (Cyclic shift values for the S1G short preamble PPDU)

$\Upsilon_{k,\mathrm{BW}}$ is defined by Equation (24-5) ~ Equation (24-8).

Δ_F is defined in Table 24-4 (Timing-related constants)

N_{STS} is defined in Table 24-6 (Frequently used parameters)

A_{LTF}^{k} is defined in by Equation (24-14)

$N_{\mathrm{LTF}}^{\mathrm{Tone}}$ has the value given in Table 24-7 (Tone scaling factor and guard interval duration values for PHY fields)

The first LTF (LTF1) consists of two periods of the long training symbol, preceded by a double length (16 *u*s) cyclic prefix. The placement of the first and subsequent LTFs in a greater than or equal to 2MHz short format PPDU is shown in Figure 24-20 (S1G greater than or equal to 2 MHz short format).

24.3.8.2.1.4 SIG definition

The SIG field carries information required to interpret S1G format PPDUs sent with a short preamble. The structure of the SIG field for the fist symbol (SIG-1) is shown in Figure 24-26 (SIG-1 structure) and for the second symbol (SIG-2) is shown in Figure 24-27 (SIG-2 structure).

B0	B1	B2	B3 B4	B5 B6	B7B 15	B16	B17 B18	B19B22	B23
reserved	STBC	reserved	BW	Nsts	PAID	SGI	Coding	MCS	Smooth-ing

Figure 24-26—SIG-1 structure

B0	B1 B9	B10B11	B12	B13	B14 B17	B18 B23
Aggregation	Length	ACK Indication	NDP Indication	Doppler	CRC	Tail

Figure 24-27—SIG-2 structure

The SIG field of S1G format PPDUs sent with a short preamble contains the fields listed in Figure 24-27 (SIG-2 structure).

Table 24-11—Fields in the SIG field of short preamble

Symbol	Bit	Field	Number of bits	Description
SIG-1	B0	Reserved	1	Reserved. Set to 1.
	B1	STBC	1	Set to 1 if all spatial streams have space time block coding and set to 0 if no spatial streams has space time block coding.
	B2	Reserved	1	Reserved. Set to 1.
	B3-B4	BW	2	Set to 0 for 2 MHz, 1 for 4 MHz, 2 for 8 MHz, 3 for 16 MHz
	B5-B6	Nsts	2	Set to 0 for 1 space time stream Set to 1 for 2 space time streams Set to 2 for 3 space time streams Set to 3 for 4 space time streams
	B7-B15	PAID	9	Partial AID: Set to the value of the TXVECTOR parameter PARTIAL_AID. Partial AID provides an abbreviated indication of the intended recipient(s) of the PSDU(see 9.17b (Group ID and partial AID in S1G PPDUs))).
	B16	Short GI	1	Set to 0 if short guard interval is not used in the Data field. Set to 1 if short guard interval is used in the Data field.
	B17-B18	Coding	2	B17 set to 0 for BCC and 1 for LDPC If B17 is 1, B18 is set to 1 if the LDPC PPDU encoding process (of an SU PPDU), results in an extra OFDM symbol (or symbols) as described in 22.3.10.5.4 (LDPC coding), otherwise set to 0. If B17 is 0, B18 is reserved and set to 1.
	B19-B22	MCS	4	MCS Index
	B23	Smoothing	1	A value of 1 indicates that channel smoothing is recommended. A value of 0 indicates that channel smoothing is not recommended.

Table 24-11—Fields in the SIG field of short preamble

SIG-2	B0	Aggregation	1	Set to 1 when aggregation is ON (AMPDU), and 0 otherwise. Note: S1G PPDUs shall be transmitted with aggregation ON whenever PHY payload size is greater than 511 bytes
	B1-B9	Length	9	Denotes the length of PPDU in number of symbols when aggregation bit is set to 1, and in number of bytes when aggregation bit is set to 0.
	B10-B11	ACK Indication	2	This field indicates the presence and type of frame a SIFS time after the current frame transmission. Set to 0 for ACK; Set to 1 for Block ACK; Set to 2 for No ACK; Set to 3 for a frame not ACK, BA or CTS
	B12	NDP Indication	1	Used to indicate that frame is a Control NDP frame. If set to 1, then the SIG field contents follow the description in 8.3.4a (NDP MAC frames)
	B13	Doppler	1	Set to 1 to indicate travelling pilots usage in packet. Otherwise 0 to indicate regular pilot tone locations.
	B14-B17	CRC	4	CRC calculated as in 24.3.8.2.1.5 (CRC calculation for S1G SIGA fields).
	B18-B23	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

NOTE—Integer fields are represented in unsigned binary format with the least significant bit in the lowest numbered bit position.

The SIG field is composed of two OFDM symbols, SIG-1 and SIG-2, each containing 24 data bits, as shown in Table 24-11 (Fields in the SIG field of short preamble). SIG-1 is transmitted before SIG-2. The SIG symbols shall be BCC encoded at rate, R = 1/2, interleaved, mapped to a BPSK constellation, and have pilots inserted following the steps described in 18.3.5.6 (Convolutional encoder), 18.3.5.7 (Data interleaving), 18.3.5.8 (Subcarrier modulation mapping), and 18.3.5.9 (Pilot subcarriers), respectively.

The first and second half of the stream of 96 complex numbers generated by these steps (before pilot insertion) is divided into two groups of 48 complex numbers $d_{k,n}$, $k = 0, \ldots, 47$, where $n = 0, 1$ respectively. All the 96 complex numbers are rotated by 90° counter-clockwise relative to their original BPSK constellation points in order to accommodate differentiation of the greater than or equal to 2MHz short format PPDU from an 1MHz format PPDU, or from a greater than or equal to 2MHz long format PPDU. The first rotated 48 complex numbers form the first symbol of SIG; and the second rotated 48 complex numbers form the second symbol of SIG.

The time domain waveform for the SIG field in a greater than or equal to 2MHz short format PPDU at transmit chain i_{TX} shall be as specified in Equation (24-17).

$$r_{\mathrm{SIG}}^{(i_{\mathrm{TX}})}\left(t\right)=\frac{1}{\sqrt{N_{\mathrm{SIG}}^{\mathrm{Tone}}N_{\mathrm{STS}}}}\sum_{n=0}^{1}w_{T_{\mathrm{SYML}}}\left(t-nT_{SYML}\right)$$
$$\sum_{i_{BW}=0}^{N_{2MHz}-1}\left(\sum_{k=-26}^{26}\sum_{m=1}^{N_{STS}}\Upsilon_{(k-K_{shift}(i_{BW})),\mathrm{BW}}\left[Q_k\right]_{i_{TX},m}\left[P_{HTLTF}\right]_{m,1}\left(j.D_{k,n,2}+p_nP_k\right).\exp\left(j2\pi(k-K_{Shift}(i_{BW}))\Delta_F(t-nT_{SYML}-T_{GI}-T_{CS}(m))\right)\right)$$
(24-17)

where

N_{2MHz} is the number of 2MHz sub-channels that are contained within the whole bandwidth of the current PPDU (e.g. $N_{2MHz}=2$ for a 4MHz PPDU).

$$K_{Shift}(i)=(N_{2MHz}-1-2i).32$$
(24-18)

$$D_{k,n,2}=\begin{cases}0, & k=0,\pm7,\pm21\\ d_{M_2'(k),n}, & \text{otherwise}\end{cases}$$
(24-19)

where $M_2'(k)$ is defined in Equation (24-20)

$$M_2'(k)=\begin{cases}k+26, & -26\le k\le -22\\ k+25, & -20\le k\le -8\\ k+24, & -6\le k\le -1\\ k+23, & 1\le k\le 6\\ k+22, & 8\le k\le 20\\ k+21, & 22\le k\le 26\end{cases}$$
(24-20)

p_n and P_k are defined in 18.3.5.10 (OFDM modulation)

$T_{CS}(m)$ represents the cyclic shift for space-time stream *m* with a value given in Table 24-9 (Cyclic shift values for the S1G short preamble PPDU)

T_{SYML} is defined in Table 24-4 (Timing-related constants)

$\Upsilon_{k,\mathrm{BW}}$ is defined by Equation (24-5) ~ Equation (24-8).

Δ_F is defined in Table 24-4 (Timing-related constants)

N_{STS} is defined in Table 24-6 (Frequently used parameters)

P_{HTLTF} is defined in in 20.3.9.4.6. (HT-LTF definition)

$N_{\mathrm{SIG}}^{\mathrm{Tone}}$ has the value given in Table 24-7 (Tone scaling factor and guard interval duration values for PHY fields)

NOTE—This definition results in a QBPSK modulation on the two symbols of SIG field, where the constellation of the data tones is rotated by 90º counter-clockwise relative to the 3rd and 4th repetitions of LTF1 field in 1MHz format preamble, and relative to the 2nd symbol of SIG-A field of the greater than or equal to 2MHz long format preamble, respectively, as shown in Figure 24-20 (S1G greater than or equal to 2 MHz short format) to Figure 24-22 (S1G 1MHz format) in 24.3.2 (S1G PPDU format)), to facilitate the differentiation among the three preamble formats at the receiver.

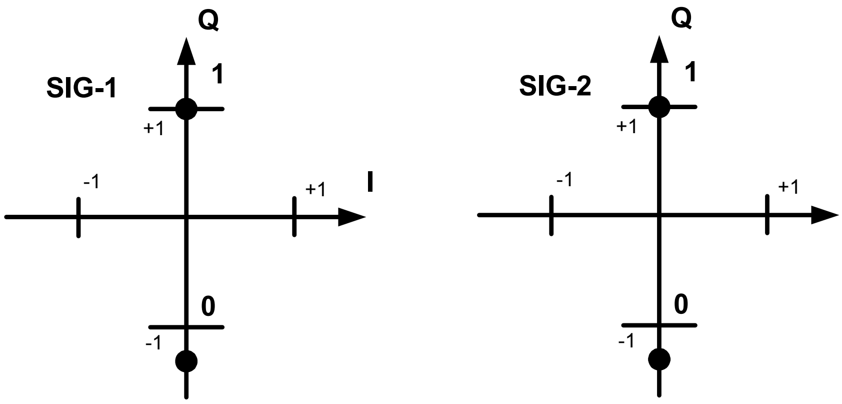


Figure 24-28—Data constellation in SIG field of greater than or equal to 2MHz short format

24.3.8.2.1.5 CRC calculation for S1G SIGA fields

The CRC protects bits 0-25 of the 1 MHz SIG field and bits 0-37 of the ≥ 2 MHz SIGA field. The value of the CRC field shall be the ones complement of

$$crc(D) = (M(D) \oplus I(D))D^4 \text{modulo } G(D) \quad (24\text{-}21)$$

where

$M(D) = m_0 D^N + m_1 D^{N-1} + \ldots + m_N D^0$ is the SIG or SIGA represented as a polynomial

where

N is 25 for the 1 MHz SIG field and 37 for the >= 2 MHz SIGA field
m_i is the ith bit of the corresponding SIG/SIGA field

$I(D) = \sum_{i=N-3}^{N} D^i$ are initialization values that are added modulo 2 to the first 4 bits of SIG/SIGA

$G(D) = D^4 + D^1 + 1$ is the CRC generating polynomial

$crc(D) = c_0 D^4 + c_1 D^2 + c_2 D^1 + c_3 D^0$

The CRC field is transmitted with c_3 first.

Figure 24-29 (4-bit CRC Calculation) shows the operation of the CRC. First, the shift register is reset to all ones. The bits are then passed through the XOR operation at the input. When the last bit has entered, the output is generated by shifting the bits out of the shift register, C3 first, through an inverter.

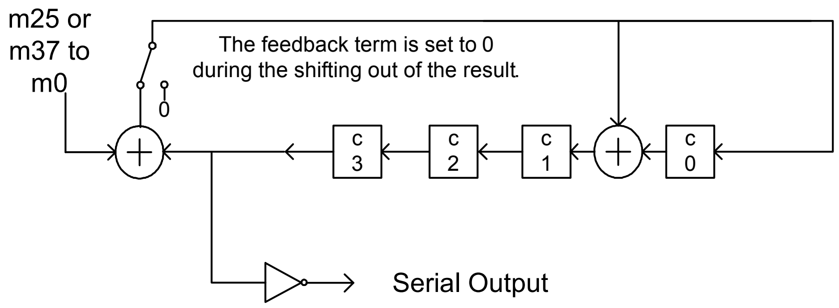


Figure 24-29—4-bit CRC Calculation

As an example, if bits { $m_0 \ldots m_{25}$ } are given by { 11 0110 0111 0110 1001 1110 1111 }, the output bits {b_3 … b_0}, where b_3 is output first, are { 0101 }.

24.3.8.2.2 Long preamble

Different from 1MHz preamble and greater than or equal to 2MHz short preamble, the greater than or equal to 2MHz long preamble may be used for both SU and MU transmissions.

The long preamble structure uses a structure that is similar to the mixed format as defined in clause 20 and clause 22.

24.3.8.2.2.1 Omni portion

Omni portion of the long preamble is always single user modulated.

24.3.8.2.2.1.1 Cyclic shift for S1G modulated fields

There are 2 sets of cyclic shift values defined in this subclause. The first set of cyclic shift values defined apply to the Omni portion, or specifically the STF, LTF, SIG-A fields of the S1G long preamble PPDU. These fields are treated as a single spatial stream to be mapped to one or more transmit antennas, at which point the cyclic shifts are applied. The cyclic shift values are defined in Table 24-12 (Per antenna cyclic shift values of S1G long preamble PPDU), which specifies the per-antenna cyclic shift value $T_{CS}^{i_{TX}}$ for antenna i_{TX} of the N_{TX} total transmit antennas.

Table 24-12—Per antenna cyclic shift values of S1G long preamble PPDU

$T_{CS}^{i_{TX}}$ for >=2MHz, Omni Portion of Long Preamble PPDU				
Total number of Tx antennas	Cyclic shift (for Tx Antenna i_{TX}) (μs)			
	1	2	3	4
1	0	-	-	-
2	0	-4	-	-
3	0	-4	-2	-
4	0	-4	-2	-6

The second set of cyclic shift values defined apply to the Data portion, or specifically the D-STF, D-LTF, SIG-B and Data fields of the S1G long preamble PPDU. In a transmission, these fields are mapped to the transmitted space-time-streams, $N_{STS,total}$, at which point the cyclic shifts are applied per space-time stream. The cyclic shift values are defined in Table 24-13 (Per space-time-stream cyclic shift values of S1G ≥ 2MHz long preamble PPDU), which specifies the per-stream cyclic shift value $T_{CS}(n)$ for space-time stream n out of $N_{STS,total}$ total space-time streams. Throughout the S1G long preamble, cyclic shifts are applied to prevent beamforming when similar signals are transmitted in different space-time streams.

For the case of when the S1G long preamble PPDU is used for a MU transmission, the cyclic shifts are applied sequentially, first per user and then per space-time stream up to the total number of users and space-time streams $N_{STS,total}$ as follows: the cyclic shift of the space-time stream number m for user u is given by $T_{CS}(M_u + m)$, of the row corresponding to $N_{STS,total}$ in Table 24-13 (Per space-time-stream cyclic shift values of S1G ≥ 2MHz long preamble PPDU). In this case, the index n takes into account the cyclic shifts already applied to space-time streams of prior users (M_u), and the space-time stream index (m) of the current user u in the sequence.

M_u is given by Table 24-6 (Frequently used parameters)

Table 24-13—Per space-time-stream cyclic shift values of S1G ≥ 2MHz long preamble PPDU

$T_{CS,S1G}^{long}(n)$ for ≥2MHz, Data portion of Long preamble PPDU				
Total number of space-time streams ($N_{STS,total}$)	Cyclic for space-time stream n (μs)			
	1	2	3	4
1	0	-	-	-

Table 24-13—Per space-time-stream cyclic shift values of S1G $\geq$ 2MHz long preamble PPDU

2	0	-4	-	-
3	0	-4	-2	-
4	0	-4	-2	-6

24.3.8.2.2.1.2 STF definition

The STF field for 2 MHz, 4 MHz, 8 MHz and 16 MHz are the same as the STF field in short preamble as specified in 24.3.8.2.2.1.2 (STF definition).
The time domain representation of the STF signal at transmit chain i_{TX} shall be as specified in Equation (24-22).

$$r_{STF}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{STF}^{Tone} N_{TX}}} w_{T_{STF}}(t) \sum_{k=-N_{SR}}^{N_{SR}} [Q_k^{(\text{omni})}]_{i_{TX},1} \Upsilon_{k,\text{BW}} S_k \exp(j2\pi k \Delta_F t) \quad (24\text{-}22)$$

where

N_{SR} is defined in Table 24-4 (Timing-related constants)

$\Upsilon_{k,\text{BW}}$ is defined by Equation (24-5) ~ Equation (24-8).

Δ_F is defined in Table 24-4 (Timing-related constants)

$N_{\text{STF}}^{\text{Tone}}$ has the value given in Tone scaling factor and guard interval duration values for PHY fieldsTable 24-7 (Tone scaling factor and guard interval duration values for PHY fields)

$Q_k^{(\text{omni})}$ is as defined in 24.3.7 (Mathematical description of signals).

24.3.8.2.2.1.3 LTF1 definition

The LTF1 field values for 2 MHz, 4 MHz, 8 MHz and 16 MHz are the same as the LTF field in short preamble as specified in 24.3.8.2.1.3 (LTF definition).

The time domain representation of the LTF1 signal at transmit chain i_{TX} shall be as specified in Equation (24-23).

$$r_{\text{LTF1}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{LTF}^{Tone} N_{TX}}} w_{T_{LTF1}}(t) \sum_{k=-N_{SR}}^{N_{SR}} [Q_k^{(\text{omni})}]_{i_{TX},1} \Upsilon_{k,\text{BW}} LTF_k \exp(j2\pi k \Delta_F (t - T_{GI2})) \quad (24\text{-}23)$$

where

N_{SR} is defined in Table 24-4 (Timing-related constants)

$\Upsilon_{k,\text{BW}}$ is defined by Equation (24-5) ~ Equation (24-8)

Δ_F is defined in Table 24-4 (Timing-related constants)

N_{LTF}^{Tone} has the value given in Table 24-7 (Tone scaling factor and guard interval duration values for PHY fields)

$Q_k^{(omni)}$ is as defined in 24.3.7 (Mathematical description of signals).

The LTF1 field consists of two periods of the long training symbol, preceded by a double length (16 *us*) cyclic prefix. The placement of the first and subsequent LTFs in a greater than or equal to 2MHz short format PPDU is shown in Figure 24-21 (S1G greater than or equal to 2MHz long format).

24.3.8.2.2.1.4 SIG-A definition

The SIG-A field of the long preamble carries information required to interpret S1G format PPDUs sent using the long preamble. The structure of the SIG-A field is different for SU PPDUs and MU PPDUs. The structure of the SIG-A field for SU PPDUs for the first symbol (SIG-A1) is shown in Table 24-30 (SIG-A-1 structure for SU PPDU) and for the second symbol (SIG-A2) is shown in Table 24-31 (SIG-A-2 structure for SU PPDU). The structure of the SIG-A field for MU PPDUs for the first symbol (SIG-A1) is shown in Table 24-32 (SIG-A-1 structure for MU PPDU)and for the second symbol (SIG-A2) is shown in Table 24-33 (SIG-A-2 structure for MU PPDU).

B0	B1	B2	B3 B4	B5 B6	B7B 15	B16	B17 B18	B19B22	B23
MU/SU	STBC	reserved	BW	Nsts	PAID	SGI	Coding	MCS	Beam-change Indication

Figure 24-30—SIG-A-1 structure for SU PPDU

B0	B1 B9	B10B11	B12 B13	B14 B17	B18 B23
Aggre-gation	Length	ACK Indica-tion	reserved	CRC	Tail

Figure 24-31—SIG-A-2 structure for SU PPDU

B0	B1	B2	B3			B10	B11 B12	B13 B18	B19	B20 B23
MU/SU	STBC	reserved	Nsts				BW	GID	SGI	Coding-I
			MU[0] Nsts	MU[1] Nsts	MU[2] Nsts	MU[3] Nsts				

Figure 24-32—SIG-A-1 structure for MU PPDU

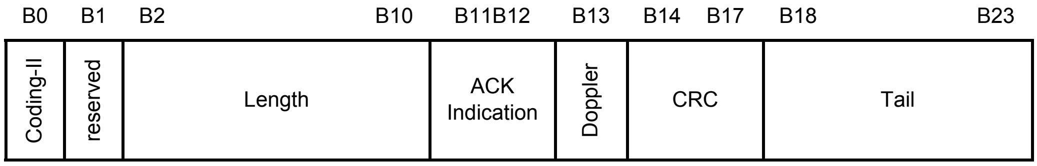


Figure 24-33—SIG-A-2 structure for MU PPDU

The SIG-A field of S1G format PPDUs sent with a long preamble for SU contains the fields listed in Table 24-14 (Fields in the SIG-A field of long preamble SU PPDU) and for MU with the fields listed in Table 24-15 (Fields in the SIG-A field of long preamble MU PPDU).

Table 24-14—Fields in the SIG-A field of long preamble SU PPDU

Symbol	Bit	Field	Number of bits	Description
SIG-A-1	B0	MU/SU	1	Set to 0 for SU PPDUs.
	B1	STBC	1	Set to 1 if all spatial streams have space time block coding and set to 0 if no spatial streams has space time block coding. Set to 0 in MU PPDUs.
	B2	Reserved	1	Reserved. Set to 1.
	B3-B4	BW	2	Set to 0 for 2 MHz, 1 for 4 MHz, 2 for 8 MHz, 3 for 16 MHz
	B5-B6	Nsts	2	Set to 0 for 1 space time stream Set to 1 for 2 space time streams Set to 2 for 3 space time streams Set to 3 for 4 space time streams
	B7-B15	PAID	9	Partial AID: Set to the value of the TXVECTOR parameter PARTIAL_AID. Partial AID provides an abbreviated indication of the intended recipi-ent(s) of the PSDU(see 9.17b (Group ID and par-tial AID in S1G PPDUs)).
	B16	Short GI	1	Set to 0 if short guard interval is not used in the Data field. Set to 1 if short guard interval is used in the Data field.
	B17-B18	Coding	2	B17 set to 0 for BCC and 1 for LDPC If B17 is 1, B18 is set to 1 if the LDPC PPDU encoding process (of an SU PPDU), results in an extra OFDM symbol (or symbols) as described in 22.3.10.5.4 (LDPC coding), otherwise set to 0. If B17 is 0, B18 is reserved and set to 1.
	B19-B22	MCS	4	MCS Index
	B23	Beam Change Indi-cation	1	A value of 1 indicates that the Q matrix is changed from the Omni portion to the Data portion of the long preamble, in at least one of the non-zero sub-carriers of the Omni portion. A value of 0 indicates that the Q matrix is un-changed in all the non-zero sub-carriers of the Omni portion. See Note-1. See Note-2.

Table 24-14—Fields in the SIG-A field of long preamble SU PPDU

SIG-A-2	B0	Aggregation	1	Set to 1 when aggregation is ON (AMPDU), and 0 otherwise. Note: S1G PPDUs shall be transmitted with aggregation ON whenever PHY payload size is greater than 511 bytes
	B1-B9	Length	9	Denotes the length of PPDU in number of symbols when aggregation bit is set to 1, and in number of bytes when aggregation bit is set to 0.
	B10-B11	ACK Indication	2	This field indicates the presence and type of frame a SIFS time after the current frame transmission. Set to 0 for ACK; Set to 1 for Block ACK; Set to 2 for No ACK; Set to 3 for a frame not ACK, BA or CTS
	B12	Reserved	1	Reserved. Bit set to 1.
	B13	Doppler	1	Set to 1 to indicate travelling pilots usage in packet. Otherwise 0 to indicate regular pilot tone locations.
	B14-B17	CRC	4	CRC calculated as in 24.3.8.2.1.5 (CRC calculation for S1G SIGA fields).
	B18-B23	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.
Note-1: If beam-change indication bit is set to 0, the receiver may do channel smoothing. Otherwise, smoothing is not recommended. Note-2: The Q matrix for Omni portion is $Q_k^{(omni)}$ as defined in 24.3.7 (Mathematical description of signals).				

Table 24-15—Fields in the SIG-A field of long preamble MU PPDU

Symbol	Bit	Field	Number of bits	Description
SIG-A-1	B0	MU/SU	1	Set to 1 for MU PPDUs
	B1	STBC	1	Set to 1 if all spatial streams of all users have space time block coding and set to 0 if no spatial streams of any user has space time block coding. NOTE—For some but not all users to have space time block coding is not allowed.
	B2	Reserved	1	Reserved. Set to 1.
	B3-B10	NSTS	8	NSTS is divided into 4 user positions of 2 bits each, , denoted by 4 subfields MU[0] Nsts …MU[3] Nsts. User position *p*, where $0 \le p \le 3$, uses bits $B(3 + 2p) - B(4 + 2p)$. The space-time streams of user u are indicated at user position $p = \text{USER\_POSITION}[u]$ where $u = 0, 1, \ldots\text{NUM\_USERS} - 1$ and the notation A[*b*] denotes the value of array A at index *b*. Zero space-time streams are indicated at positions not listed in the USER_POSITION array.(#3599) Set to 0 for 0 space time streams Set to 1 for 1 space time stream Set to 2 for 2 space time streams Set to 3 for 3 space time streams
	B11-B12	BW	2	Set to 0 for 2 MHz, 1 for 4 MHz, 2 for 8 MHz, 3 for 16 MHz
	B13-B18	GID	6	In an MU PPDU the Group ID is set as defined in 22.3.11.4 (Group ID)
	B19	Short GI	1	Set to 0 if short guard interval is not used in the Data field. Set to 1 if short guard interval is used in the Data field.
	B20-B23	Coding-I	4	If the MU[0] NSTS field is non-zero, then B20 indicates coding for user 0: set to 0 for BCC, 1 for LDPC. If the MU[0] NSTS field is 0, then B20 is reserved and set to 1. If the MU[1] NSTS field is non-zero, then B21 indicates coding for user 1: set to 0 for BCC, 1 for LDPC. If the MU[1] NSTS field is 0, then B21 is is reserved and set to 1. If the MU[2] NSTS field is non-zero, then B22 indicates coding for user 2: set to 0 for BCC, 1 for LDPC. If the MU[2] NSTS field is 0, then B22 is reserved and set to 1. If the MU[3] NSTS field is non-zero, then B23 indicates coding for user 3: set to 0 for BCC, 1 for LDPC. If the MU[3] NSTS field is 0, then B23 is reserved and set to 1.

Table 24-15—Fields in the SIG-A field of long preamble MU PPDU

SIG-A-2	B0	Coding-II	1	Set to 1 if at least one LDPC user's PPDU encoding process results in an extra OFDM symbol (or symbols) as described in 22.3.10.5.4 (LDPC coding) and 22.3.10.5.5 (Encoding process for MU PPDUs). Set to 0 otherwise.
	B1	Reserved	1	Reserved. Set to 1.
	B2-B10	Length	9	Denotes the length of PPDU in number of symbols. Note: AMPDU is always used for MU PPDUs.
	B11-B12	ACK Indication	2	This field indicates the presence and type of frame a SIFS time after the current frame transmission. Set to 0 for ACK; Set to 1 for Block ACK; Set to 2 for No ACK; Set to 3 for a frame not ACK, BA or CTS
	B13	Doppler	1	Set to 1 to indicate travelling pilots usage in packet. Otherwise 0 to indicate regular pilot tone locations.
	B14-B17	CRC	4	CRC calculated as in 24.3.8.2.1.5 (CRC calculation for S1G SIGA fields).
	B18-B23	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

NOTE—Integer fields are represented in unsigned binary format with the least significant bit in the lowest numbered bit position.

The SIG-A field is composed of two OFDM symbols, SIG-A1 and SIG-A2, each containing 24 data bits, as shown in Table 24-14 (Fields in the SIG-A field of long preamble SU PPDU). SIG-A1 is transmitted before SIG-A2. The SIG symbols shall be BCC encoded at rate, R = 1/2, interleaved, mapped to a BPSK constellation, and have pilots inserted following the steps described in 18.3.5.6 (Convolutional encoder), 18.3.5.7 (Data interleaving), 18.3.5.8 (Subcarrier modulation mapping), and 18.3.5.9 (Pilot subcarriers), respectively. The first and second half of the stream of 96 complex numbers generated by these steps (before pilot insertion) is divided into two groups of 48 complex numbers $d_{k,n}$, $k = 0, \ldots, 47$, where $n = 0, 1$ respectively. The first group of the 48 complex numbers are rotated by 90° counter-clockwise relative to their original BPSK constellation points in order to accommodate differentiation of the greater than or equal to 2MHz long format PPDU from an 1MHz format PPDU. The second group of the 48 complex numbers without rotations may be used to accommodate differentiation of the greater than or equal to 2MHz long format PPDU from a greater than or equal to 2MHz short format PPDU. The first rotated 48 complex numbers form the first symbol of SIG-A; and the second un-rotated 48 complex numbers form the second symbol of SIG-A.

The time domain waveform for the SIG-A field in a greater than or equal to 2MHz long format PPDU at transmit chain i_{TX} shall be as specified in Equation (24-24).

$$r_{SIG-A}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{SIG-A}^{Tone} N_{TX}}} \sum_{n=0}^{1} w_{T_{SYML}}(t - nT_{SYML}) \sum_{i_{BW}=0}^{N_{2MHz}-1} \left(\sum_{k=-26}^{26} [Q_k^{(\mathrm{omni})}]_{i_{TX},1} \Upsilon_{(k-K_{Shift}(i_{BW})),BW}((-1)^n j^{n+1} D_{k,n,2} + p_n P_k) \exp(j2\pi(k - K_{Shift}(i_{BW}))\Delta_F(t - nT_{SYML} - T_{GI})) \right) \quad (24\text{-}24)$$

where

N_{2MHz}, $K_{Shift}(i)$, and $D_{k,n,2}$ are the same as those defined in 24.3.8.2.1.4 (SIG definition).

p_n and P_k are defined in 18.3.5.10 (OFDM modulation)

T_{SYML} is defined in Table 24-4 (Timing-related constants)

$\Upsilon_{k,\mathrm{BW}}$ is defined by Equation (24-5) ~ Equation (24-8).

Δ_F is defined in Table 24-4 (Timing-related constants)

$N_{\mathrm{SIG\text{-}A}}^{\mathrm{Tone}}$ has the value given in Tone scaling factor and guard interval duration values for PHY fieldsTable 24-7 (Tone scaling factor and guard interval duration values for PHY fields)

$Q_k^{(\mathrm{omni})}$ is as defined in 24.3.7 (Mathematical description of signals).

NOTE— As shown in Figure 24-20 (S1G greater than or equal to 2 MHz short format) to Figure 24-22 (S1G 1MHz format) in 24.3.2 (S1G PPDU format), this definition results in a QBPSK modulation on the first symbol of SIG-A field, where the constellation of the data tones is rotated by 90º counter-clockwise relative to the 3rd repetition of LTF1 field in 1MHz format preamble, facilitating its differentiation from 1MHz format; and the second symbol of SIG-A field is BPSK modulated, facilitating its differentiation from greater than or equal to 2MHz short format.

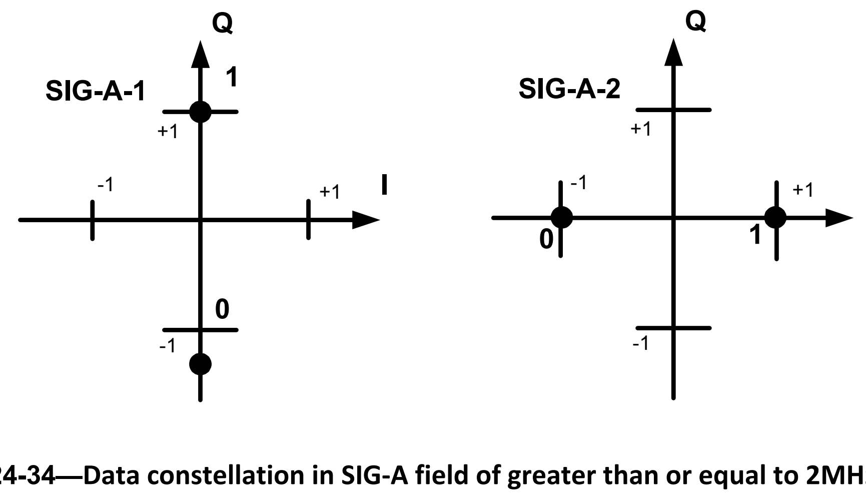


Figure 24-34—Data constellation in SIG-A field of greater than or equal to 2MHz long format

24.3.8.2.2.2 Data portion

Data portion of the long preamble could be either single user or multiuser modulated.

24.3.8.2.2.2.1 Cyclic shift for S1G modulated fields

Same as 24.3.8.2.1.1 (Cyclic shift for S1G modulated fields).

24.3.8.2.2.2.2 D-STF definition

The main purpose of the D-STF field is to improve automatic gain control estimation in a SU or MU MIMO transmission. The duration of the D-STF field is 40 µs. The frequency domain sequence $\{S_k\}$ used to construct the D-STF field is the same as the STF field in short or long preamble as indicated in 24.3.8.2.1.2 (STF definition).

The time domain representation of the D-STF signals at transmit chain i_{TX} shall be as specified in Equation (24-25).

$$r_{\text{D-STF}}^{(i_{\text{TX}})}(t) = \frac{1}{\sqrt{N_{\text{D-STF}}^{\text{Tone}} N_{\text{STS,total}}}} w_{T_{\text{D-STF}}}(t) \sum_{k=-N_{SR}}^{N_{SR}} \sum_{u=0}^{N_u-1} \sum_{m=1}^{N_{STS,u}} \left(\begin{array}{l} \left[Q_k\right]_{i_{TX},(M_u+m)} \Upsilon_{k,\text{BW}} . S_k \\ .\exp\left(j2\pi k \Delta_F (t - T_{CS}(M_u+m)) \right) \end{array} \right) \tag{24-25}$$

where

N_{SR} is defined in Table 24-4 (Timing-related constants)

$T_{CS(m)}$ represents the cyclic shift for space-time stream *m* with a value given in Table 24-13 (Per space-time-stream cyclic shift values of S1G ≥ 2MHz long preamble PPDU)

$\Upsilon_{k,\text{ BW}}$ is defined by Equation (24-5) ~ Equation (24-8)

Δ_F is defined in Table 24-4 (Timing-related constants)

$N_{STS,total}$, $N_{STS,u}$, N_u, and M_u are defined in Table 24-6 (Frequently used parameters).

$N_{\text{D-STF}}^{\text{Tone}}$ has the value given in Tone scaling factor and guard interval duration values for PHY fields Table 24-7 (Tone scaling factor and guard interval duration values for PHY fields).

The duration of the D-STF field is $T_{\text{D-STF}}$ regardless of the Short GI field setting in SIG-A.

24.3.8.2.2.2.3 D-LTF definition

The D-LTF field values for 2 MHz, 4 MHz, 8 MHz and 16 MHz are the same as the LTF field in short preamble as specified in 24.3.8.2.1.3 (LTF definition).

The generation of the time domain D-LTF symbols per frequency segment is shown in Figure 24-25 (Generation of LTF symbols) in 24.3.8.2.1.3 (LTF definition).

The time domain representation of the D-LTF signals at transmit chain i_{TX} shall be as specified in Equation (24-26).

$$r_{\text{D-LTF}}^{(i_{\text{TX}})}(t) = \frac{1}{\sqrt{N_{\text{D-LTF}}^{\text{Tone}} N_{\text{STS,total}}}} \sum_{n=0}^{N_{LTF}-1} w_{T_{\text{D-LTF}}}\left(t - nT_{D-LTF}\right)$$

$$\sum_{k=-N_{SR}}^{N_{SR}} \sum_{u=0}^{N_u-1} \sum_{m=1}^{N_{STS,u}} \begin{pmatrix} \left[Q_k\right]_{i_{TX},(M_u+m)} \Upsilon_{k,\text{BW}} \cdot \left[A_{LTF}^k\right]_{(M_u+m),(n+1)} LTF_k \\ .\exp\left(j2\pi k\Delta_F(t - nT_{D-LTF} - T_{GI} - T_{CS}(M_u+m))\right) \end{pmatrix}$$

(24-26)

where

N_{SR} is defined in Table 24-4 (Timing-related constants)

$T_{CS(m)}$ represents the cyclic shift for space-time stream *m* with a value given in Table 24-13 (Per space-time-stream cyclic shift values of S1G ≥ 2MHz long preamble PPDU)

$\Upsilon_{k,\text{ BW}}$ is defined by Equation (24-5) ~ Equation (24-8)

Δ_F is defined in Table 24-4 (Timing-related constants)

$N_{STS,total}$, $N_{STS,u}$, N_u, and M_u are defined in Table 24-6 (Frequently used parameters)

A_{LTF}^k is defined in Equation (24-14).

$N_{\text{D-STF}}^{\text{Tone}}$ has the value given in Tone scaling factor and guard interval duration values for PHY fieldsTable 24-7 (Tone scaling factor and guard interval duration values for PHY fields).

As indicated by Equation (24-26), the duration of each symbol of the D-LTF field is $T_{\text{D-LTF}}$ regardless of the Short GI field setting in SIG-A.

The generation of the time domain D-LTF symbols is the same as Figure 24-25 (Generation of LTF symbols), with N_{STS} replaced by $N_{STS,total}$.

24.3.8.2.2.2.4 SIG-B definition

If the SU/MU indication subfield in SIG-A field is set to 0 (SU), then SIG-B field is one symbol that is identical to the first D-LTF field (D-LTF1). In this case, the time domain representation of the SIG-B field at transmit chain i_{TX} shall be as specified in Equation (24-26) with *n=0*.

If the SU/MU indication subfield in SIG-A field is set to 1 (MU), then SIG-B field is one symbol and contains 26 bits in a 2 MHz PPDU, 27 bits in a 4 MHz PPDU and 29 bits in 8 MHz and 16 MHz PPDUs for each user. The fields in the SIG-B field are listed in Table 24-16 (Fields in the SIG-B field).

Table 24-16—Fields in the SIG-B field

Field	Bit Allocation (number of bits)				Description
	2 MHz	4 MHz	8 MHz	16 MHz	
MCS	B0-B3 (4)	B0-B3 (4)	B0-B3 (4)	B0-B3 (4)	Per-user MCS in MU-MIMO
Tail	B4-B9 (6)	B4-B9 (6)	B4-B9 (6)	B4-B9 (6)	All 0s
CRC	B10-B17 (8)	B10-B17 (8)	B10-B17 (8)	B10-B17 (8)	
Reserved	B18-B25 (8)	B18-B26 (9)	B18-B28 (11)	B18-B28 (11)	All 1s
Total # bits	**26**	**27**	**29**	**29**	

In this case, the padding, encoding, interleaving and modulation flow for the data subcarriers of SIG-B field in 2 MHz, 4 MHz, 8 MHz and 16 MHz are identical to those specified for 20 MHz, 40 MHz, 80 MHz and 160 MHz, respectively, as shown in 22.3.8.2.6 (VHT-SIG-B definition). Different from the VHT-SIG-B field defined in clause 22, the pilot subcarriers of SIG-B field is mapped by the first column of P_{HTLTF} matrix to N_{STS}, total space-time streams, and the pilot polarity of the SIG-B symbol is p_2 instead of p_3. The time domain representation for SIG-B field signal at transmit chain i_{TX} shall be as specified in :

$$r_{\text{SIG-B}}^{(i_{\text{TX}})}(t) = \frac{1}{\sqrt{N_{\text{SIG-B}}^{\text{Tone}} N_{\text{STS,total}}}} w_{T_{\text{SIG-B}}}(t) \sum_{k=-N_{SR}}^{N_{SR}} \sum_{u=0}^{N_u-1} \sum_{m=1}^{N_{STS,u}} \begin{pmatrix} \left[Q_k\right]_{i_{TX},(M_u+m)} \Upsilon_{k,\text{BW}} \cdot \left[P_{HTLTF}\right]_{(M_u+m),1} \left(D_{k,BW}^{(u)} + p_2 P_0^k\right) \\ .\exp\left(j2\pi k \Delta_F (t - T_{GI} - T_{CS}(M_u+m))\right) \end{pmatrix}$$

(24-27)

where

N_{SR} is defined in Table 24-4 (Timing-related constants)

$T_{CS(m)}$ represents the cyclic shift for space-time stream *m* with a value given in Table 24-13 (Per space-time-stream cyclic shift values of S1G ≥ 2MHz long preamble PPDU)

$\Upsilon_{k,\text{BW}}$ is defined by Equation (24-5) ~ Equation (24-8)

Δ_F is defined in Table 24-4 (Timing-related constants)

$N_{STS,total}$, $N_{STS,u}$, N_u, and M_u are defined in Table 24-6 (Frequently used parameters)

P_{HTLTF} is defined in Equation (20-27) in 20.3.9.4.6 (HT-LTF definition)

p_n is defined in 18.3.5.10 (OFDM modulation)

P_n^k is defined in 22.3.10.10 (Pilot Subcarriers)

$N_{\text{SIG-B}}^{\text{Tone}}$ has the value given in Tone scaling factor and guard interval duration values for PHY fieldsTable 24-7 (Tone scaling factor and guard interval duration values for PHY fields).

For a 2 MHz transmission,

$$D_{k,2}^{(u)} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M_2'(k)}^{(u)}, \text{otherwise} \end{cases} \quad (24\text{-}28)$$

$$M_2'(k) = \begin{cases} k+28, & -28 \le k \le -22 \\ k+27, & -20 \le k \le -8 \\ k+26, & -6 \le k \le -1 \\ k+25, & 1 \le k \le 6 \\ k+24, & 8 \le k \le 20 \\ k+23, & 22 \le k \le 28 \end{cases} \quad (24\text{-}29)$$

For a 4 MHz VHT transmission,

$$D_{k,4}^{(u)} = \begin{cases} 0, k = 0, \pm 1, \pm 11, \pm 25, \pm 53 \\ d_{M_4'(k)}^{(u)}, \text{otherwise} \end{cases} \quad (24\text{-}30)$$

$$M_4'(k) = \begin{cases} k+58, & -58 \le k \le -54 \\ k+57, & -52 \le k \le -26 \\ k+56, & -24 \le k \le -12 \\ k+55, & -10 \le k \le -2 \\ k+52, & 2 \le k \le 10 \\ k+51, & 12 \le k \le 24 \\ k+50, & 26 \le k \le 52 \\ k+49, & 54 \le k \le 58 \end{cases} \quad (24\text{-}31)$$

For an 8 MHz transmission,

$$D_{k,8}^{(u)} = \begin{cases} 0, k = 0, \pm1, \pm11, \pm39, \pm75, \pm103 \\ d_{M_8'(k)}^{(u)}, \text{otherwise} \end{cases} \quad (24\text{-}32)$$

$$M_8'(k) = \begin{cases} k + 122, & -122 \le k \le -104 \\ k + 121, & -102 \le k \le -76 \\ k + 120, & -74 \le k \le -40 \\ k + 119, & -38 \le k \le -12 \\ k + 118, & -10 \le k \le -2 \\ k + 115, & 2 \le k \le 10 \\ k + 114, & 12 \le k \le 38 \\ k + 113, & 40 \le k \le 74 \\ k + 112, & 76 \le k \le 102 \\ k + 111, & 104 \le k \le 122 \end{cases} \quad (24\text{-}33)$$

For a 16 MHz transmission

$$D_{k,16}^{(u)} = \begin{cases} 0, k = 0, \pm1, \pm2, \pm3, \pm4, \pm5, \pm25, \pm53, \pm89, \pm117, \pm127, \pm128, \pm129, \pm139, \pm167, \pm203, \pm231 \\ d_{M_{16}'(k)}^{(u)}, \text{otherwise} \end{cases} \quad (24\text{-}34)$$

$$M'_{16}(k) = \begin{cases} k+250, & -250 \le k \le -232 \\ k+249, & -230 \le k \le -204 \\ k+248, & -202 \le k \le -168 \\ k+247, & -166 \le k \le -140 \\ k+246, & -138 \le k \le -130 \\ k+243, & -126 \le k \le -118 \\ k+242, & -116 \le k \le -90 \\ k+241, & -88 \le k \le -54 \\ k+240, & -52 \le k \le -26 \\ k+239, & -24 \le k \le -6 \\ k+228, & 6 \le k \le 24 \\ k+227, & 26 \le k \le 52 \\ k+226, & 54 \le k \le 88 \\ k+225, & 90 \le k \le 116 \\ k+224, & 118 \le k \le 126 \\ k+221, & 130 \le k \le 138 \\ k+220, & 140 \le k \le 166 \\ k+219, & 168 \le k \le 202 \\ k+218, & 204 \le k \le 230 \\ k+217, & 232 \le k \le 250 \end{cases} \quad (24\text{-}35)$$

24.3.8.3 1 MHz PHY

24.3.8.3.1 Cyclic shift for S1G modulated fields

The cyclic shift values defined in this subclause apply to the STF, LTF, SIG and Data fields of the S1G 1MHz PPDU. Throughout the S1G 1MHz preamble, cyclic shifts are applied to prevent beamforming when similar signals are transmitted in different space-time streams. The same cyclic shift is applied to these streams during the transmission of the Data field of the S1G 1MHz PPDU. The cyclic shift value $T_{CS}(n)$ for space-time stream n out of $N_{STS,total}$ total space-time streams is shown in Table 24-17 (Cyclic shift values of S1G 1MHz PPDU).

Table 24-17—Cyclic shift values of S1G 1MHz PPDU

$T_{CS}(n)$ values for 1MHz PPDU

Table 24-17—Cyclic shift values of S1G 1MHz PPDU

Total number of space-time streams ($N_{STS,total}$)	Cyclic shift for space-time stream n (μs)			
	1	2	3	4
1	0	-	-	-
2	0	-4	-	-
3	0	-4	-1	-
4	0	-4	-1	-5

24.3.8.3.2 STF definition

The STF field in 1MHz preamble is repeated with 4 OFDM symbols, i.e. twice the duration of the STF fields in greater than or equal to 2MHz preambles.

The time domain representation of the STF signal at transmit chain i_{TX} shall be as specified in Equation (24-36).

$$r_{\mathrm{STF}}^{(i_{\mathrm{TX}})}(t) = \frac{\alpha(\mathrm{MCS})}{\sqrt{N_{\mathrm{STF}}^{\mathrm{Tone}} N_{\mathrm{STS}}}} w_{T_{\mathrm{STF}}}(t) \sum_{k=-N_{SR}}^{N_{SR}} \sum_{m=1}^{N_{STS}} \left[Q_k\right]_{i_{TX},m} \left[P_{HTLTF}\right]_{m,1} .S_k \exp\left(j2\pi k \Delta_F (t - T_{CS}(m))\right) \tag{24-36}$$

where

N_{SR} is defined in Table 24-4 (Timing-related constants)

$T_{CS(m)}$ represents the cyclic shift for space-time stream m with a value given in Table 24-17 (Cyclic shift values of S1G 1MHz PPDU)

Δ_F is defined in Table 24-4 (Timing-related constants)

N_{STS} is defined in Table 24-6 (Frequently used parameters)

P_{HTLTF} is defined in Equation (20-27) in 20.3.9.4.6 (HT-LTF definition)

$N_{\mathrm{STF}}^{\mathrm{Tone}}$ has the value given in Tone scaling factor and guard interval duration values for PHY fieldsTable 24-7 (Tone scaling factor and guard interval duration values for PHY fields).

S_k has non-zero values $[0.5, -1, 1, -1, -1, -0.5] \times (1 + j) \times \sqrt{2/3}$ on tones k = [–12:4:-4,4:4:12] respectively

$\alpha(MCS)$ is an MCS dependent scaling factor, with the following value

$$\alpha(\mathrm{MCS}) = \begin{cases} \sqrt{2}, & \mathrm{MCS=10} \\ 1, & \mathrm{otherwise} \end{cases}$$

24.3.8.3.3 LTF definition

The duration of the first LTF (LTF1) field in 1MHz preamble is of 4 OFDM symbols with repetitions, i.e. twice the duration of the LTF1 fields in greater than or equal to 2MHz preambles. The first two repetitions have the same structure as the LTF1 field in greater than or equal to 2MHz preambles, i.e. they consist of two periods of the long training symbol, preceded by a double length (16 *us*) cyclic prefix. Each of the last two repetitions of LTF1 field consists one period of the long training symbol preceded by a normal length (8 *us*) cyclic prefix. The duration of the each of the remaining LTFs in 1MHz preamble is of one OFDM symbol.

The placement of the first and subsequent LTFs in a 1MHz format PPDU is shown in Figure 24-22 (S1G 1MHz format).

The generation of the time domain D-LTF symbols is the same as Table 24-25 (Generation of LTF symbols).

The time domain representation of the first two repetitions of the LTF1 field, and the last two repetitions of the LTFs field shall be as specified in Equation (24-37) and Equation (24-38), respectively

$$r_{\text{LTF1\_1,2}}^{(i_{\text{TX}})}(t) = \frac{1}{\sqrt{N_{\text{LTF}}^{\text{Tone}} N_{\text{STS}}}} w_{T_{\text{LTF1}}}(t) \sum_{k=-N_{SR}}^{N_{SR}} \sum_{m=1}^{N_{STS}} \left(\begin{array}{c} \left[Q_k\right]_{i_{TX},m} \Upsilon_{k,\text{BW}} \left[A_{LTF}^{k}\right]_{m,n} LTF_k \\ .\exp\left(j2\pi k\Delta_F (t - T_{GI2} - T_{CS}(m))\right) \end{array} \right) \quad (24\text{-}37)$$

$$r_{\text{LTF1\_3,4}}^{(i_{\text{TX}})}(t) = \frac{1}{\sqrt{N_{\text{LTF}}^{\text{Tone}} N_{\text{STS}}}} w_{T_{\text{LTF1}}}(t) \sum_{k=-N_{SR}}^{N_{SR}} \sum_{m=1}^{N_{STS}} \left(\begin{array}{c} \left[Q_k\right]_{i_{TX},m} \Upsilon_{k,\text{BW}} \left[A_{LTF}^{k}\right]_{m,n} LTF_k \\ .\exp\left(j2\pi k\Delta_F (t - T_{GI} - T_{CS}(m))\right) \end{array} \right) \quad (24\text{-}38)$$

where

N_{SR} and T_{LTF} are defined in Table 24-4 (Timing-related constants)

$T_{CS(m)}$ represents the cyclic shift for space-time stream *m* with a value given in Table 24-17 (Cyclic shift values of S1G 1MHz PPDU)

$\Upsilon_{k,\text{BW}}$ is defined by Equation (24-5) ~ Equation (24-8)

Δ_F is defined in Table 24-4 (Timing-related constants)

N_{STS} is defined in Table 24-6 (Frequently used parameters)

$N_{\text{LTF}}^{\text{Tone}}$ has the value given in Tone scaling factor and guard interval duration values for PHY fieldsTable 24-7 (Tone scaling factor and guard interval duration values for PHY fields).

A_{LTF}^{k} is defined in Equation (24-39).

$$A_{LTF}^{k} = \begin{cases} \left[P_{HTLTF}\right]_{*,1} . \left[1 \quad 1 \quad 1 \quad 1\right], & \text{if } k \in K_{\text{Pilot\_Fix}} \\ P_{HTLTF}, & \text{otherwise} \end{cases} \quad (24\text{-}39)$$

where

$K_{\text{Pilot\_Fix}}$ is the subcarrier indices for the fixed pilot tones. For a 1 MHz transmission, $K_{\text{Pilot\_Fix}} = \{\pm 7\}$.

$[P_{HTLTF}]_{*,1}$ is the first column of the P_{HTLTF} matrix.

$LTF_{-16:15}$ ={0 0 0 1 -1 1 -1 -1 1 -1 1 1 -1 1 1 1 0 -1 -1 -1 1 -1 -1 -1 1 -1 1 1 1 -1 0 0}

NOTE – This LTF sequence is chosen to be orthogonal to both halves of the 2MHz LTF sequence in order to facilitate classification between 1MHz and 2MHz preambles. The orthogonality metric between two equal length sequences {A} and {B} is defined as $\sum_{k} A(k)B(k)A(k+1)^{*}B(k+1)^{*} = 0$ with k=1,2,3,..16,18,19,..31 skipping the 1MHz DC location on k=17.

NOTE—This definition results in a BPSK modulation on the last two symbols of LTF1 field, to facilitate the differentiation from the greater than or equal to 2MHz preambles.

The time domain representation of the LTF2~LTF$_{\mathrm{NLTF}}$ signals at transmit chain i_{TX} shall be as specified in Equation (24-40).

$$r^{(i_{\mathrm{TX}})}_{\mathrm{LTF2\sim LTF_{N_{LTF}}}}(t) = \frac{1}{\sqrt{N^{\mathrm{Tone}}_{\mathrm{LTF}} N_{\mathrm{STS}}}} \sum_{n=1}^{N_{LTF}-1} w_{T_{\mathrm{LTF}}}\left(t-(n-1)T_{LTF}\right)$$
$$\sum_{k=-N_{SR}}^{N_{SR}} \sum_{m=1}^{N_{STS}} \left(\begin{array}{l} \left[Q_k\right]_{i_{TX},m} \cdot \left[A^{k}_{LTF}\right]_{m,(n+1)} LTF_k \\ \cdot\exp\left(j2\pi k\Delta_F (t-(n-1)T_{LTF}-T_{GI}-T_{CS}(m))\right) \end{array} \right) \quad (24\text{-}40)$$

where

N_{SR} and T_{LTF} are defined in Table 24-4 (Timing-related constants)

$T_{CS(m)}$ represents the cyclic shift for space-time stream *m* with a value given in Table 24-13 (Per space-time-stream cyclic shift values of S1G ≥ 2MHz long preamble PPDU)

Δ_F is defined in Table 24-4 (Timing-related constants)

N_{STS} is defined in Table 24-6 (Frequently used parameters)

A^{k}_{LTF} is defined in Equation (24-39)

$N^{\mathrm{Tone}}_{\mathrm{LTF}}$ has the value given in Tone scaling factor and guard interval duration values for PHY fieldsTable 24-7 (Tone scaling factor and guard interval duration values for PHY fields).

24.3.8.3.4 SIG definition

The SIG field carries information required to interpret 1MHz S1G format PPDUs sent with a short preamble. The structure of the 6 symbol SIG field (which carries 6 information bits per symbol) is shown in. Note that unlike other SIG field structures the indexing of the bits incorporates all the SIG symbols. i.e., B0-B5 denote the first symbol, B6-B11 the second, and so on.

B0 B1	B2	B3B4	B5	B6	B7 B10	B11	B12 B20	B21B22	B23	B24	B25	B26 B29	B30 B35
Nsts	SGI	Coding	STBC	reserved	MCS	Aggregation	Length	ACK Indication	Smoothing	NDP Indication	Doppler	CRC	Tail

Table 24-18—Structure of the 6 symbol SIG field of S1G 1MHz PPDU

The SIG field of S1G 1MHz PPDUs contains the fields listed in Table 24-19 (Fields in the SIG field of 1MHz PPDU).

Table 24-19—Fields in the SIG field of 1MHz PPDU

Symbol	Bit	Field	Number of bits	Description
SIG-1	B0-B1	NSTS	2	Set to 0 for 1 space time stream Set to 1 for 2 space time streams Set to 2 for 3 space time streams Set to 3 for 4 space time streams
	B2	Short GI	1	Set to 0 if short guard interval is not used in the Data field. Set to 1 if short guard interval is used in the Data field.
	B3-B4	Coding	2	B3 set to 0 for BCC and 1 for LDPC If B3 is 1, B4 is set to 1 if the LDPC PPDU encoding process (of an SU PPDU), results in an extra OFDM symbol (or symbols) as described in 22.3.10.5.4 (LDPC coding), otherwise set to 0. If B3 is 0, B4 is reserved and set to 1.
	B5	STBC	1	Set to 1 if all spatial streams have space time block coding and set to 0 if no spatial streams has space time block coding.
SIG-2	B6	Reserved	1	Reserved. Set to 1.
	B7-B10	MCS	4	MCS Index
	B11	Aggregation	1	Set to 1 when aggregation is ON (AMPDU), and 0 otherwise. Note: S1G PPDUs shall be transmitted with aggregation ON whenever PHY payload size is greater than 511 bytes
SIG-3 and SIG-4	B12-B20	Length	9	Denotes the length of PPDU in number of symbols when aggregation bit is set to 1, and in number of bytes when aggregation bit is set to 0.
	B21-22	ACK Indication	2	This field indicates the presence and type of frame a SIFS time after the current frame transmission. Set to 0 for ACK; Set to 1 for Block ACK; Set to 2 for No ACK; Set to 3 for a frame not ACK, BA or CTS
	B23	Smoothing	1	A value of 1 indicates that channel smoothing is recommended. A value of 0 indicates that channel smoothing is not recommended.

Table 24-19—Fields in the SIG field of 1MHz PPDU

SIG-5	B24	NDP Indication	1	Used to indicate that frame is a Control NDP frame. If set to 1, then the SIG field contents follow the description in 8.3.4a (NDP MAC frames)
	B25	Doppler	1	Set to 1 to indicate travelling pilots usage in packet. Otherwise 0 to indicate regular pilot tone locations.
	B26-B29	CRC	4	CRC calculated as in 24.3.8.2.1.5 (CRC calculation for S1G SIGA fields).
SIG-6	B30-B35	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

NOTE—Integer fields are represented in unsigned binary format with the least significant bit in the lowest numbered bit position.

The SIG field of 1MHz format is composed of six OFDM symbols, SIG-1 ~ SIG-6, each containing 6 data bits, as shown in Table 24-19 (Fields in the SIG field of 1MHz PPDU). SIG-1 is transmitted first and SIG-6 is the last. The SIG symbols shall be BCC encoded at rate, R = 1/2, and repeated two times for the encoded bits within each OFDM symbol, interleaved, mapped to a BPSK constellation, and have pilots inserted, following the steps for MCS10 transmission flow described in Clause 24.3.9 (Data field). The stream of 144 complex numbers generated by these steps (before pilot insertion) is divided into six groups of 24 complex numbers $d_{k,n}$, $k = 0, \ldots, 23$, where $n = 0, 1, \ldots, 5$ respectively. All the 144 complex numbers are BPSK modulated. The first 24 complex numbers form the first symbol of SIG; and the second rotated 24 complex numbers form the second symbol of SIG, and so forth.

The time domain waveform for the SIG field in a 1MHz format PPDU at transmit chain i_{TX} shall be as specified in Equation (24-41).

$$r_{\mathrm{SIG}}^{(i_{\mathrm{TX}})}(t) = \frac{1}{\sqrt{N_{\mathrm{SIG}}^{\mathrm{Tone}} N_{\mathrm{STS}}}} \sum_{n=0}^{5} w_{T_{\mathrm{SYML}}}\left(t - nT_{SYML}\right). \sum_{k=-13}^{13} \sum_{m=1}^{N_{STS}} \left[Q_k\right]_{i_{TX},m} \left[P_{HTLTF}\right]_{m,1} \left(D_{k,n,1} + p_n P_n^{k}\right).\exp\left(j2\pi k\Delta_F(t - nT_{SYML} - T_{GI} - T_{CS}(m))\right) \quad (24\text{-}41)$$

where

p_n is defined in 18.3.5.10 (OFDM modulation), and P_n^k is defined in 22.3.10.10 (Pilot Subcarriers).

$T_{CS(m)}$ represents the cyclic shift for space-time stream *m* with a value given in Table 24-17 (Cyclic shift values of S1G 1MHz PPDU)

T_{SYML} is defined in Table 24-4 (Timing-related constants)

Δ_F is defined in Table 24-4 (Timing-related constants)

N_{STS} is defined in Table 24-6 (Frequently used parameters)

P_{HTLTF} is defined in Equation (20-27) in 20.3.9.4.6 (HT-LTF definition)

$N_{\text{SIG}}^{\text{Tone}}$ has the value given in Tone scaling factor and guard interval duration values for PHY fieldsTable 24-7 (Tone scaling factor and guard interval duration values for PHY fields).

$$D_{k,n,1} = \begin{cases} 0, & k = 0, \pm 7 \\ d_{M_1'(k),n}, & \text{otherwise} \end{cases} \tag{24-42}$$

where
$M'_1(k)$ is defined in Equation (24-53)

$$M_1'(k) = \begin{cases} k+13, & -13 \le k \le -8 \\ k+12, & -6 \le k \le -1 \\ k+11, & 1 \le k \le 6 \\ k+10, & 8 \le k \le 13 \end{cases} \tag{24-43}$$

24.3.9 Data field

24.3.9.1 General

The number of OFDM symbols in the Data field is determined by the Length/Duration field in SIG or SIG-A field of the three S1G PPDU formats, the preamble duration and the setting of the Short GI field in SIG or SIG-A field, (see 24.3.8.2.1.4 (SIG definition), 24.3.8.2.2.1.4 (SIG-A definition), and 24.3.8.3.4 (SIG definition)).When BCC encoding is used, the Data field shall consist of the SERVICE field, the PSDU, the PHY pad bits and the tail bits (bits for SU and bits for each user *u* in MU). When LDPC encoding is used, the Data field shall consist of the SERVICE field, the PSDU and the PHY pad bits. No tail bits are present when LDPC encoding is used.

24.3.9.2 SERVICE field

In S1G PPDUs, the SERVICE field has 8 bits, which shall be denoted as bits 0-7. The bit 0 shall be transmitted first in time.

The SERVICE field is as shown in Table 24-20 (SERVICE field).

Table 24-20—SERVICE field

Bits	Field	Description
B0-B6	Scrambler Initialization	Set to 0
B7	Reserved	Set to 0

24.3.9.3 Scrambler

The SERVICE, PSDU and PHY pad parts of the Data field shall be scrambled by the scrambler defined in 18.3.5.5 (PLCP DATA scrambler and descrambler).

24.3.9.4 Coding

24.3.9.4.1 General

The Data field shall be encoded using either the binary convolutional code (BCC) defined in 24.3.9.4.2 (BCC encoder parsing operation) and 24.3.9.4.3 (Binary convolutional coding and puncturing), or the low density parity check (LDPC) code defined in 24.3.9.4.4 (LDPC coding). The encoder is selected by the coding bit(s) in SIG or SIG-A field of the three S1G PPDU formats, as defined in 24.3.8.2.1.4 (SIG definition), 24.3.8.2.2.1.4 (SIG-A definition), and 24.3.8.3.4 (SIG definition). When BCC FEC encoding is used, the number of encoders is determined by rate-dependent parameters as defined in 24.5 (Parameters for S1G-MCSs). The operation of the BCC FEC is described in 24.3.9.4.2 (BCC encoder parsing operation) and 24.3.9.4.3 (Binary convolutional coding and puncturing). The operation of the LDPC coder is described in 24.3.9.4.4 (LDPC coding). Support for the reception of a BCC encoded Data field is mandatory.

24.3.9.4.2 BCC encoder parsing operation

The BCC encoder parsing operation for S1G PPDUs is the same as those specified in 22.3.10.5.2 (BCC encoder parsing operation).

24.3.9.4.3 Binary convolutional coding and puncturing

The binary convolutional coding and puncturing operation for S1G PPDUs is the same as those specified in 22.3.10.5.3 (Binary convolutional coding and puncturing).

24.3.9.4.3.1 Padding for BCC

For BCC encoder, the number of PHY padding bits, $N_{PAD,u}$, is calculated using Equation (22-52) of 22.3.11 (General). In the case of SU, $N_{PAD} = N_{PAD,0}$.

The total number of data symbols, N_{SYM}, for SU PPDU using BCC is calculated by in 22.4.3 (TXTIME and PSDU_LENGTH calculation).

The total number of Data symbols, N_{SYM}, for MU PPDU is given by in 22.3.10.5.5 (Encoding process for VHT MU PPDUs).

The padding flow for BCC encoded PPDUs is as follows:

For an S1G MU PPDU, or an S1G SU PPDU with the Aggregation bit setting to 1 in its SIG or SIG-A field, the MAC delivers a PSDU that fills the available octets in the Data field of the PPDU for each user u (i.e. append the maximum number of octets that is less than or equal to $N_{PAD,u}$). The PHY determines the number of PHY pad bits, which is $N_{PAD,u}$ modulo 8, and appends them to the PSDU, each of the PHY padding bits could be either 0 or 1. In this case, the Length subfield in SIG or SIG-A field shall set the appropriate value indicating N_{SYM} data symbols.

For an S1G SU PPDU with the Aggregation bit setting to 0 in its SIG or SIG-A field, MAC padding is not conducted and the PHY directly appends N_{PAD} padding bits to the PSDU, each of the PHY padding bits could be either 0 or 1. In this case, the Length field shall set the appropriate value indicating PSDU_LENGTH in number of octets.

Both the PSDU and the PHY padding bits are scrambled and finally the $6.N_{ES}$ zero tail bits are appended after the scrambled PSDU and PHY padding bits.

24.3.9.4.4 LDPC coding

The LDPC operation for S1G PPDUs is the same as those specified in 22.3.10.5.4 (LDPC coding).

24.3.9.4.4.1 Padding for LDPC

In the case of SU LDPC encoding, the number of PHY padding bits, N_{PAD}, is calculated using Equation (22-53) of 22.3.11 (General).

In the case of MU LDPC encoding, the number of PHY padding bits, $N_{PAD,u}$, is calculated using Equation (22-54) of 22.3.11 (General).

The padding flow for LDPC encoded PPDUs is as follows:

The initial parameter computation $N_{SYM,init}$, N_{pld} and N_{avbits} are identical to those defined in 22.3.10.5.4 (LDPC coding).

For an S1G MU PPDU, or an S1G SU PPDU with the Aggregation bit setting to 1 in its SIG or SIG-A field, the MAC delivers a PSDU that fills the available octets in the Data field of the PPDU for each user *u* (i.e. append the maximum number of octets that is less than or equal to N_{PAD} or $N_{PAD,u}$). The PHY determines the number of pad bits, which is N_{PAD} modulo 8 or $N_{PAD,u}$ modulo 8, and appends them to the PSDU, each of the PHY padding bits could be either 0 or 1. In this case, the Length subfield in SIG or SIG-A field shall set the appropriate value indicating N_{SYM} data symbols.

For an S1G SU PPDU with the Aggregation bit setting to 0 in its SIG or SIG-A field, MAC padding is not conducted and the PHY directly appends N_{PAD} padding bits to the PSDU, each of the PHY padding bits could be either 0 or 1. In this case, the Length field shall set the appropriate value indicating PSDU_LENGTH in number of octets

Both the PSDU and the PHY padding bits are scrambled, and then finally the scrambled PSDU and PHY padding bits are LDPC encoded according to 22.3.10.5.4 (LDPC coding).

In both cases, if $N_{SYM} > N_{SYM,\ init}$, the second bit in Coding or Coding-I subfield of SIG or SIG-A field shall be set to 1 (see 24.3.8.2.1.4 (SIG definition), 24.3.8.2.2.1.4 (SIG-A definition), and 24.3.8.3.4 (SIG definition)).

24.3.9.4.5 Encoding process for S1G MU PPDUs

The encoding process for S1G MU PPDUs using greater than or equal to 2MHz long format is the same as those specified in 22.3.10.5.5 (Encoding process for VHT MU PPDUs).

24.3.9.5 Repetition for 1MHz MCS10

In an 1 MHz PPDU that is modulated by MCS10, the 6 information bits of each OFDM symbol are encoded with R=1/2, then the 12 encoded bits in each OFDM symbol is block-wise repeated by the following steps.

Assume that the sequence [$C_1 \ldots C_{12}$] represents the 12 encoded bits in each OFDM symbol, the output bit stream after the repetition is:

$$C_{out}=[[C_1 \ldots C_{12}], [C_1 \ldots C_{12}] \text{ XOR } s], \quad (24\text{-}44)$$

where
s=[1 0 0 0 0 1 0 1 0 1 1 1].

The 24 output bits of the repetition are then sent to BCC interleaver (if BCC encoded) or the constellation mapper (if LDPC encoded).

24.3.9.6 Stream parser

The stream parser for S1G PPDUs is the same as those specified in 22.3.10.6 (Stream parser) with up to 4 spatial streams.

For 1MHz PPDU modulated using MCS10, more than one spatial stream shall not be applied.

24.3.9.7 Segment parser

The segment parser for S1G 16MHz PPDUs is the same as those specified for 160MHz PPDUs in 22.3.10.7 (Segment parser) .

24.3.9.8 BCC interleaver

The BCC interleaver for S1G 2MHz, 4MHz, 8MHz and 16MHz PPDUs are the same as those defined for 20MHz, 40MHz, 80MHz, and 160MHz PPDUs respectively as specified in 22.3.10.8 (BCC interleaver) .

For 1MHz PPDUs, the interleaver parameters are defined by Table 24-21 (Number of rows and columns in the interleaver for 1MHz).

Table 24-21—Number of rows and columns in the interleaver for 1MHz

Parameter	1 MHz
N_{COL}	8
N_{ROW}	$3 \times N_{BPSCS}$
N_{ROT} $(N_{SS} \leq 4)$	2

The interleaver parameters for 1MHz MCS10 is identical to the parameters used for 1MHz MCS0.

24.3.9.9 Constellation mapping

24.3.9.9.1 General

The constellation mappings for S1G PPDUs modulated using MCS0 to MCS9 are the same as those specified in 22.3.10.9.1 (General) with the same MCS indices.

The constellation mapping for 1MHz MCS10 is identical to the BPSK constellation mapping that is applied in MCS0.

24.3.9.9.2 LDPC tone mapping

The LDPC tone mapping for S1G 2MHz, 4MHz, 8MHz and 16MHz PPDUs are the same as those defined for 20MHz, 40MHz, 80MHz, and 160MHz PPDUs respectively as specified in 22.3.10.9.2 (LDPC tone mapping)

For LDPC encoded 1MHz PPDUs, LDPC tone mapping is not applied.

24.3.9.9.3 Segment deparser

The segment deparser for S1G 16MHz PPDUs is the same as those specified for 160MHz PPDUs in 22.3.10.9.3 (Segment deparser) .

24.3.9.9.4 Space-time block coding

The STBC for S1G PPDUs is the same as those specified in 22.3.10.9.4 (Space-time block coding) .

For 1MHz PPDU modulated using MCS10, STBC shall not be applied.

24.3.9.10 Pilot subcarriers

For a 1 MHz SIG field and Data field, two pilot tones shall be inserted in subcarriers. In the case of fixed pilots, the pilot mapping for subcarrier *k* for symbol *n* shall be as specified in Equation (24-45).

$$P_n^{\{-7,7\}} = \{\Psi_{(n \bmod 2)+2}, \Psi_{((n+1) \bmod 2)+2}\} \quad (24\text{-}45)$$

$$P_n^{k \notin \{-7,7\}} = 0$$

where

ψ_m is given in Table 22-21 (Pilot values for 80MHz transmission) in Clause 22.3.10.10 Pilot Subcarriers.

For greater than or equal to 2MHz PPDUs, in the case of fixed pilots, P_n^k with same FFT sizes is identical to what is defined in Clause 22.3.10.10 Pilot Subcarriers.

In the case of travelling pilots, at symbol *n*, P_n^k is defined as

$$P_n^k = \begin{cases} 1.5 \times P_{n,\text{fix}}^{k_{\text{Pilot\_Fix}}^{(l)}}, k \in K_{\text{Pilot\_Travel}}(n) \text{ and } k = K_{\text{Pilot\_Travel}}^{(l)}(n) \\ 0, \text{otherwise} \end{cases} \quad (24\text{-}46)$$

where

$K_{\text{Pilot\_Travel}}(n)$ is the set of travelling pilot subcarrier positions corresponding to data symbol *n* (*n* = 0,1,2,….N_{SYM}-1).

$K_{\text{Pilot\_Travel}}^{(l)}(n)$ is the pilot tone position in the pilot subcarrier set $K_{\text{Pilot\_Travel}}(n)$ corresponding to pilot index *l*, as shown in Table 24-22 (Travelling pilot positions for NSTS=1, 1MHz S1G PPDU)~Table 24-29 (Travelling pilot positions for NSTS=2 and STBC=1, 8MHz S1G PPDU);

$P_{n,\text{fix}}^k$ is identical to P_n^k for fixed pilots.

$k^{(l)}_{\text{Pilot\_Fix}}$ is the pilot tone position corresponding to pilot index l in the case of fixed pilots, specifically,

For 1MHz, $\{k^{(0)}_{\text{Pilot\_Fix}}, k^{(1)}_{\text{Pilot\_Fix}}\} = \{-7, 7\}$

For 2MHz, $\{k^{(0)}_{\text{Pilot\_Fix}}, \ldots, k^{(3)}_{\text{Pilot\_Fix}}\} = \{-21, -7, 7, 21\}$

For 4MHz, $\{k^{(0)}_{\text{Pilot\_Fix}}, \ldots, k^{(5)}_{\text{Pilot\_Fix}}\} = \{-53, -25, -11, 11, 25, 53\}$

For 8MHz, $\{k^{(0)}_{\text{Pilot\_Fix}}, \ldots, k^{(7)}_{\text{Pilot\_Fix}}\} = \{-103, -75, -39, -11, 11, 39, 75, 103\}$

For 16MHz, $\{k^{(0)}_{\text{Pilot\_Fix}}, \ldots, k^{(15)}_{\text{Pilot\_Fix}}\} = \{-231, -203, -167, -139, -117, -89, -53, -25, 25, 53, 89, 117, 139, 167, 203, 231\}$

The travelling pilot positions for symbol n, $K_{\text{Pilot\_Travel}}(n)$, are derived by the following paragraphs:

For an S1G SU PPDU where in its SIG or SIG-A field the NSTS subfield indicates one space time stream and the Doppler subfield is set to 1, the traveling pilots positions $K_{\text{Pilot\_Travel}}(n)$ varies from symbol to symbol according to Table 24-22 (Travelling pilot positions for NSTS=1, 1MHz S1G PPDU)~Table 24-25 (Travelling pilot positions for NSTS=1, 8MHz S1G PPDU) for bandwidth 1MHz, 2MHz, 4MHz and 8MHz. In this case, for data symbol n (n = 0,1,2,…N_{SYM}-1), the pilot positions $K_{\text{Pilot\_Travel}}(n)$ equal to those in the column corresponding to the pattern index

$$m(n) = n \text{ modulo } N_{TP,\,BW} \tag{24-47}$$

where $N_{TP,\,BW}$ is the travelling pilot pattern period with the following values:

$$N_{TP,\,1\text{MHz}} = 13$$
$$N_{TP,\,2\text{MHz}} = 14$$
$$N_{TP,\,4\text{MHz}} = 19$$
$$N_{TP,\,8\text{MHz}} = 32$$
$$N_{TP,\,16\text{MHz}} = 32$$

Table 24-22—Travelling pilot positions for NSTS=1, 1MHz S1G PPDU

Pilot Index l	Pattern Index m												
	0	1	2	3	4	5	6	7	8	9	10	11	12
0	-2	-10	-5	-13	-8	-3	-11	-6	-1	-9	-4	-12	-7
1	12	4	9	1	6	11	3	8	13	5	10	2	7

Table 24-23—Travelling pilot positions for NSTS=1, 2MHz S1G PPDU

Pilot Index *l*	Pattern Index *m*													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	-28	-24	-20	-16	-26	-22	-18	-27	-23	-19	-15	-25	-21	-17
1	-12	-8	-4	-2	-14	-10	-6	-11	-7	-3	1	-13	-9	-5
2	4	8	12	16	2	6	10	5	9	13	17	-1	3	7
3	20	24	28	26	14	18	22	21	25	23	27	11	15	19

Table 24-24—Travelling pilot positions for NSTS=1, 4MHz S1G PPDU

Pilot Index *l*	Pattern Index *m*																		
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0	-49	-41	-33	-25	-17	-9	-58	-50	-42	-34	-26	-18	-10	-2	-51	-43	-35	-27	-19
1	-30	-22	-14	-6	-55	-47	-39	-31	-23	-15	-7	-56	-48	-40	-32	-24	-16	-8	-57
2	-11	-3	-52	-44	-36	-28	-20	-12	-4	-53	-45	-37	-29	-21	-13	-5	-54	-46	-38
3	11	19	27	35	43	51	2	10	18	26	34	42	50	58	9	17	25	33	41
4	30	38	46	54	5	13	21	29	37	45	53	4	12	20	28	36	44	52	3
5	49	57	8	16	24	32	40	48	56	7	15	23	31	39	47	55	6	14	22

Table 24-25—Travelling pilot positions for NSTS=1, 8MHz S1G PPDU

Pilot Index l	Pattern Index m																														
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	-122	-118	-114	-110	-106	-102	-98	-94	-120	-116	-112	-108	-104	-100	-96	-92	-121	-117	-113	-109	-105	-101	-97	-93	-119	-115	-111	-107	-103	-99	-95	-91
1	-90	-86	-82	-78	-74	-70	-66	-62	-88	-84	-80	-76	-72	-68	-64	-60	-89	-85	-81	-77	-73	-69	-65	-61	-87	-83	-79	-75	-71	-67	-63	-59
2	-58	-54	-50	-46	-42	-38	-34	-30	-56	-52	-48	-44	-40	-36	-32	-28	-57	-53	-49	-45	-41	-37	-33	-29	-55	-51	-47	-43	-39	-35	-31	-27
3	-26	-22	-18	-14	-10	-6	-2	2	-24	-20	-16	-12	-8	-4	2	4	-25	-21	-17	-13	-9	-5	-2	3	-23	-19	-15	-11	-7	-3	2	5
4	6	10	14	18	22	26	30	34	8	12	16	20	24	28	32	36	7	11	15	19	23	27	31	35	9	13	17	21	25	29	33	37
5	38	42	46	50	54	58	62	66	40	44	48	52	56	60	64	68	39	43	47	51	55	59	63	67	41	45	49	53	57	61	65	69
6	70	74	78	82	86	90	94	98	72	76	80	84	88	92	96	100	71	75	79	83	87	91	95	99	73	77	81	85	89	93	97	101
7	102	106	110	114	118	122	120	-120	104	108	112	116	120	122	-2	-122	103	107	111	115	119	121	2	-121	105	109	113	117	121	121	-2	-121

For an S1G SU PPDU where in its SIG or SIG-A field the NSTS subfield indicates two space-time streams, STBC subfield is set to 1 and the Doppler subfield is set to 1, the traveling pilots positions $K_{\text{Pilot\_Travel}}(n)$ varies every other symbol according to Table 24-26 (Travelling pilot positions for NSTS=2 and STBC=1, 1MHz S1G PPDU) ~ Table 24-29 (Travelling pilot positions for NSTS=2 and STBC=1, 8MHz S1G PPDU) for bandwidth 1MHz, 2MHz, 4MHz and 8MHz. In this case, for data symbol n (n = 0,1,2,….N_{SYM}-1), the pilot positions $K_{\text{Pilot\_Travel}}(n)$ equal to those in the column corresponding to the pattern index

$$m(n) = \left\lfloor \frac{n}{2} \right\rfloor \text{ modulo } N_{TP,\,BW} \tag{24-48}$$

where $\lfloor x \rfloor$ is largest integer that is less than or equal to x; and $N_{TP,\,BW}$ is the travelling pilot pattern period with the following values:

$$N_{TP,\,1\text{MHz}} = 7$$
$$N_{TP,\,2\text{MHz}} = 7$$
$$N_{TP,\,4\text{MHz}} = 10$$
$$N_{TP,\,8\text{MHz}} = 16$$
$$N_{TP,\,16\text{MHz}} = 16$$

Table 24-26—Travelling pilot positions for NSTS=2 and STBC=1, 1MHz S1G PPDU

Pilot Index l	Pattern Index m						
	0	1	2	3	4	5	6
0	-3	-13	-9	-5	-1	-11	-7
1	11	1	5	9	13	3	7

Table 24-27—Travelling pilot positions for NSTS=2 and STBC=1, 2MHz S1G PPDU

Pilot Index l	Pattern Index m						
	0	1	2	3	4	5	6
0	-28	-24	-20	-16	-26	-22	-18
1	-12	-8	-4	-2	-14	-10	-6
2	4	8	12	16	2	6	10
3	20	24	28	26	14	18	22

Table 24-28—Travelling pilot positions for NSTS=2 and STBC=1, 4MHz S1G PPDU

Pilot Index l	Pattern Index m									
	0	1	2	3	4	5	6	7	8	9
0	-50	-44	-38	-32	-26	-20	-14	-8	-2	-56
1	-30	-24	-18	-12	-6	-58	-54	-48	-42	-36
2	-10	-4	-58	-52	-46	-40	-34	-28	-22	-16
3	10	16	22	28	34	40	46	52	58	4
4	30	36	42	48	54	58	6	12	18	24
5	50	56	2	8	14	20	26	32	38	44

Table 24-29—Travelling pilot positions for NSTS=2 and STBC=1, 8MHz S1G PPDU

Pilot Index l	Pattern Index m															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	-122	-118	-114	-110	-106	-102	-98	-94	-120	-116	-112	-108	-104	-100	-96	-92
1	-90	-86	-82	-78	-74	-70	-66	-62	-88	-84	-80	-76	-72	-68	-64	-60
2	-58	-54	-50	-46	-42	-38	-34	-30	-56	-52	-48	-44	-40	-36	-32	-28
3	-26	-22	-18	-14	-10	-6	-2	2	-24	-20	-16	-12	-8	-4	2	4
4	6	10	14	18	22	26	30	34	8	12	16	20	24	28	32	36
5	38	42	46	50	54	58	62	66	40	44	48	52	56	60	64	68
6	70	74	78	82	86	90	94	98	72	76	80	84	88	92	96	100
7	102	106	110	114	118	122	120	-120	104	108	112	116	120	122	-2	-122

For a 16MHz S1G PPDU with travelling pilots, in the data symbol n (n = 0,1,2,…. N_{SYM}-1), there are totally 16 pilot subcarriers, whose positions $K_{\mathrm{Pilot\_Travel}}(n)$ are expressed as:

$$K_{\mathrm{Pilot\_Travel}}(n) = \begin{cases} K_{\mathrm{Pilot\_Travel,8MHz}}(n) - 128, \text{ for pilot indices } 0 \le l < 7 \\ K_{\mathrm{Pilot\_Travel,8MHz}}(n) + 128, \text{ for pilot indices } 8 \le l < 15 \end{cases} \quad (24\text{-}49)$$

where $K_{\text{Pilot\_Travel,8MHz}}(n)$ is the travelling pilot positions of the 8 pilot subcarriers for symbol index n and 8MHz, calculated based on Table 24-25 (Travelling pilot positions for NSTS=1, 8MHz S1G PPDU) in the case of single space-time stream, or based on Table 24-29 (Travelling pilot positions for NSTS=2 and STBC=1, 8MHz S1G PPDU) in the case of STBC with two space-time streams.

For S1G MU PPDUs, or S1G SU PPDUs with more than two space-time streams, or S1G SU PPDUs with two space-time streams without STBC, travelling pilots are not defined.

24.3.9.11 OFDM modulation

24.3.9.11.1 Transmission in S1G format

For S1G transmissions using greater than or equal to 2MHz short format, the Data field signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$, shall be as specified in Equation (24-50).

$$r_{\text{Data}}^{(i_{\text{TX}})}(t) = \frac{1}{\sqrt{N_{\text{Data}}^{\text{Tone}} N_{\text{STS}}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{\text{SYM}}}\left(t - T_{Accum}(n)\right). \sum_{k=-N_{SR}}^{N_{SR}} \sum_{m=1}^{N_{STS}} \left(\begin{array}{l} \left[Q_k\right]_{i_{TX},m} \gamma_{k,BW} \left(\tilde{D}_{k,m,n,BW} + \left[P_{HTLTF}\right]_{m,1} . p_{n+2} P_n^{\text{k}}\right) \\ \quad . \exp\left(j2\pi k \Delta_F (t - T_{Accum}(n) - T_{GI,Data}(n) - T_{CS}(m))\right) \end{array} \right) \quad (24\text{-}50)$$

For S1G transmissions using greater than or equal to 2MHz long format, the Data field signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$, shall be as specified in Equation (24-51).

$$r_{\text{Data}}^{(i_{\text{TX}})}(t) = \frac{1}{\sqrt{N_{\text{Data}}^{\text{Tone}} N_{\text{STS,total}}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{\text{SYM}}}\left(t - T_{Accum}(n)\right). \sum_{k=-N_{SR}}^{N_{SR}} \sum_{u=0}^{N_u-1} \sum_{m=1}^{N_{STS,u}} \left(\begin{array}{l} \left[Q_k\right]_{i_{TX},(M_u+m)} \gamma_{k,BW} \left(\tilde{D}_{k,m,n,BW} + \left[P_{HTLTF}\right]_{m,1} . p_{z(n)} P_{(z(n)-2)}^{\text{k}}\right) \\ \quad . \exp\left(j2\pi k \Delta_F (t - T_{Accum}(n) - T_{GI,Data}(n) - T_{CS}(m))\right) \end{array} \right) \quad (24\text{-}51)$$

For S1G transmissions using 1MHz format, the Data field signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$, shall be as specified in Equation (24-52).

$$r_{\text{Data}}^{(i_{\text{TX}})}(t) = \frac{1}{\sqrt{N_{\text{Data}}^{\text{Tone}} N_{\text{STS}}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{\text{SYM}}}\left(t - T_{Accum}(n)\right). \sum_{k=-N_{SR}}^{N_{SR}} \sum_{m=1}^{N_{STS}} \left(\begin{array}{l} \left[Q_k\right]_{i_{TX},m} \gamma_{k,BW} \left(\tilde{D}_{k,m,n,BW} + \left[P_{HTLTF}\right]_{m,1} . p_{n+6} P_n^{\text{k}}\right) \\ \quad . \exp\left(j2\pi k \Delta_F (t - T_{Accum}(n) - T_{GI,Data}(n) - T_{CS}(m))\right) \end{array} \right) \quad (24\text{-}52)$$

where

N_{SR} is defined in Table 24-4 (Timing-related constants)

p_n is defined in 18.3.5.10 (OFDM modulation)

P_n^k is defined in 24.3.9.10 (Pilot subcarriers)

$T_{CS(m)}$ represents the cyclic shift for space-time stream *m* with a value given in Table 24-9 (Cyclic shift values for the S1G short preamble PPDU) in the case of ≥2MHz formats, and in Table 24-17 (Cyclic shift values of S1G 1MHz PPDU) in the case of 1MHz format.

$\Upsilon_{k,\mathrm{BW}}$ is defined by Equation (24-5) ~ Equation (24-8)

Δ_F is defined in Table 24-4 (Timing-related constants)

N_{STS}, $N_{STS,total}$, and $N_{STS,u}$ are defined in Table 24-6 (Frequently used parameters)

P_{HTLTF} is defined in Equation (20-27) in 20.3.9.4.6 (HT-LTF definition)

$N_{\mathrm{Data}}^{\mathrm{Tone}}$ has the value given in Tone scaling factor and guard interval duration values for PHY fieldsTable 24-7 (Tone scaling factor and guard interval duration values for PHY fields).

N_u, and M_u are defined in Table 24-6 (Frequently used parameters)

$z(n)$ in Equation (24-51) is defined as below:

$$z(n) = \begin{cases} n+2, & \text{if the MU/SU bit in SIG-A field is set to 0} \\ n+3, & \text{if the MU/SU bit in SIG-A field is set to 1} \end{cases}$$

$T_{GI,Data}(n)$ is the guard interval duration with the value as below:

$$T_{GI,Data}(n) = \begin{cases} T_{GI}, \text{ if } n = 0 \\ T_{GI}, \text{ if } n > 0 \text{ and Short GI subfield of SIG or SIG-A field is 0} \\ T_{SGI}, \text{ if } n > 0 \text{ and Short GI subfield of SIG or SIG-A field is 1} \end{cases} \quad (24\text{-}53)$$

$\tilde{D}_{k,m,n,BW}$ is as defined by Equation (24-54)

$$\tilde{D}_{k,m,n,BW} = \begin{cases} 0, & \text{if } k \in K_{\mathrm{Pilot}}(\mathrm{n}) \\ \tilde{d}_{M'_{BW}(k),m,n}, & \text{otherwise} \end{cases} \quad (24\text{-}54)$$

where

$$K_{\mathrm{Pilot}}(n) = \begin{cases} K_{\mathrm{Pilot\_Fix}}, & \text{if the Doppler bit in SIG or SIG-A field is set to 0} \\ K_{\mathrm{Pilot\_Travel}}(n), & \text{if the Doppler bit in SIG or SIG-A field is set to 1} \end{cases} \quad (24\text{-}55)$$

in which $K_{\mathrm{Pilot\_Fix}}$ is defined in 24.3.8.2.1.3 (LTF definition) for ≥2MHz and 24.3.8.3.3 (LTF definition) for 1MHz, and $K_{\mathrm{Pilot\_Travel}}(n)$ is defined in 24.3.9.9 (Pilot subcarriers); and $M'_{BW}(k)$ is defined in Equation (24-29) to Equation (24-35) in 24.3.8.2.2.2.4 (SIG-B definition) for 2,4,8,16MHz, as well as Equation (24-43) in 24.3.8.3.4 (SIG definition) for 1MHz.

$T_{Accum}(n)$ is the accumulated duration from data symbol 0 to data symbol (*n-1*):

$$T_{Accum}(n) = \begin{cases} 0, & \text{if } n = 0 \\ T_{SYML} + (n-1)T_{SYM}, & \text{if } n > 0 \end{cases} \quad (24\text{-}56)$$

where
T_{SYML} and T_{SYM} are defined in Table 24-4 (Timing-related constants).

Q_k is a spatial mapping/steering matrix with N_{TX} rows and N_{STS} or $N_{STS,total}$ columns for subcarrier k. Q_k may be frequency dependent. Refer to the examples of listed in 20.3.11.11.2 (Spatial mapping) for examples of that could be used for S1G SU PPDUs. Note that implementations are not restricted to the spatial mapping matrix examples listed in Section 20.3.11.11.2 (Spatial mapping) and the number of transmit chains N_{TX} could be up to 4. For SU PPDUs to which beamforming is applied, Q_k is a beamforming steering matrix and is derived from the TXVECTOR parameter EXPANSION_MAT. For S1G MU PPDUs, Q_k is the DL-MU-MIMO steering matrix and is derived from the TXVECTOR parameter EXPANSION_MAT. The beamforming steering matrices and DL-MU-MIMO steering matrices are implementation specific.

The auto-detection between 1MHz and 2MHz preambles assumes channel smoothness. It is recommended that the spatial mapping matrix Q_k applied to LTF1 is chosen such that it preserves the smoothness of the physical channel. This can, for example, be achieved by minimizing the amplitude and phase variation of each element of Q_k in successive tones.

Examples:

a) The following may be used Q_k: Q_k as defined for cyclic shift diversity using the values specified in the corresponding tables.

b) The following Q_k should not be used – antenna hopping as described in 802.11REVmb section 20.3.11.11.2 (C)-(2) - the values of Q_k on successive tones flip between 1 and 0.

24.3.9.12 1MHz and 2MHz duplicate transmission

24.3.9.12.1 1MHz duplicate transmission

1MHz duplicate transmission is used to transmit to S1G STAs that may be present in a part of a 2 MHz, 4 MHz, 8MHz or 16 MHz channel.

In an 1MHz duplicated PPDU, both the 1MHz preamble and data field are duplicated in each 1MHz sub-channel of the 2MHz, 4MHz, 8MHz or 16MHz channel. Both an 1MHz data PPDU and an 1MHz NDP may be duplicated.

For 1MHz duplicated transmission the Data field signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$, shall be as specified in Equation (24-47).

$$r^{(i_{TX})}_{\mathrm{Data,1MHz,BW}}(t) = \frac{1}{\sqrt{N^{\mathrm{Tone}}_{\mathrm{1MHz\_DUP\_Data}} N_{\mathrm{STS}}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{\mathrm{SYM}}}\left(t - T_{Accum}(n)\right). \sum_{i_{\mathrm{BW}}=0}^{N_{1MHz}-1} \left(\sum_{k=-13}^{13} \sum_{m=1}^{N_{STS}} \left(\begin{array}{l} \left[Q_k\right]_{i_{TX},m} \gamma_{1MHz,(k-K_{Shift,1MHz}(i_{BW})),BW} \left(\tilde{D}_{k,m,n,1MHz} + \left[P_{HTLTF}\right]_{m,1} \cdot p_{n+6} P^{k}_{n}\right) \\ .\exp\left(\begin{array}{l} j2\pi(k - K_{Shift,1MHz}(i_{BW}))\Delta_F \cdot \\ (t - T_{Accum}(n) - T_{GI,Data}(n) - T_{CS}(m)) \end{array} \right) \end{array} \right) \right) \quad (24\text{-}57)$$

where

p_n is defined in 18.3.5.10 (OFDM modulation)

P_n^k is defined in 24.3.9.10 (Pilot subcarriers)

$T_{CS(m)}$ represents the cyclic shift for space-time stream *m* with a value given in Table 24-17 (Cyclic shift values of S1G 1MHz PPDU).

$\Upsilon_{1MHz,k,\mathrm{BW}}$ is defined by Equation (24-9) ~ Equation (24-12)

Δ_F is defined in Table 24-4 (Timing-related constants)

N_{STS} is defined in Table 24-6 (Frequently used parameters)

P_{HTLTF} is defined in Equation (20-27) in 20.3.9.4.6 (HT-LTF definition)

$N^{\mathrm{Tone}}_{\mathrm{1MHz\_DUP\_Data}}$ has the value given in Tone scaling factor and guard interval duration values for PHY fieldsTable 24-7 (Tone scaling factor and guard interval duration values for PHY fields)

$T_{GI,Data}(n)$ is defined in Equation (24-53)

$\tilde{D}_{k,\,n,\,n,\,BW}$ is defined in Equation (24-54)

$T_{Accum}(n)$ is defined in Equation (24-56)

N_{1MHz} is the number of 1MHz sub-channels that are contained within the whole bandwidth of the cur rent PPDU (e.g. $N_{1MHz} = 4$ for a 4MHz PPDU).

$$K_{Shift,1MHz}(i) = (N_{1MHz} - 1 - 2i).16 \qquad (24\text{-}58)$$

24.3.9.12.2 2MHz duplicate transmission

2MHz duplicate transmission is used to transmit to S1G STAs that may be present in a part of a 4 MHz, 8MHz or 16 MHz channel.

In a 2MHz duplicated PPDU, both the 2MHz preamble (short or long format) and data field are duplicated in each 2MHz sub-channel of the 4MHz, 8MHz or 16MHz channel.

2MHz NDP sounding or short MAC frame shall not be duplicated. Instead, a 4MHz, 8MHz or 16MHz NDP shall be transmitted whenever needed.

For 2MHz short format duplicated transmission the Data field signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$, shall be as specified in Equation (24-59).

$$r^{(i_{\mathrm{TX}})}_{\mathrm{Data,2MHz,BW}}(t) = \frac{1}{\sqrt{N^{\mathrm{Tone}}_{\mathrm{1MHz\_DUP\_Data}} N_{\mathrm{STS}}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{\mathrm{SYM}}}\left(t - T_{Accum}(n)\right). \sum_{i_{\mathrm{BW}}=0}^{N_{2MHz}-1} \left(\sum_{k=-28}^{28} \sum_{m=1}^{N_{STS}} \left(\begin{array}{l} \left[Q_k\right]_{i_{TX},m} \gamma_{(k-K_{Shift}(i_{BW})),BW} \left(\tilde{D}_{k,m,n,2MHz} + \left[P_{HTLTF}\right]_{m,1} \cdot p_{n+2} P_n^{\mathrm{k}}\right) \\ .\exp\left(\begin{array}{l} j2\pi(k - K_{Shift}(i_{BW}))\Delta_F. \\ (t - T_{Accum}(n) - T_{GI,Data}(n) - T_{CS}(m)) \end{array} \right) \end{array} \right) \right), \qquad (24\text{-}59)$$

and for 2MHz long format duplicated transmission the Data field signal from transmit chain i_{TX}, $\le i_{TX} \le N_{T}$ shall be as specified in Equation (24-60).

$$r_{\text{Data,2MHz,BW}}^{(i_{\text{TX}})}(t) = \frac{1}{\sqrt{N_{\text{1MHz\_DUP\_Data}}^{\text{Tone}} N_{\text{STS}}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{\text{SYM}}}\left(t - T_{Accum}(n)\right).$$

$$\sum_{i_{\text{BW}}=0}^{N_{2MHz}-1} \left(\sum_{k=-28}^{28} \sum_{m=1}^{N_{STS}} \left(\begin{array}{l} \left[Q_k\right]_{i_{TX},m} \gamma_{(k-K_{Shift}(i_{BW})),BW} \left(\tilde{D}_{k,m,n,2MHz} + \left[P_{HTLTF}\right]_{m,1} \cdot p_{z(n)} P_{z(n)-2}^{\text{k}}\right) \\ .\exp\left(\begin{array}{l} j2\pi(k - K_{Shift}(i_{BW}))\Delta_F . \\ (t - T_{Accum}(n) - T_{GI,Data}(n) - T_{CS}(m)) \end{array} \right) \end{array} \right) \right) \quad , \quad (24\text{-}60)$$

where

p_n is defined in 18.3.5.10 (OFDM modulation)

P_n^k is defined in 24.3.9.10 (Pilot subcarriers)

$T_{CS(m)}$ represents the cyclic shift for space-time stream *m* with a value given in Table 24-9 (Cyclic shift values for the S1G short preamble PPDU).

$\Upsilon_{k,\text{ BW}}$ is defined by Equation (24-5) ~ Equation (24-8)

Δ_F is defined in Table 24-4 (Timing-related constants)

N_{STS} is defined in Table 24-6 (Frequently used parameters)

P_{HTLTF} is defined in Equation (20-27) in 20.3.9.4.6 (HT-LTF definition)

$N_{\text{2MHz\_DUP\_Data}}^{\text{Tone}}$ has the value given in Tone scaling factor and guard interval duration values for PHY fieldsTable 24-7 (Tone scaling factor and guard interval duration values for PHY fields)

$T_{GI,Data}(n)$ is defined in Equation (24-53)

$\tilde{D}_{k,\,n,\,n,\,BW}$ is defined in Equation (24-54)

$T_{Accum}(n)$ is defined in Equation (24-56)

N_{2MHz} is the number of 1MHz sub-channels that are contained within the whole bandwidth of the cur rent PPDU (e.g. $N_{2MHz} = 2$ for a 4MHz PPDU).

$K_{Shift}(i)$ is defined in Equation (24-18).

24.3.10 SU-MIMO and DL-MU-MIMO Beamforming

24.3.10.1 General

S1G SU-MIMO and DL-MU-MIMO beamforming are techniques used by a STA with multiple antennas (the beamformer) to steer signals using knowledge of the channel to improve throughput. The general description of SU-MIMO and DL-MU-MIMO beamforming is identical to its VHT counterparts as described in 22.3.11.1 (General) with VHT replaced by S1G.

Note that in S1G band, the SU-MIMO allows beamforming up to 4 space-time streams, and for DL-MU-MIMO beamforming allows up to 4 total number of space-time streams for all users each with up to 3 space-time streams.

S1G beamforming exchange is defined only for 2MHz, 4MHz, 8MHz and 16MHz.

24.3.10.2 Beamforming Feedback Matrix V

The description of beamforming feedback matrix V in S1G band is identical to its VHT counterpart as described in 22.3.11.2 (Beamforming feedback matrix V) with VHT replaced by S1G.

Note that the compressed beamforming feedback using 20.3.12.3.6 (Compressed beamforming feedback matrix) is the only Clause 24 beamforming feedback format defined. When the ψ angle is not included in the feedback frame, in the case of SU feedback with single column, ψ angle values are assumed as given below, which correspond to the first column of the V matrix having elements with equal magnitude:

$$\text{If } N_r \times N_c = 4 \times 1,\ \psi_{21} = 0.25\pi, \psi_{31} = 0.196\pi, \psi_{41} = 0.167\pi$$
$$\text{If } N_r \times N_c = 3 \times 1,\ \psi_{21} = 0.25\pi, \psi_{31} = 0.196\pi$$
$$\text{If } N_r \times N_c = 2 \times 1,\ \psi_{21} = 0.25\pi$$

24.3.10.3 Maximum Number of Total Spatial Streams in S1G MU PPDUs

An MU capable STA shall support reception of S1G MU PPDUs with the total number of space-time streams across the NUM_USERS users being less than or equal to its Compressed Steering Number of Beamformer Antennas Supported in the S1G Capabilities Info field. The upper limit is 4 spatial streams.

24.3.10.4 Group ID

The description of Group ID in S1G band is identical to its VHT counterpart as described in 22.3.11.4 (Group ID) with VHT replaced by S1G.

24.3.11 S1G preamble format for sounding PPDUs

An NDP may be used for sounding or for NDP MAC frames. When used for sounding, an NDP shall indicate multiple space-time streams in SIG field and use more than one LTF fields; when used for NDP MAC frames, an NDP shall use single space-time stream with one LTF field

NDP is the only S1G sounding format.

NDP for sounding is defined only using the greater than or equal to 2MHz short format, and NDP for sounding is not allowed for 1MHz transmissions. NDP MAC frames may either use a greater than or equal to 2MHz short format, or an 1MHz format.

The format of a S1G NDP PPDU for sounding is shown in Figure 24-35 (S1G NDP for Sounding Format).

2 symbols	2 symbols	2 symbols	1 symbol per LTF
STF	LTF1	SIG	LTF2~LTFN$_{LTF}$

Figure 24-35—S1G NDP for Sounding Format

NOTE—The number of LTF symbols in the NDP is determined by the NSTS subfield in SIG field.

The S1G NDP PPDU for sounding has the following properties:

— uses the S1G PPDU format but without the Data field
— uses the greater than or equal to 2MHz short format
— uses the following settings in SIG field:
  - MCS field is set to 0
  - Length/Duration field is set to 0
  - Bandwidth field is set to the same value as the TXVECTOR parameter CH_BANDWIDTH in the preceding S1G NDP Announcement frame.
  - NSTS field indicates two or more space-time streams
  - The NDP indication bit is set to 0
— contains two or more LTF fields.

The format of a S1G NDP MAC frame in 2MHz, 4MHz, 8MHz or 16MHz is shown in Figure 24-36 (S1G NDP MAC frame for ≥2MHz).

2 symbols	2 symbols	2 symbols
STF	LTF1	SIG

Figure 24-36—S1G NDP MAC frame for ≥2MHz

The format of a S1G NDP MAC frame in 1MHz is shown in Figure 24-37 (S1G NDP MAC frame for 1MHz).

4 symbols	4 symbols	6 symbols
STF	LTF1	SIG

Figure 24-37—S1G NDP MAC frame for 1MHz

The S1G NDP MAC frame has the following properties:
— uses the S1G PPDU format but without the Data field
— uses either the greater than or equal to 2MHz short format or the 1MHz format
— uses the following settings in SIG field:
  - The NDP indication bit is set to 1
— contains only one LTF field

The SIG field formats of NDP MAC frames are as in Figure 24-38 (SIG field format for 1MHz NDP MAC frame) and Figure 24-39 (SIG field format for >=2MHz NDP MAC frame).

B0	B24	B25	B26	B29	B30	B35

Figure 24-38—SIG field format for 1MHz NDP MAC frame

NDP MAC frame body	NDP Indication	CRC	Tail

Figure 24-38—SIG field format for 1MHz NDP MAC frame

B0 B36	B37	B38 B41	B30 B35
NDP MAC frame body	NDP Indication	CRC	Tail

Figure 24-39—SIG field format for >=2MHz NDP MAC frame

The NDP MAC frame body field is described in 8.3.4a (NDP MAC frames).

The NDP Indication field is set to 1.

The CRC field is described in 24.3.8.2.1.5 (CRC calculation for S1G SIGA fields). Tail field is set to 0.

24.3.12 Regulatory requirements

WLANs implemented in accordance with this standard are subject to equipment certification and operating requirements established by regional and national regulatory administrations. The PHY specification establishes minimum technical requirements for interoperability, based upon established regulations at the time this standard was issued. These regulations are subject to revision, or may be superseded. Requirements that are subject to local geographic regulations are annotated within the PHY specification. Regulatory requirements that do not affect interoperability are not addressed in this standard. Implementers are referred to the regulatory sources in Annex D for further information. Operation in countries within defined regulatory domains may be subject to additional or alternative national regulations.

24.3.13 Channelization

STAs compliant with the physical layer defined in Clause 24 (Sub 1 GHz (S1G) PHY specification) operate in the channels (700MHz ~ 1GHz) defined in Annex E.

The channel center frequency is defined as:

Channel center frequency = Channel starting frequency + 0.5[MHz] × ChannelCenterFrequencyIndex

where Channel center frequency, Channel starting frequency and ChannelCenterFrequencyIndex are given by the operating class (Annex E). Channel spacing in Annex E denotes the corresponding bandwidth for S1G operation.

24.3.14 Transmit RF delay

The transmitter RF delay is defined in 18.3.8.6 (TX RF delay).

24.3.15 Slot time

The slot time for the S1G PHY shall be 52 μs.

24.3.16 Transmit and receive port impedance

Transmit and receive antenna port impedance for each transmit and receive antenna is defined in 18.3.8.8 (Transmit and receive antenna port impedance).

24.3.17 S1G transmit specification

24.3.17.1 Transmit spectrum mask

NOTE 1-In the presence of additional regulatory restrictions, the device has to meet both the regulatory requirements and the mask defined in this section.

NOTE 2-Transmit spectral mask figures in this subclause are not drawn to scale.

NOTE 3-For rules regarding TX center frequency leakage levels see (Transmit modulation accuracy specifications are described in 24.3.17.4.2 (Transmitter center frequency leakage) and 24.3.17.4.3 (Transmitter constellation error). The test method is described in 24.3.17.4.4 (Transmitter modulation accuracy (EVM) test). Transmit center frequency leakage). The spectral mask requirements in this section do not apply to the RF LO.

For a 1MHz mask S1G PPDU, the interim transmit spectral mask shall have a 0dBr (dB relative to the maximum spectral density of the signal) bandwidth of 0.9 MHz, -20 dBr at 0.6 MHz frequency offset, -28 dBr at 1 MHz frequency offset and -40 dBr at 1.5 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets in between 0.45 and 0.6 MHz, 0.6 and 1 MHz, and 1 and 1.5 MHz shall be linearly interpolated in dB domain from the requirements for 0.45, 0.6, 1 and 1.5 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectral mask and -40 dBm/MHz at any frequency offset. Figure 24-40 (Transmit spectral mask for 1 MHz channel) shows an example of the resulting overall spectral mask when the -40 dBr spectrum level is above -40 dBm/MHz.

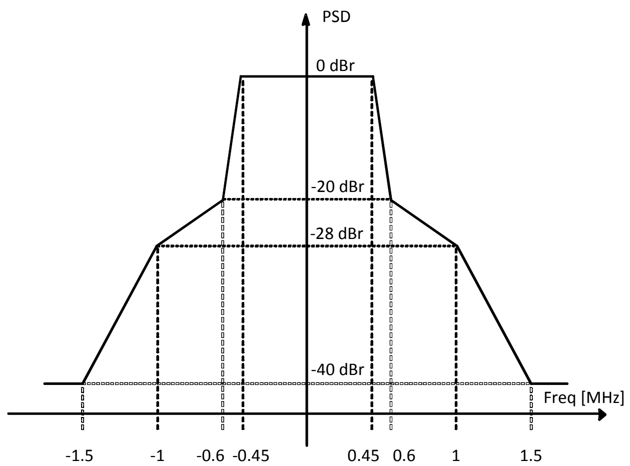


Figure 24-40—Transmit spectral mask for 1 MHz channel

For a 2MHz mask S1G PPDU, the interim transmit spectral mask shall have a 0dBr (dB relative to the maximum spectral density of the signal) bandwidth of 1.8 MHz, -20 dBr at 1.1 MHz frequency offset, -28 dBr at 2 MHz frequency offset and -40 dBr at 3 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets in between 0.9 and 1.1 MHz, 1.1 and 2 MHz, and 2 and 3 MHz shall be linearly interpolated in dB domain from the requirements for 0.9, 1.1, 2 and 3 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectral mask and -43 dBm/MHz at any frequency offset. Figure 24-41 (Transmit spectral mask for 2 MHz channel) shows an example of the resulting overall spectral mask when the -40 dBr spectrum level is above -43 dBm/MHz.

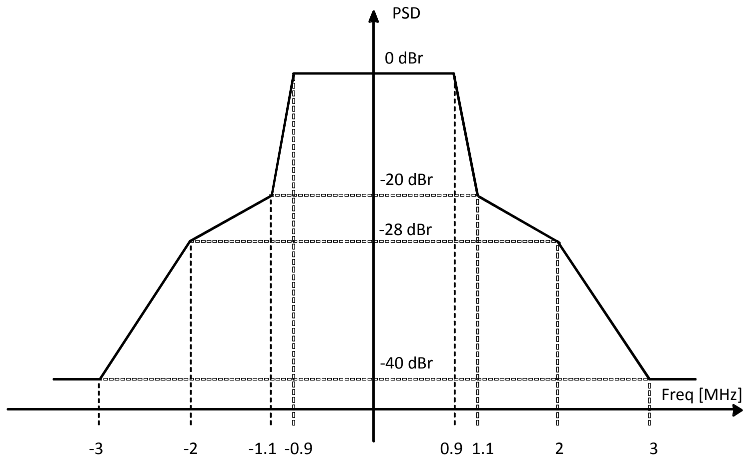


Figure 24-41—Transmit spectral mask for 2 MHz channel

For a 4MHz mask S1G PPDU, the interim transmit spectral mask shall have a 0dBr (dB relative to the maximum spectral density of the signal) bandwidth of 3.8 MHz, -20 dBr at 2.1 MHz frequency offset, -28 dBr at 4 MHz frequency offset and -40 dBr at 6 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets in between 1.9 and 2.1 MHz, 2.1 and 4 MHz, and 4 and 6 MHz shall be linearly interpolated in dB domain from the requirements for 1.9, 2.1, 4 and 6 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectral mask and -46 dBm/MHz at any frequency offset. Figure 24-42 (Transmit spectral mask for 4 MHz channel) shows an example of the resulting overall spectral mask when the -40 dBr spectrum level is above -46 dBm/MHz.

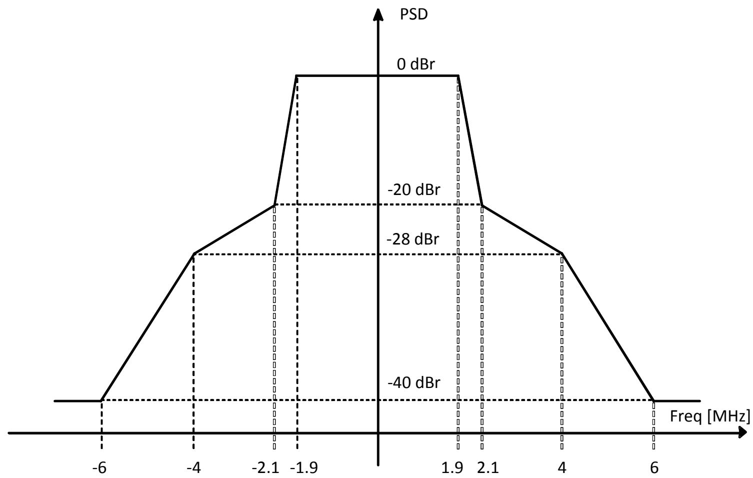


Figure 24-42—Transmit spectral mask for 4 MHz channel

For a 8MHz mask S1G PPDU, the interim transmit spectral mask shall have a 0dBr (dB relative to the maximum spectral density of the signal) bandwidth of 7.8 MHz, -20 dBr at 4.1 MHz frequency offset, -28 dBr at 8 MHz frequency offset and -40 dBr at 12 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets in between 3.9 and 4.1 MHz, 4.1 and 8 MHz, and 8 and 12 MHz shall be linearly interpolated in dB domain from the requirements for 3.9, 4.1, 8 and 12 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectral mask and -49 dBm/MHz at any frequency offset. Figure 24-43 (Transmit spectral mask for 8 MHz channel) shows an example of the resulting overall spectral mask when the -40 dBr spectrum level is above -49 dBm/MHz.

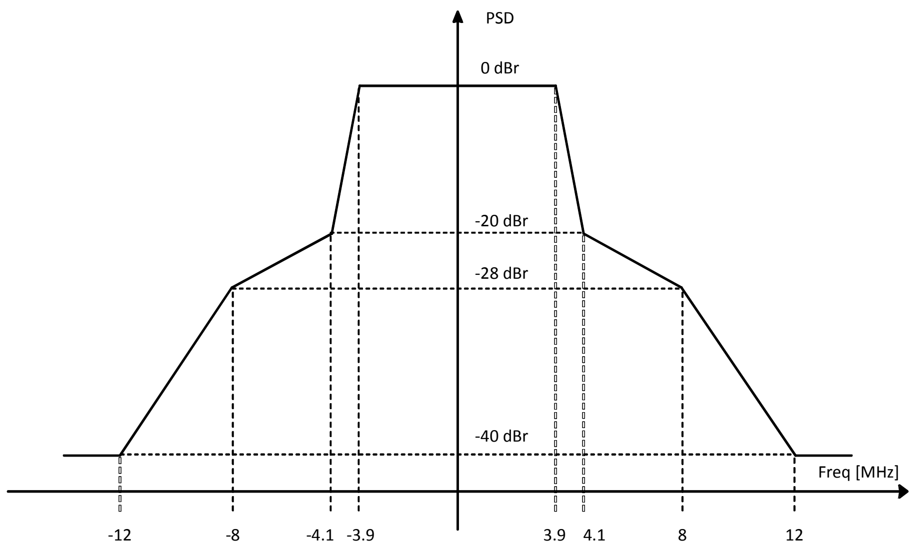


Figure 24-43—Transmit spectral mask for 8 MHz channel

For a 16MHz mask S1G PPDU, the interim transmit spectral mask shall have a 0dBr (dB relative to the maximum spectral density of the signal) bandwidth of 15.8 MHz, -20 dBr at 8.1 MHz frequency offset, -28 dBr at 16 MHz frequency offset and -40 dBr at 24 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets in between 7.9 and 8.1 MHz, 8.1 and16 MHz, and 16 and 24 MHz shall be linearly interpolated in dB domain from the requirements for 7.9, 8.1, 16 and 24 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectral mask and -49 dBm/ MHz at any frequency offset. Figure 24-44 (Transmit spectral mask for 16 MHz channel) shows an example of the resulting overall spectral mask when the -40 dBr spectrum level is above -49 dBm/MHz.

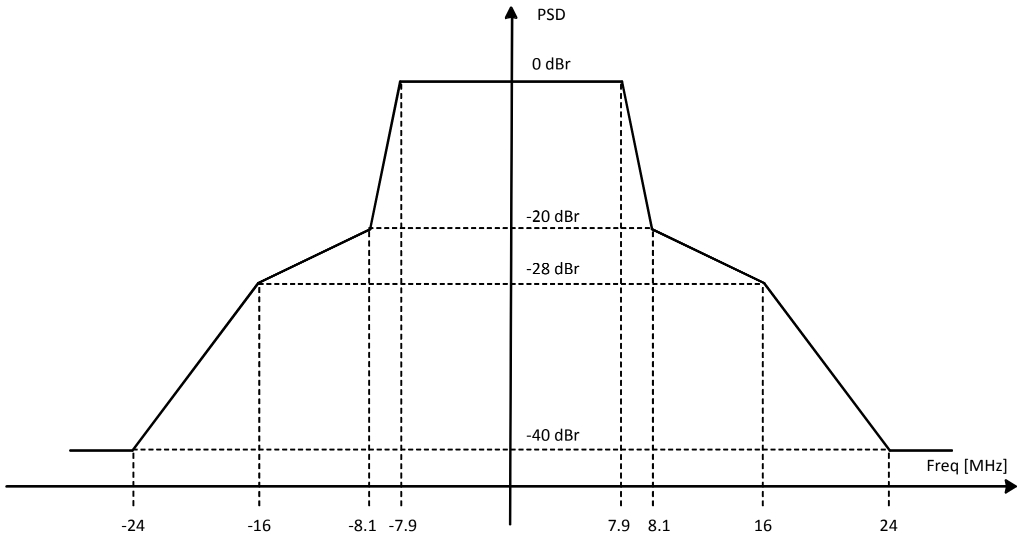


Figure 24-44—Transmit spectral mask for 16 MHz channel

Measurements shall be made using a 10 kHz resolution bandwidth and a 100Hz video bandwidth.

24.3.17.2 Spectral flatness

Spectral flatness measurements shall be conducted using BPSK modulated PPDUs.

Let $E_{i,avg}$ denote the average constellation energy of a BPSK modulated subcarrier *i* in a S1G data symbol.

In a normal mode S1G transmission or contiguous 1MHz or 2MHz Duplicate mode transmission having a bandwidth listed in Table 24-30 (Maximum Spectral Flatness Deviations), $E_{i,avg}$ of each of the subcarriers with indices listed as tested subcarrier indices shall not deviate by more than the specified maximum deviation in Table 1 from the average of $E_{i,avg}$ over subcarrier indices listed as averaging subcarrier indices. Averaging of $E_{i,avg}$ is done in the linear domain.

For the spectral flatness test, the transmitting STA shall be configured to use a spatial mapping matrix Q_k with flat frequency response. Each output port under test of the transmitting STA shall be connected through a cable to one input port of the testing instrumentation. The requirements apply to 1 MHz, 2 MHz, 4 MHz, 8 MHz and 16 MHz normal mode transmissions and transmissions based on 1 and 2 MHz duplicated segments.

Table 24-30—Maximum Spectral Flatness Deviations

Format	BW of Transmission (MHz)	Averaging subcarrier indices (inclusive)	Tested subcarrier indices (inclusive)	Maximum Deviation (dB)
Normal Mode S1G	1	-8 to -1 and +1 to +8	-8 to -1 and +1 to +8	±4
			-13 to -9 and +9 to +13	+4/-6
	2	-16 to -1 and +1 to +16	-16 to -1 and +1 to +16	±4
			-28 to -17 and +17 to +28	+4/-6
	4	-42 to -2 and +2 to +42	-42 to -2 and +2 to +42	±4
			-58 to -43 and +43 to +58	+4/-6
	8	-84 to -2 and +2 to +84	-84 to -2 and +2 to +84	±4
			-122 to -85 and +85 to +122	+4/-6
	16	-172 to -130, -126 to -44, +44 to +126, and +130 to +172	-172 to -130, -126 to -44, +44 to +126, and +130 to +172	±4
			-250 to -173, -43 to -6, +6 to +43, and +173 to +250	+4/-6

Table 24-30—Maximum Spectral Flatness Deviations

1MHz Duplicate Mode	2	-15 to -3 and +3 to +15	-15 to -3 and +3 to +15	±4
			-29 to -17 and +17 to +29	
	4	-42 to -35, -29 to -17, -15 to -3, +3 to +15, +17 to +29, and +35 to +42	-42 to -35, -29 to -17, -15 to -3, +3 to +15, +17 to +29, and +35 to +42	±4
			-61 to -49, -47 to -43, +43 to +47, and +49 to +61	+4/-6
	8	-84 to -81, -79 to -67, -61 to -49, -47 to -35, -29 to -17, -15 to -3, +3 to +15, +17 to +29, +35 to +47, +49 to +61, +67 to +79, and +81 to +84	-84 to -81, -79 to -67, -61 to -49, -47 to -35, -29 to -17, -15 to -3, +3 to +15, +17 to +29, +35 to +47, +49 to +61, +67 to +79, and +81 to +84	±4
			-125 to -113, -111 to -99, -93 to -85, +85 to +93, +99 to +111, and +113 to +125	+4/-6
	16	-172 to -163, -157 to -145, -143 to -131, -125 to -113, -111 to -99, -93 to -81, -79 to -67, -61 to -49, -47 to -44, +44 to +47, +49 to +61, +67 to +79, +81 to +93, +99 to +111, +113 to +125, +131 to +143, +145 to +157, and +163 to +172	-172 to -163, -157 to -145, -143 to -131, -125 to -113, -111 to -99, -93 to -81, -79 to -67, -61 to -49, -47 to -44, +44 to +47, +49 to +61, +67 to +79, +81 to +93, +99 to +111, +113 to +125, +131 to +143, +145 to +157, and +163 to +172	±4
			-253 to -241, -239 to -227, -221 to -209, -207 to -195, -189 to -177, -175 to -173, -43 to -35, -29 to -17, -15 to -3, +3 to +15, +17 to +29, +35 to +43,+173 to +175, +177 to +189, +195 to +207, +209 to +221, +227 to +239, and +241 to +253	+4/-6

Table 24-30—Maximum Spectral Flatness Deviations

2MHz Duplicate Mode	4	-42 to -33, -31 to -6, +6 to +31, and +33 to +42	-42 to -33, -31 to -6, +6 to +31, and +33 to +42	±4
			-58 to -43 and +43 to +58	+4/-6
	8	-84 to -70, -58 to -33, -84 to -70, -58 to -33, +33 to +58, +70 to +84	-84 to -70,-58 to -33, -31 to -6, +6 to +31, +33 to +58, +70 to +84	±4
			-122 to -97, -95 to -85 and +85 to +95, +97 to +122	+4/-6
	16	-172 to -161, -159 to -134, -122 to -97, -95 to -70, -58 to -44, +44 to +58, +70 to +95, +97 to +122, +134 to +159, +161 to +172	-172 to -161, -159 to -134, -122 to -97, -95 to -70, -58 to -44, +44 to +58, +70 to +95, +97 to +122, +134 to 159, +161 to +172	±4
			-250 to -225, -223 to -198, -186 to -173, -43 to -33, -31 to -6, +6 to +31, +33 to +43, +173 to +186, +198 to 223, +225 to +250	+4/-6

24.3.17.3 Transmit center frequency and symbol clock frequency tolerance

The symbol clock frequency and transmit center frequency tolerance shall be ±20 ppm maximum. The transmit center frequency and the symbol clock frequency for all transmit antennas and frequency segments shall be derived from the same reference oscillator.

24.3.17.4 Modulation accuracy

24.3.17.4.1 Introduction to modulation accuracy tests

Transmit modulation accuracy specifications are described in 24.3.17.4.2 (Transmitter center frequency leakage) and 24.3.17.4.3 (Transmitter constellation error). The test method is described in 24.3.17.4.4 (Transmitter modulation accuracy (EVM) test). Transmit center frequency leakage

24.3.17.4.2 Transmitter center frequency leakage

TX LO leakage shall meet the following requirements for all formats and bandwidths:

— When the RF LO is in the center of the transmitted PPDU BW, the power measured at the center of transmission BW using resolution BW 31.25 kHz shall not exceed the average power per-subcarrier of the transmitted PPDU, or equivalently,$(P - 10\log_{10}(N_{ST}))$, where P is the transmit power per antenna in dBm, and N_{ST} is defined in Table 24-4 (Timing-related constants).

— When the RF LO is not at the center of the transmitted PPDU BW, the power measured at the location of the RF LO using resolution BW 31.25 kHz shall not exceed the maximum of -27dB relative to the total transmit power and -15dBm, or equivalently max(P-27,-15), where P is the transmit power per antenna in dBm.

The transmit center frequency leakage is specified per antenna.

24.3.17.4.3 Transmitter constellation error

The relative constellation RMS error, calculated by first averaging over subcarriers, OFDM PPDUs and spatial streams (see Equation (20-89)) shall not exceed a data-rate dependent value according to Table 24-31 (Allowed relative constellation error versus constellation size and coding rate). The number of spatial streams under test shall be equal to the number of utilized transmitting STA antenna (output) ports and also equal to the number of utilized testing instrumentation input ports. In the test, N_{SS}=N_{STS} (no STBC) shall be used. Each output port of the transmitting STA shall be connected through a cable to one input port of the testing instrumentation. The requirements apply to 1 MHz, 2 MHz, 4 MHz, 8 MHz and 16 MHz transmissions.

Table 24-31—Allowed relative constellation error versus constellation size and coding rate

Modulation	Coding rate	Relative constellation error (dB)
BPSK	1/2 rep2	TBD
BPSK	1/2	-5
QPSK	1/2	-10
QPSK	3/4	-13
16-QAM	1/2	-16
16-QAM	3/4	-19
64-QAM	2/3	-22
64-QAM	3/4	-25
64-QAM	5/6	-27
256-QAM	3/4	-30
256-QAM	5/6	-32

24.3.17.4.4 Transmitter modulation accuracy (EVM) test

The transmit modulation accuracy test shall be performed by instrumentation capable of converting the transmitted signals into a stream of complex samples at sampling rate greater than or equal to the bandwidth of the signal being transmitted; except that for duplicate transmissions, each 1 MHz or 2 MHz subchannel may be tested independently while all subchannels are being transmitted.

The instrument shall have sufficient accuracy in terms of I/Q arm amplitude and phase balance, DC offsets, phase noise, and analog to digital quantization noise. A possible embodiment of such a setup is converting the signals to a low IF frequency with a microwave synthesizer, sampling the signal with a digital oscilloscope and decomposing it digitally into quadrature components. The sampled signal shall be processed in a manner similar to an actual receiver, according to the following steps, or equivalent procedure:

a) Start of PPDU shall be detected.

b) Transition from STF to LTF1 shall be detected and fine timing shall be established.

c) Coarse and fine frequency offsets shall be estimated.

d) Symbols in a PPDU shall be de-rotated according to estimated frequency offset.

e) For each LTF symbol, transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, and de-rotate the subcarrier values according to the estimated phase.

f) Estimate the complex channel response coefficient for each of the subcarriers and each of the transmit streams.

g) For each of the data OFDM symbols: transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, de-rotate the subcarrier values according to the estimated phase, group the results from all the receiver chains in each subcarrier to a vector, and multiply the vector by a zero-forcing equalization matrix generated from the estimated channel.

h) For each data-carrying subcarrier in each spatial stream, find the closest constellation point and compute the Euclidean distance from it.

i) Compute the average across PPDUs of the RMS of all errors per PPDU as given by Equation (20-89).

The test shall be performed over at least 20 PPDUs (as defined in Equation (20-89)). The PPDUs under test shall be at least 16 data OFDM symbols long. Random data shall be used for the symbols.

24.3.18 S1G receiver specification

24.3.18.1 Receiver minimum input sensitivity

The packet error ratio (PER) shall be less than 10% for a PSDU length of 256 octets with the rate-dependent input levels listed in Table 24-32 (Receiver minimum input level sensitivity). The test in this subclause and the minimum sensitivity levels specified in Table 24-32 (Receiver minimum input level sensitivity) apply only to non-STBC modes, 8 us GI, BCC and S1G PPDU**.**

Table 24-32—Receiver minimum input level sensitivity

Modulation	Rate (R)	**Minimum Sensitivity (1MHz PPDU)** (dBm)	**Minimum Sensitivity (2MHz PPDU)** (dBm)	**Minimum Sensitivity (4MHz PPDU)** (dBm)	**Minimum Sensitivity (8MHz PPDU)** (dBm)	**Minimum Sensitivity (16MHz PPDU)** (dBm)
BPSK	1/2 & 2x repetition	-98	n.a.	n.a.	n.a.	n.a.
BPSK	1/2	-95	-92	-89	-86	-83
QPSK	1/2	-92	-89	-86	-83	-80
QPSK	3/4	-90	-87	-84	-81	-78
16-QAM	1/2	-87	-84	-81	-78	-75
16-QAM	3/4	-83	-80	-77	-74	-71
64-QAM	2/3	-79	-76	-73	-70	-67

Table 24-32—Receiver minimum input level sensitivity

64-QAM	3/4	-78	-75	-72	-69	-66
64-QAM	5/6	-77	-74	-71	-68	-65
256-QAM	3/4	-72	-69	-66	-63	-60
256-QAM	5/6	-70	-67	-64	-61	-58

24.3.18.2 Adjacent channel rejection

Adjacent channel rejection for *W* MHz channels (where *W* is 1, 2, 4, 8 or 16) shall be measured by setting the desired signal's strength 3 dB above the rate dependent sensitivity specified in 24.3.18.1 (Receiver minimum input sensitivity) and raising the power of the interfering signal of *W* MHz bandwidth until 10% PER is caused for a PSDU length of 256 octets. The power difference between the interfering and desired channel is the corresponding adjacent channel rejection. The center frequency of the adjacent channel shall be placed *W* MHz away from the center frequency of the desired signal.

The interfering signal in the adjacent channel shall be a conformant OFDM signal, unsynchronized with the signal in the channel under test, and shall have a minimum duty cycle of 50%. For a conforming OFDM PHY, the corresponding rejection shall be no less than specified in Table 24-33 (Minimum required adjacent and nonadjacent channel rejection levels).

The test in this subclause and the adjacent sensitivity levels specified in Table 24-33 (Minimum required adjacent and nonadjacent channel rejection levels) only apply to non-STBC modes with 8us GI and BCC.

The measurement of adjacent channel rejection for 2/4/8/16 MHz operation in a regulatory domain is only required if such a frequency band plan is permitted in that regulatory domain.

24.3.18.3 Nonadjacent channel rejection

Nonadjacent channel rejection for *W* MHz channels (where *W* is 1, 2, 4, 8 or 16) shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in Table 24-33 (Minimum required adjacent and nonadjacent channel rejection levels), and raising the power of the interfering signal of W MHz bandwidth until a 10% PER occurs for a PSDU length of 256 octets. The power difference between the interfering and desired channel is the corresponding nonadjacent channel rejection. The center frequency of the nonadjacent channel shall be placed 2×*W* MHz or more away from the center frequency of the desired signal.

The interfering signal in the nonadjacent channel shall be a conformant OFDM signal, unsynchronized with the signal in the channel under test, and shall have a minimum duty cycle of 50%. For a conforming OFDM PHY, the corresponding rejection shall be no less than specified in Table 24-33 (Minimum required adjacent and nonadjacent channel rejection levels).

The test in this subclause and the nonadjacent sensitivity levels specified in Table 24-33 (Minimum required adjacent and nonadjacent channel rejection levels) only apply to non-STBC modes with 8us GI and BCC.

Table 24-33—Minimum required adjacent and nonadjacent channel rejection levels

Modulation	Rate, R	Adjacent Channel Rejection (dB)		Non-Adjacent Channel Rejection (dB)	
		1MHz Channel	2/4/8/16 MHz Channel	1MHz Channel	2/4/8/16 MHz Channel
BPSK	1/4 (1/2 with 2x Repetition)	19		35	
BPSK	1/2	16	16	32	32
QPSK	1/2	13	13	29	29
QPSK	3/4	11	11	27	27
16-QAM	1/2	8	8	24	24
16-QAM	3/4	4	4	20	20
64-QAM	2/3	0	0	16	16
64-QAM	3/4	-1	-1	15	15
64-QAM	5/6	-2	-2	14	14
256-QAM	3/4	-7	-7	9	9
256-QAM	5/6	-9	-9	7	7

The measurement of non-adjacent channel rejection for 2/4/8/16 MHz operation in a regulatory domain is only required if such a frequency band plan is permitted in that regulatory domain.

24.3.18.4 Receiver maximum input level

The receiver shall provide a maximum PER of 10% at a PSDU length of 256 octets, for a maximum input level of -30 dBm, measured at each antenna for any baseband S1G modulation.

24.3.18.5 CCA sensitivity

24.3.18.5.1 General

24.3.18.5.2 CCA sensitivity for operating classes requiring CCA-ED

24.3.18.5.3 CCA sensitivity for signals occupying the primary 2 MHz channel

24.3.18.5.4 CCA sensitivity for signals not occupying the primary 2 MHz channel

24.3.18.6 RSSI

The RSSI parameter returned in the RXVECTOR shall be calculated during the reception of the (D-)LTFs and shall be a monotonically increasing function of the received power.

24.3.19 PHY transmit procedure

The typical transmit procedure is shown in Figure 24-45 (PHY transmit procedure for an SU transmission). For this, the FORMAT parameter of the PHY-TXSTART.request(TXVECTOR) primitive is S1G. These transmit procedures do not describe the operation of optional features, such as LDPC, STBC or MU.

NOTE 1-For an MU PPDU the A-MPDU is per user in the MAC sublayer and the S1G Training Symbols, S1G-SIG-B, and Data are per user in the PHY layer in Figure 24-45 (PHY transmit procedure for an SU transmission), with the number S1G Training Symbols depending on the total number of space-time streams across all users.

In order to transmit data, the MAC generates a PHY-TXSTART.request primitive, which causes the PHY entity to enter the transmit state. Further, the PHY is set to operate at the appropriate frequency through station management via the PLME, as specified in 24.4 (S1G PLME).

Other transmit parameters, such as S1G-MCS Coding types and transmit power, are set via the PHY-SAP using the PHY-TXSTART.request(TXVECTOR) primitive, as described in 24.2.2 (TXVECTOR and RXVECTOR parameters).

The PHY indicates the state of the primary channel and other channels (if any) via the PHY-CCA.indication primitive (see 24.3.18.5 (CCA sensitivity)) and 7.3.5.11 (PHY-CCA.indication)). Note that under some circumstances, the MAC uses the value of the PHY-CCA.indication primitive before (and if) issuing the PHY-TXSTART.request primitive. Transmission of the PPDU shall be initiated by the PHY after receiving the PHY-TXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request primitive are specified in Table 24-1 (TXVECTOR and RXVECTOR parameters).

After the PHY preamble transmission is started, the PHY entity immediately initiates data scrambling and data encoding. The encoding method for the Data field is based on the FEC_CODING, CH_BANDWIDTH, NUM_STS, STBC, MCS, and NUM_USERS parameter of the TXVECTOR, as described in 24.3.2 (S1G PPDU format).

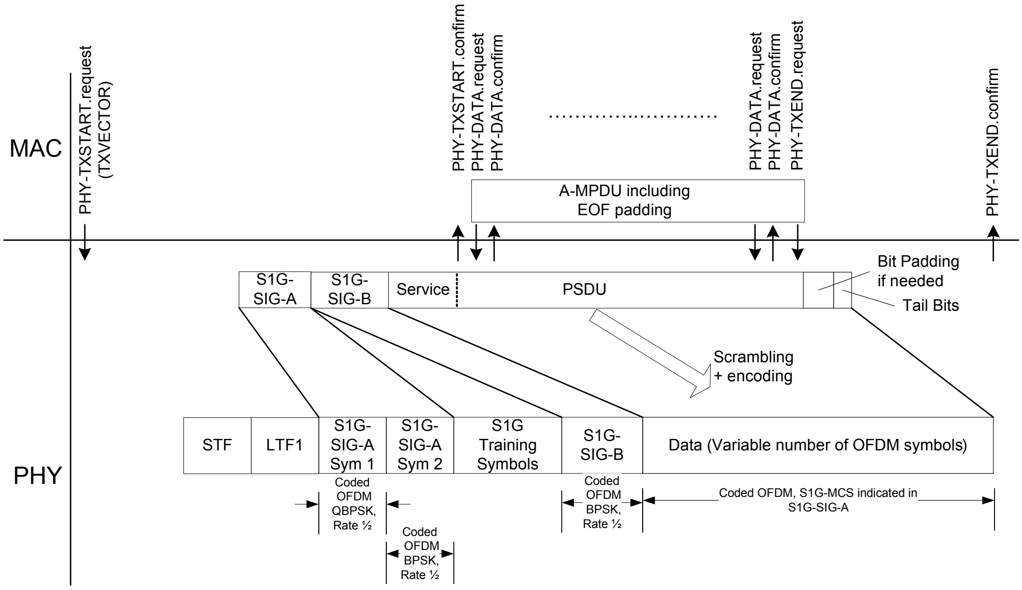
The SERVICE field and PSDU are encoded as described in 24.3.3 (Transmitter block diagram). The data shall be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Zero to seven PHY padding bits are appended to the PSDU to make the number of bits in the coded PSDU an integral multiple of the number of coded bits per OFDM symbol.

Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PSDU transmission is terminated by receiving a PHY-TXEND.request primitive. Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. In an SU transmission, normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number of OFDM symbols indicated by NSYM (see 24.4.3 (TXTIME and PSDU_LENGTH calculation)).

In the PHY, the GI or short GI is inserted in every data OFDM symbol as a countermeasure against delay spread.

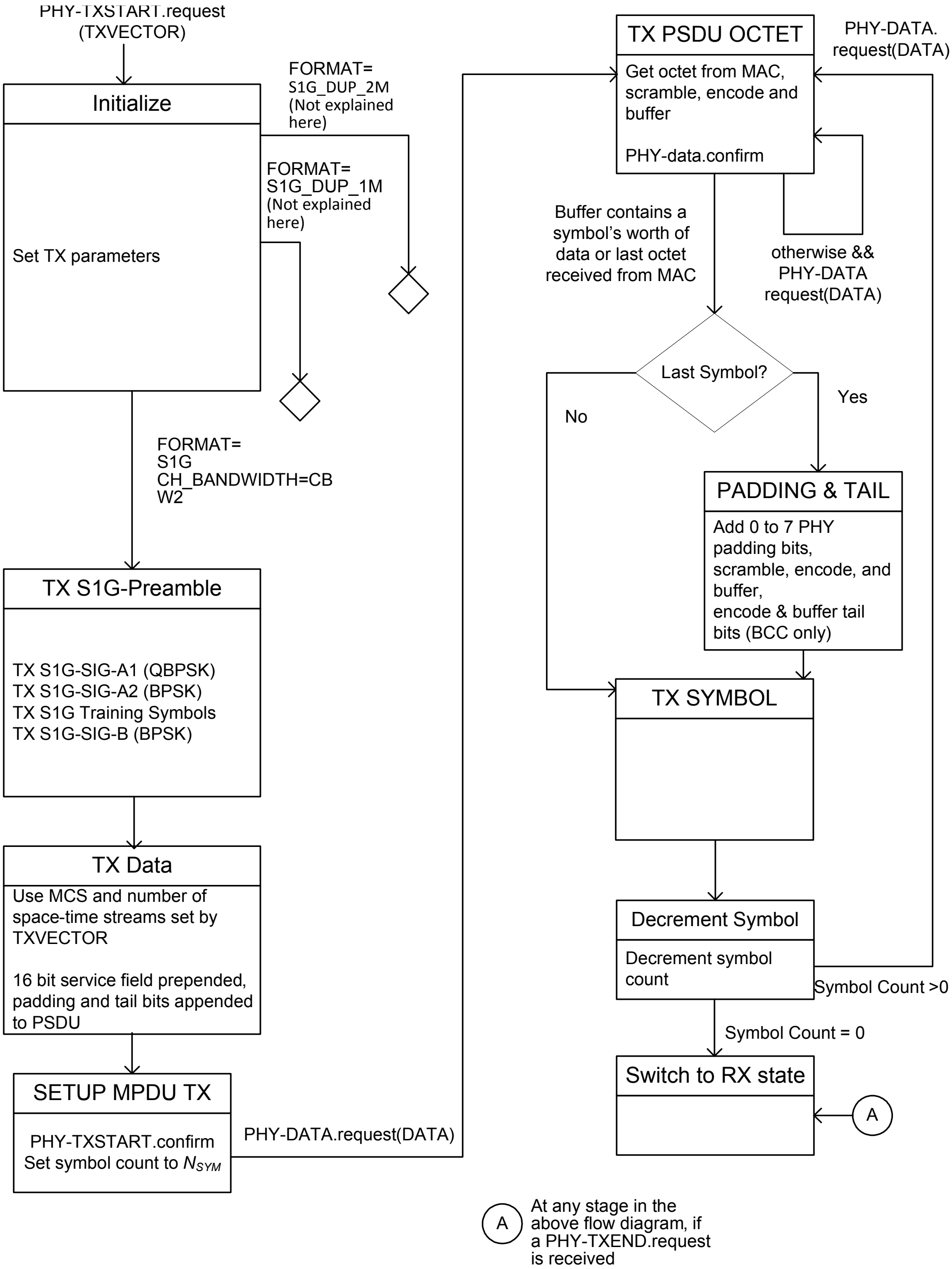
When the PPDU transmission is completed the PHY entity enters the receive state.

A typical state machine implementation of the transmit PHY for an SU transmission is provided in Figure 24-46 (PHY transmit state machine for an SU transmission). Request (.request) and confirmation (.confirm) primitives are issued once per state as shown. This state machine does not describe the operation of optional features, such as multi-user, LDPC or STBC.



NOTE—This procedure does not describe the operation of optional features, such as MU-MIMO, LDPC or STBC.

Figure 24-45—PHY transmit procedure for an SU transmission



NOTE—This state machine does not describe the operation of optional features, such as MU-MIMO, LDPC or STBC.

Figure 24-46—PHY transmit state machine for an SU transmission

24.3.20 PHY receive procedure

A typical PHY receive procedure is shown in Figure 24-47 (PHY Receive procedure for an SU transmission) for S1G format. A typical state machine implementation of the receive PHY is given in Figure 24-48 (PHY receive state machine). This receive procedure and state machine do not describe the operation of optional features, such as LDPC or STBC. Through station management (via the PLME) the PHY is set to the appropriate frequency, as specified in 24.4 (S1G PLME). The PHY has also been configured with group information (i.e., group membership and position in group) so that it can receive data intended for the STA. Other receive parameters, such as RSSI and indicated DATARATE, may be accessed via the PHY-SAP.

Upon receiving the transmitted PHY preamble overlapping the primary 1 MHz and/or 2MHz channel, the PHY measures a receive signal strength. This activity is indicated by the PHY to the MAC via a PHY-CCA.indication primitive. A PHY-CCA.indication(BUSY, channel-list) primitive is also issued as an initial indication of reception of a signal as specified in 24.3.18.5 (CCA sensitivity). The CH_BANDWIDTH parameter indicates one of the 1MHz, 2MHz, 4MHz, 8MHz and 16MHz contiguous channel widths.

The PHY shall not issue a PHY-RXSTART.indication primitive in response to a PPDU that does not overlap the primary 1 MHz and/or 2MHz channel.

The PHY includes the most recently measured RSSI value in the PHY-RXSTART.indication(RXVECTOR) primitive issued to the MAC.

After the PHY-CCA.indication(BUSY, channel-list) is issued, the PHY entity shall begin receiving the training symbols and searching for SIG-A in order to set the maximum duration of the data stream. If the check of the SIG-A parity bit is not valid, a PHY-RXSTART.indication primitive is not issued, and instead the PHY shall issue the error condition PHY-RXEND.indication(FormatViolation) primitive. If a valid SIG-A parity bit is indicated, the S1G PHY shall maintain PHY-CCA.indication(BUSY, channel-list) for the predicted duration of the transmitted PPDU, as defined by RXTIME in Equation (24-105), for all supported modes, unsupported modes, Reserved S1G-SIG-A Indication, invalid S1G-SIG-A CRC and invalid SIG-A Length field value. Reserved S1G-SIG-A Indication is defined as a S1G-SIG-A with Reserved bits equal to 0 or a combination not valid as defined in 24.3.8.3.4 (SIG definition), or a combination of S1G-MCS and NSTS not included in 24.5 (Parameters for S1G-MCSs) or any other S1G-SIG-A field bit combinations that do not correspond to modes of PHY operation defined in Clause 24 (Sub 1 GHz (S1G) PHY specification). If the S1G-SIG-A indicates an unsupported mode, the PHY shall issue PHY-RXEND.indication(UnsupportedRate). If the S1G-SIG-A indicates an invalid CRC or Reserved S1G-SIG-A Indication or if the SIG-A Length field is invalid, the PHY shall issue the error condition PHY-RXEND.indication(FormatViolation).

After receiving a valid S1G-SIG-A indicating a supported mode, the PHY entity shall begin receiving the rest of S1G training symbols and S1G-SIG-B. If the received group ID in S1G-SIG-A has a value indicating a S1G SU PPDU (see 9.17b (Group ID and partial AID in S1G PPDUs)), the PHY entity may choose not to decode S1G-SIG-B. If S1G-SIG-B is not decoded, subsequent to an indication of a valid S1G-SIG-A CRC, a PHY-RXSTART.indication(RXVECTOR) primitive shall be issued. The RXVECTOR associated with this primitive includes the parameters specified in Table 24-1 (TXVECTOR and RXVECTOR parameters).

If the Group ID field in S1G-SIG-A has a value indicating a S1G MU PPDU (see 9.17b (Group ID and partial AID in S1G PPDUs)), the PHY, in a STA that is MU beamformee capable, shall decode S1G-SIG-B. If the S1G-SIG-B indicates an unsupported mode, the PHY shall issue the error condition PHY-RXEND.indication(UnsupportedRate) primitive.

If S1G-SIG-B was decoded the PHY may check the S1G-SIG-B CRC in the SERVICE field. If the S1G-SIG-B CRC in the SERVICE field is not checked a PHY-RXSTART.indication(RXVECTOR) primitive shall be issued. The RXVECTOR associated with this primitive includes the parameters specified in Table 24-1 (TXVECTOR and RXVECTOR parameters).

The PHY optionally filters out the PPDU based on the GroupID, MU[0-3] NSTS and Partial AID fields of S1G-SIG-A and the contents of the PHYCONFIG_VECTOR. This procedure follows its VHT counterpart as described in 22.3.21.

If the PPDU is filtered out, the PHY shall issue a PHY-RXEND.indication(Filtered) primitive.

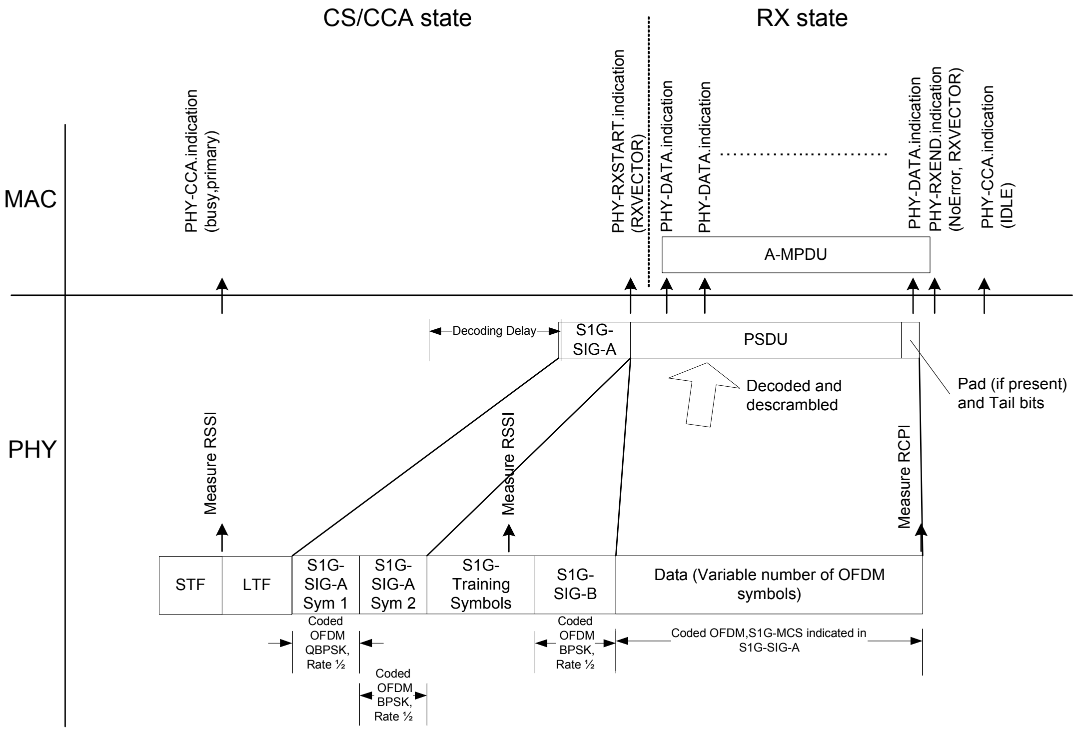
Following training and signal fields, the Data field shall be received. The number of symbols in the Data field is determined by Equation (24-104)

Editor's Note: Equation 24-104 to 24-105 to be added. Indication of decoding LDPC vs. BCC, and calculation of PSDU_LENGTH to be added.

If S1G-SIG-B is decoded and the S1G-SIG-B CRC in the SERVICE field is checked and not valid, the PHY shall issue the error condition PHY-RXEND.indication(FormatViolation) primitive. If the S1G-SIG-B field is decoded and the S1G-SIG-B CRC field is checked and valid, a PHY-RXSTART.indication(RXVECTOR) primitive shall be issued. The RXVECTOR associated with this primitive includes the parameters specified in Table 24-1 (TXVECTOR and RXVECTOR parameters).

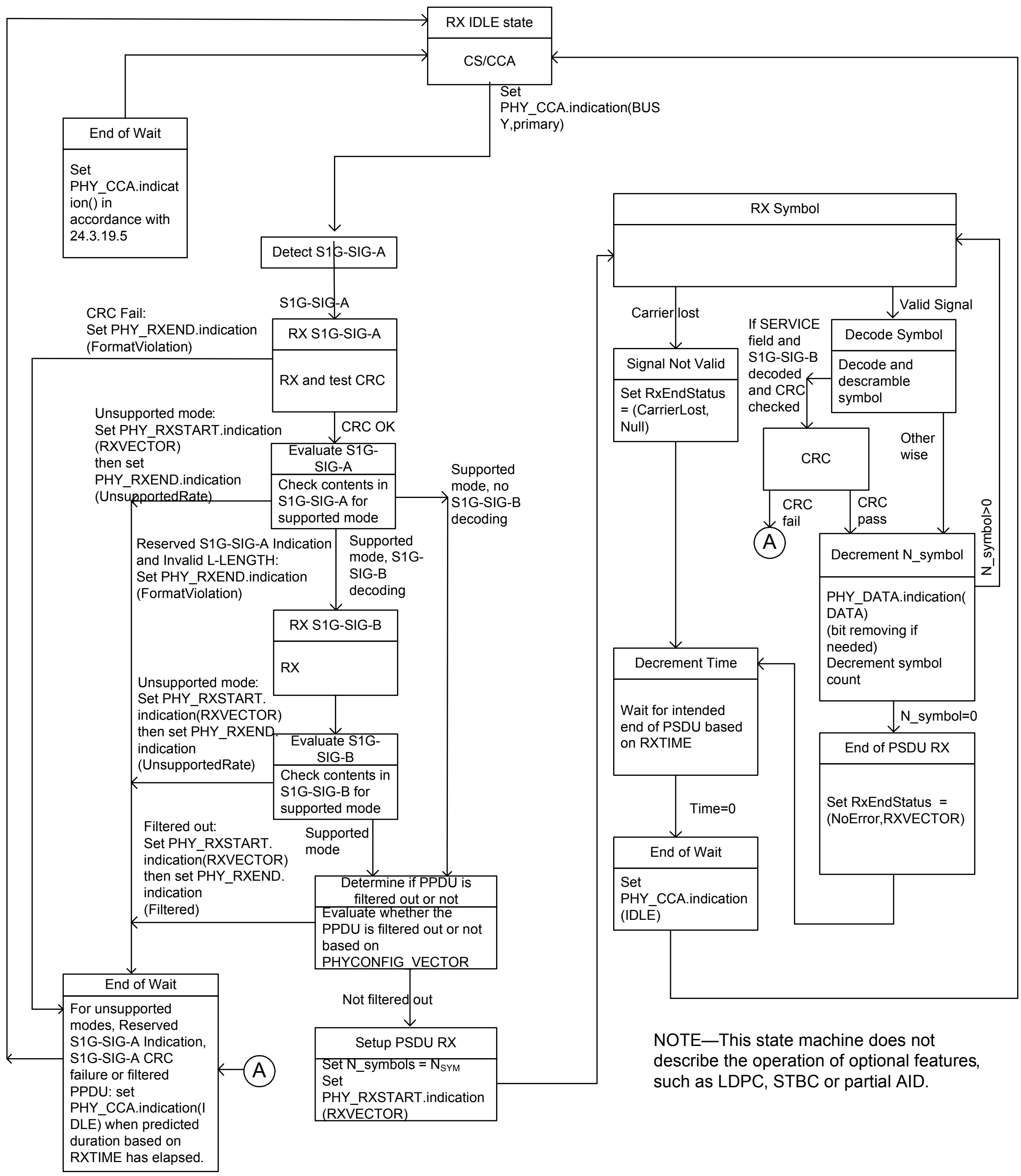
If signal loss occurs during reception prior to completion of the PSDU reception, the error condition PHY-RXEND.indication(CarrierLost) shall be reported to the MAC. After waiting for the end of the PSDU as determined by Equation (22-105), the PHY shall set the PHY-CCA.indication(IDLE) primitive and return to the RX IDLE state.

The received PSDU bits are assembled into octets, decoded, and presented to the MAC using a series of PHY-DATA.indication(DATA) primitive exchanges. Any final bits that cannot be assembled into a complete octet are considered pad bits and discarded. After the reception of the final bit of the last PSDU octet, and possible padding and tail bits, the receiver shall be returned to the RX IDLE state, as shown in Figure 24-48 (PHY receive state machine).



NOTE—This procedure does not describe the operation of optional features, such as LDPC or STBC. This procedure describes the case where S1G-SIG-A indicates a mode not requiring decoding of S1G-SIG-B.

Figure 24-47—PHY Receive procedure for an SU transmission



NOTE—This state machine does not describe the operation of optional features, such as LDPC, STBC or partial AID.

Figure 24-48—PHY receive state machine

24.4 S1G PLME

24.4.1 PLME_SAP sublayer management primitives

Table 24-34 (S1G PHY MIB attributes) lists the MIB attributes that may be accessed by the PHY entities and the intra-layer of higher level LMEs. These attributes are accessed via the PLME-GET, PLME-SET, PLME-RESET, and PLME-CHARACTERISTICS primitives defined in 6.5 (PLME SAP interface).

24.4.2 PHY MIB

SIG PHY MIB attributes are defined in Annex C with specific values defined in Table 24-34 (S1G PHY MIB attributes). The "Operational semantics" column in Table 24-34 (S1G PHY MIB attributes) contains two types: static and dynamic.

— Static MIB attributes are fixed and cannot be modified for a given PHY implementation.
— Dynamic MIB attributes are interpreted according to the MAX-ACCESS field of the MIB attribute.

When MAX-ACCESS is read-only, the MIB attribute value may be updated by the PLME and read from the MIB attribute by management entities. When MAX-ACCESS is read-write, the MIB attribute may be read and written by management entities but shall not be updated by the PLME.

Table 24-34—S1G PHY MIB attributes

Managed Object	Default value/ range	Operational Semantics
dot11PHYOperationTable		
dot11PHYType	S1G (TBD)	Static
dot11PHYTxPowerTable		
dot11NumberSupportedPowerLevels	Implementation dependent	Static
dot11TxPowerLevel1	Implementation dependent	Static
dot11TxPowerLevel2	Implementation dependent	Static
dot11TxPowerLevel3	Implementation dependent	Static
dot11TxPowerLevel4	Implementation dependent	Static
dot11TxPowerLevel5	Implementation dependent	Static
dot11TxPowerLevel6	Implementation dependent	Static

Table 24-34—S1G PHY MIB attributes

dot11TxPowerLevel7	Implementation dependent	Static
dot11TxPowerLevel8	Implementation dependent	Static
dot11CurrentTxPowerLevel	Implementation dependent	Static
dot11TxPowerLevelExtended	Implementation dependent	Static
dot11CurrentTxPowerLevelExtended	Implementation dependent	Static
dot11PHYS1GTable		
dot11CurrentPrimaryChannel	Implementation dependent	Dynamic
dot11CurrentChannelWidth	Implementation dependent	Dynamic
dot11CurrentChannelCenterFrequencyIndex	Implementation dependent	Dynamic
dot11S1GChannelWidthOptionImplemented	Implementation dependent	Static
dot11ShortGIOptionIn1MImplemented	False/Boolean	Static
dot11ShortGIOptionIn1MActivated	False/Boolean	Dynamic
dot11ShortGIOptionIn2MImplemented	False/Boolean	Static
dot11ShortGIOptionIn2MActivated	False/Boolean	Dynamic
dot11ShortGIOptionIn4MImplemented	False/Boolean	Static
dot11ShortGIOptionIn4MActivated	False/Boolean	Dynamic
dot11ShortGIOptionIn8MImplemented	False/Boolean	Static
dot11ShortGIOptionIn8MActivated	False/Boolean	Dynamic
dot11ShortGIOptionIn16MImplemented	False/Boolean	Static
dot11ShortGIOptionIn16MActivated	False/Boolean	Dynamic
dot11S1GLDPCCodingOptionImplemented	False/Boolean	Static
dot11S1GLDPCCodingOptionActivated	False/Boolean	Dynamic
dot11S1GTxSTBCOptionImplemented	False/Boolean	Static

Table 24-34—S1G PHY MIB attributes

dot11S1GTxSTBCOptionActivated	False/Boolean	Dynamic
dot11S1GRxSTBCOptionImplemented	False/Boolean	Static
dot11S1GRxSTBCOptionActivated	False/Boolean	Dynamic
dot11S1GMaxNTxChainsImplemented	Implementation dependent	Static
dot11S1GMaxNTxChainsActivated	Implementation dependent	Dynamic
dot11TransmitBeamformingConfigTable		
dot11ReceiveStagggerSoundingOptionImplemented	False/Boolean	Static
dot11TransmitStagggerSoundingOptionImplemented	False/Boolean	Static
dot11ReceiveNDPOptionImplemented	False/Boolean	Static
dot11TransmitNDPOptionImplemented	False/Boolean	Static
dot11ImplicitTransmitBeamformingOptionImplemented	False/Boolean	Static
dot11CalibrationOptionImplemented	Implementation dependent	Static
dot11ExplicitCSITransmitBeamformingOptionImplemente d	False/Boolean	Static
dot11ExplicitNonCompressedBeamformingMatrixOptionI mplemented	False/Boolean	Static
dot11ExplicitTransmitBeamformingCSIFeedbackOptionIm plemented	Implementation dependent	Static
dot11ExplicitNoncompressedBeamformingFeedbackOptio nImplemented	Implementation dependent	Static
dot11ExplicitcompressedBeamformingFeedbackOptionIm plemented	Implementation dependent	Static
dot11NumberBeamformingCSISupportAntenna	Implementation dependent	Static
dot11NumberNonCompressedBeamformingMatrixSupport Antenna	Implementation dependent	Static
dot11NumberCompressedBeamformingMatrixSupportAnte nna	Implementation dependent	Static
dot11SUBeamformerOptionImplemented	False/Boolean	Static
dot11SUBeamformeeOptionImplemented	False/Boolean	Static

Table 24-34—S1G PHY MIB attributes

dot11MUBeamformerOptionImplemented	False/Boolean	Static
dot11MUBeamformeeOptionImplemented	False/Boolean	Static
dot11S1GNumberSoundingDimensions	Implementation dependent	Static
dot11BeamformeeNTxSupport	Implementation dependent	Static

24.4.3 TXTIME and PSDU_LENGTH calculation

For short preamble format for >= 2MHz bandwidth, the value of the TXTIME parameter returned by the PLME-TXTIME.confirm primitive shall be calculated for an S1G PPDU using Equation (24-61) for short GI and Equation (24-62) for long GI.

$$\text{TXTIME} = T_{PREAMBLE} + T_{SIG} + T_{LTF} \cdot (N_{LTF} - 1) + T_{SYML}\left\lceil \frac{T_{SYMS} \cdot N_{SYM}}{T_{SYML}} \right\rceil \quad (24\text{-}61)$$

$$\text{TXTIME} = T_{PREAMBLE} + T_{SIG} + T_{LTF} \cdot (N_{LTF} - 1) + T_{SYML} \cdot N_{SYM} \quad (24\text{-}62)$$

where

$\lceil x \rceil$ denotes the smallest integer greater than or equal to x

$T_{PREAMBLE} = T_{STF} + T_{LTF1}$

T_{STF}, T_{LTF1}, T_{LTF}, T_{SYML} and T_{SYMS} are defined in Table 24-4 (Timing-related constants)

T_{SIG} is defined in Table 24-5 (Timing-related constants for SIG/SIG-A field in ≥2MHz PPDUs).

N_{LTF} is defined in Table 24-10 (Number of LTFs required for different numbers of space time streams)

For long preamble format for >=2MHz bandwidth, the value of the TXTIME parameter returned by the PLME-TXTIME.confirm primitive shall be calculated for an S1G PPDU using Equation (24-63) for short GI and Equation (24-64) for long GI.

$$\text{TXTIME} = T_{PREAMBLE} + T_{SIG-A} + T_{D\_PREAMBLE} + T_{SIG-B} + T_{SYML}\left\lceil \frac{T_{SYMS} \cdot N_{SYM}}{T_{SYML}} \right\rceil \quad (24\text{-}63)$$

$$\text{TXTIME} = T_{PREAMBLE} + T_{SIG-A} + T_{D\_PREAMBLE} + T_{SIG-B} + T_{SYML}N_{SYM} \quad (24\text{-}64)$$

Where

$\lceil x \rceil$ denotes the smallest integer greater than or equal to x

$T_{PREAMBLE} = T_{STF} + T_{LTF1}$

$T_{D\_PREAMBLE} = T_{DSTF} + T_{DLTF} \cdot N_{LTF}$

T_{STF}, T_{LTF1}, T_{DSTF}, T_{DLTF}, T_{SIG-B}, T_{SYML} and T_{SYMS} are defined in Table 24-4 (Timing-related constants)

T_{SIG-A} is defined in Table 24-5 (Timing-related constants for SIG/SIG-A field in ≥2MHz PPDUs).

N_{LTF} is defined in Table 24-10 (Number of LTFs required for different numbers of space time streams).

For 1MHz bandwidth preamble format, the value of the TXTIME parameter returned by the PLME-TXTIME.confirm primitive shall be calculated for an S1G PPDU using Equation (24-65) for short GI and Equation (24-66) for long GI.

$$\text{TXTIME} = 2T_{PREAMBLE} + 3T_{SIG} + T_{LTF} \cdot (N_{LTF} - 1) + T_{SYML}\left\lceil \frac{T_{SYMS} \cdot N_{SYM}}{T_{SYML}} \right\rceil \quad (24\text{-}65)$$

$$\text{TXTIME} = 2T_{PREAMBLE} + 3T_{SIG} + T_{LTF} \cdot (N_{LTF} - 1) + T_{SYML}N_{SYM} \quad (24\text{-}66)$$

Where

$\lceil x \rceil$ denotes the smallest integer greater than or equal to x

$T_{PREAMBLE} = T_{STF} + T_{LTF1}$

T_{STF}, T_{LTF1}, T_{LTF}, T_{SIG}, T_{SYML} and T_{SYMS} are defined in Table 24-4 (Timing-related constants)

T_{SIG-A} is defined in Table 24-5 (Timing-related constants for SIG/SIG-A field in ≥2MHz PPDUs).

N_{LTF} is defined in Table 24-10 (Number of LTFs required for different numbers of space time streams).

For an NDP, there is no Data field and $N_{SYM} = 0$.

For a S1G SU PPDU using BBC encoding, the total number of data symbols in the Data field is given by Equation (24-67).

$$N_{SYM} = m_{STBC} \times \left\lceil \frac{8 \cdot APEP\_LENGTH + N_{service} + N_{tail} \cdot N_{ES}}{m_{STBC} \cdot N_{DBPS}} \right\rceil \quad (24\text{-}67)$$

Where

m_{STBC} is equal to 2 when STBC is used, and 1 otherwise;

N_{ES} and N_{DBPS} are defined in Table 24-6 (Frequently used parameters)

$N_{service}$ and N_{tail} are defined in Table 24-4 (Timing-related constants)

For an S1G SU PPDU using LDPC encoding, the total number of data symbols in the Data field, N_{SYM}, is given in 24.3.9.4.4 (LDPC coding).

For an S1G MU PPDU, the total number of data symbols in the Data field, N_{SYM}, is given by Equation (22-63).

The value of the PSDU_LENGTH parameter returned in the PLME-TXTIME.confirm primitive for an S1G SU PPDU using BCC encoding is calculated using Equation (24-68)

$$PSDU\_LENGTH = \left\lfloor \frac{N_{SYM} \cdot N_{DBPS} - N_{service} - N_{tail}N_{ES}}{8} \right\rfloor \quad (24\text{-}68)$$

Where

N_{SYM} is given by Equation (24-67)

$\lfloor x \rfloor$ denotes the largest integer smaller than or equal to x

N_{ES} and N_{DBPS} are defined in Table 24-6 (Frequently used parameters)

$N_{service}$ and N_{tail} are defined in Table 24-4 (Timing-related constants).

The value of the PSDU_LENGTH parameter returned in the PLME-TXTIME.confirm primitive for an S1G SU PPDU using LDPC encoding is calculated using Equation (24-69)

$$PSDU\_LENGTH = \left\lfloor \frac{N_{SYM,\,init} \cdot N_{DBPS} - N_{service}}{8} \right\rfloor \tag{24-69}$$

Where

$N_{SYM,\,init}$ is given by Equation (22-62)

$\lfloor x \rfloor$ denotes the largest integer smaller than or equal to x

N_{DBPS} is defined in Table 24-6 (Frequently used parameters)

$N_{service}$ is defined in Table 24-4 (Timing-related constants).

The value of the PSDU_LENGTH parameter for user u returned in the PLME-TXTIME.confirm primitive and in the RXVECTOR for an S1G MU PPDU is calculated using Equation (24-70)

$$PSDU\_LENGTH_u = \begin{cases} \left\lfloor \frac{N_{SYM} \cdot N_{DBPS,\,u} - N_{service} - N_{tail} N_{ES,\,u}}{8} \right\rfloor & \text{when BCC is used for user } u \\ \left\lfloor \frac{N_{SYM\_\mathrm{max}\_init} \cdot N_{DBPS,\,u} - N_{service}}{8} \right\rfloor & \text{when LDPC is used for user } u \end{cases} \tag{24-70}$$

Where

$\lfloor x \rfloor$ denotes the largest integer smaller than or equal to x

$N_{SYM\_\mathrm{max\_init}}$ is given by Equation (22-65)

$N_{ES,\,u}$ is N_{ES} for user u, where N_{ES} is defined in Table 24-6 (Frequently used parameters)

$N_{DBPS,\,u}$ is N_{DBPS} for user u, where N_{DBPS} is defined in Table 24-6 (Frequently used parameters)

$N_{service}$ and N_{tail} are defined in Table 24-4 (Timing-related constants).

The value of the PSDU_LENGTH parameter returned in the PLME-TXTIME.confirm primitive for an NDP is 0.

24.4.4 PHY characteristics

The static SIG PHY characteristics, provided through the PLME-CHARACTERISTICS service primitive, shall be as shown in Table 20-25 (MIMO PHY characteristics) and Table 22-29 (VHT PHY characteristics) unless otherwise listed in Table 24-35 (S1G PHY characteristics). The definitions for these characteristics are given in 6.5 (PLME SAP interface).

Table 24-35—S1G PHY characteristics

Characteristics	Value
aSlotTime	52 us
aSIFSTime	160 us
aSignalExtension	TBD us
aCCATime	< 40us
aPHY-RX-START-Delay	600 us for 1MHz preamble; 280 us for >=2MHz short/long preamble.
aRxTxTurnaroundTime	TBD (2) us
aRxTxSwitchTime	<< TBD (1) us
aAirPropagationTime	6 us
aMACProcessingDelay	< TBD (2) us
aPreambleLength	160 us
aSTFLength	80 us
aLTFOneLength	80 us
aLTFLength	40 us
aPLCPHeaderLength	80 us
aPLCPSIGTwoLength	80 us
aPLCPServiceLength	8 bits
aDTT2UTTTime	320 us
Inter-frame Spacing	A constant multiple of 40 us
aCCAMidTime	250 us
aPPDUMaxTime	27.840 ms (see NOTE1)
aPSDUMaxLength	797160 octets (see NOTE2)
NOTE1 – this is the maximum PPDU duration in us for a 1MHz S1G PPDU with a bandwidth of 1 MHz, S1G-MCS10 and 1 spatial stream, limited by PSDU length of 511 byes. NOTE2 – this is the maximum length in octets for a S1G SU PPDU with a bandwidth of 16 MHz, S1G-MCS9 and 4 spatial streams, limited by 511 data symbols in aPPDUMaxTime.	

24.5 Parameters for S1G-MCSs

The rate-dependent parameters for 1 MHz, 2 MHz, 4 MHz, 8 MHz, and 16 MHz, N_{SS} = 1,...,4 are given in Table 24-36 (S1G MCSs for 1MHz, Nss = 1) through Table 24-55 (S1G MCSs for 16MHz, Nss = 4). Support for 4 ms GI is optional in all cases. Support for MCS 8 and 9 (when valid) is optional in all cases. A S1G AP-STA shall support single spatial stream MCSs within the range MCS 0 through MCS 7 for all channel widths for which it has indicated support regardless of the Tx or Rx Highest Supported Data Rate sub-field values in the VHT Supported MCS Set field. A S1G non-AP-STA shall support single spatial stream MCSs within the range MCS 0 through MCS 2 for 1 and 2MHz channel widths. When more than one spatial stream is supported, the Tx or Rx Highest Supported Data Rate sub-field values in the VHT Supported MCS Set field may result in a reduced MCS range (cut-off) for greater than one spatial stream. Support for 1MHz, 2 MHz with N_{SS} = 1 is mandatory. Support for 1 and 2MHz with N_{SS} = 2,3,4 is optional. Support for 4,8 and 16 MHz with N_{SS} = 1,...,4 is optional.

Table 24-36—S1G MCSs for 1MHz, Nss = 1

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	24	2	24	12	1	300.0	333.3
1	QPSK	1/2	2	24	2	48	24	1	600.0	666.7
2	QPSK	3/4	2	24	2	48	36	1	900.0	1000.0
3	16-QAM	1/2	4	24	2	96	48	1	1200.0	1333.3
4	16-QAM	3/4	4	24	2	96	72	1	1800.0	2000.0
5	64-QAM	2/3	6	24	2	144	96	1	2400.0	2666.7
6	64-QAM	3/4	6	24	2	144	108	1	2700.0	3000.0
7	64-QAM	5/6	6	24	2	144	120	1	3000.0	3333.3
8	256-QAM	3/4	8	24	2	192	144	1	3600.0	4000.0
9	256-QAM	5/6	8	24	2	192	160	1	4000.0	4444.4
10	BPSK	1/4	1	24	2	24	6	1	150.0	166.7

Table 24-37—S1G MCSs for 1MHz, Nss = 2

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	24	2	48	24	1	600.0	666.7
1	QPSK	1/2	2	24	2	96	48	1	1200.0	1333.3
2	QPSK	3/4	2	24	2	96	72	1	1800.0	2000.0
3	16-QAM	1/2	4	24	2	192	96	1	2400.0	2666.7
4	16-QAM	3/4	4	24	2	192	144	1	3600.0	4000.0
5	64-QAM	2/3	6	24	2	288	192	1	4800.0	5333.3
6	64-QAM	3/4	6	24	2	288	216	1	5400.0	6000.0
7	64-QAM	5/6	6	24	2	288	240	1	6000.0	6666.7
8	256-QAM	3/4	8	24	2	384	288	1	7200.0	8000.0
9	256-QAM	5/6	8	24	2	384	320	1	8000.0	8888.9

Table 24-38—S1G MCSs for 1MHz, Nss = 3

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	24	2	72	36	1	900.0	1000.0
1	QPSK	1/2	2	24	2	144	72	1	1800.0	2000.0
2	QPSK	3/4	2	24	2	144	108	1	2700.0	3000.0
3	16-QAM	1/2	4	24	2	288	144	1	3600.0	4000.0
4	16-QAM	3/4	4	24	2	288	216	1	5400.0	6000.0
5	64-QAM	2/3	6	24	2	432	288	1	7200.0	8000.0
6	64-QAM	3/4	6	24	2	432	324	1	8100.0	9000.0
7	64-QAM	5/6	6	24	2	432	360	1	9000.0	10000.0
8	256-QAM	3/4	8	24	2	576	432	1	10800.0	12000.0
9	256-QAM	5/6	8	24	2	576	480	1	12000.0	13333.3

Table 24-39—S1G MCSs for 1MHz, Nss = 4

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	24	2	96	48	1	1200.0	1333.3
1	QPSK	1/2	2	24	2	192	96	1	2400.0	2666.7
2	QPSK	3/4	2	24	2	192	144	1	3600.0	4000.0
3	16-QAM	1/2	4	24	2	384	192	1	4800.0	5333.3
4	16-QAM	3/4	4	24	2	384	288	1	7200.0	8000.0
5	64-QAM	2/3	6	24	2	576	384	1	9600.0	10666.7
6	64-QAM	3/4	6	24	2	576	432	1	10800.0	12000.0
7	64-QAM	5/6	6	24	2	576	480	1	12000.0	13333.3
8	256-QAM	3/4	8	24	2	768	576	1	14400.0	16000.0
9	256-QAM	5/6	8	24	2	768	640	1	16000.0	17777.8

Table 24-40—S1G MCSs for 2MHz, Nss = 1

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	52	4	52	26	1	650.0	722.2
1	QPSK	1/2	2	52	4	104	52	1	1300.0	1444.4
2	QPSK	3/4	2	52	4	104	78	1	1950.0	2166.7
3	16-QAM	1/2	4	52	4	208	104	1	2600.0	2888.9
4	16-QAM	3/4	4	52	4	208	156	1	3900.0	4333.3
5	64-QAM	2/3	6	52	4	312	208	1	5200.0	5777.8
6	64-QAM	3/4	6	52	4	312	234	1	5850.0	6500.0
7	64-QAM	5/6	6	52	4	312	260	1	6500.0	7222.2
8	256-QAM	3/4	8	52	4	416	312	1	7800.0	8666.7
9	Not valid									

Table 24-41—S1G MCSs for 2MHz, Nss = 2

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	52	4	104	52	1	1300.0	1444.4
1	QPSK	1/2	2	52	4	208	104	1	2600.0	2888.9
2	QPSK	3/4	2	52	4	208	156	1	3900.0	4333.3
3	16-QAM	1/2	4	52	4	416	208	1	5200.0	5777.8
4	16-QAM	3/4	4	52	4	416	312	1	7800.0	8666.7
5	64-QAM	2/3	6	52	4	624	416	1	10400.0	11555.6
6	64-QAM	3/4	6	52	4	624	468	1	11700.0	13000.0
7	64-QAM	5/6	6	52	4	624	520	1	13000.0	14444.4
8	256-QAM	3/4	8	52	4	832	624	1	15600.0	17333.3
9	Not valid									

Table 24-42—S1G MCSs for 2MHz, Nss = 3

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	52	4	156	78	1	1950.0	2166.7
1	QPSK	1/2	2	52	4	312	156	1	3900.0	4333.3
2	QPSK	3/4	2	52	4	312	234	1	5850.0	6500.0
3	16-QAM	1/2	4	52	4	624	312	1	7800.0	8666.7
4	16-QAM	3/4	4	52	4	624	468	1	11700.0	13000.0
5	64-QAM	2/3	6	52	4	936	624	1	15600.0	17333.3
6	64-QAM	3/4	6	52	4	936	702	1	17550.0	19500.0
7	64-QAM	5/6	6	52	4	936	780	1	19500.0	21666.7
8	256-QAM	3/4	8	52	4	1248	936	1	23400.0	26000.0
9	256-QAM	5/6	8	52	4	1248	1040	1	26000.0	28888.9

Table 24-43—S1G MCSs for 2MHz, Nss = 4

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	52	4	208	104	1	2600.0	2888.9
1	QPSK	1/2	2	52	4	416	208	1	5200.0	5777.8
2	QPSK	3/4	2	52	4	416	312	1	7800.0	8666.7
3	16-QAM	1/2	4	52	4	832	416	1	10400.0	11555.6
4	16-QAM	3/4	4	52	4	832	624	1	15600.0	17333.3
5	64-QAM	2/3	6	52	4	1248	832	1	20800.0	23111.1
6	64-QAM	3/4	6	52	4	1248	936	1	23400.0	26000.0
7	64-QAM	5/6	6	52	4	1248	1040	1	26000.0	28888.9
8	256-QAM	3/4	8	52	4	1664	1248	1	31200.0	34666.7
9	Not valid									

Table 24-44—S1G MCSs for 4MHz, Nss = 1

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	108	6	108	54	1	1350.0	1500.0
1	QPSK	1/2	2	108	6	216	108	1	2700.0	3000.0
2	QPSK	3/4	2	108	6	216	162	1	4050.0	4500.0
3	16-QAM	1/2	4	108	6	432	216	1	5400.0	6000.0
4	16-QAM	3/4	4	108	6	432	324	1	8100.0	9000.0
5	64-QAM	2/3	6	108	6	648	432	1	10800.0	12000.0
6	64-QAM	3/4	6	108	6	648	486	1	12150.0	13500.0
7	64-QAM	5/6	6	108	6	648	540	1	13500.0	15000.0
8	256-QAM	3/4	8	108	6	864	648	1	16200.0	18000.0
9	256-QAM	5/6	8	108	6	864	720	1	18000.0	20000.0

Table 24-45—S1G MCSs for 4MHz, Nss = 2

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	108	6	216	108	1	2700.0	3000.0
1	QPSK	1/2	2	108	6	432	216	1	5400.0	6000.0
2	QPSK	3/4	2	108	6	432	324	1	8100.0	9000.0
3	16-QAM	1/2	4	108	6	864	432	1	10800.0	12000.0
4	16-QAM	3/4	4	108	6	864	648	1	16200.0	18000.0
5	64-QAM	2/3	6	108	6	1296	864	1	21600.0	24000.0
6	64-QAM	3/4	6	108	6	1296	972	1	24300.0	27000.0
7	64-QAM	5/6	6	108	6	1296	1080	1	27000.0	30000.0
8	256-QAM	3/4	8	108	6	1728	1296	1	32400.0	36000.0
9	256-QAM	5/6	8	108	6	1728	1440	1	36000.0	40000.0

Table 24-46—S1G MCSs for 4MHz, Nss = 3

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	108	6	324	162	1	4050.0	4500.0
1	QPSK	1/2	2	108	6	648	324	1	8100.0	9000.0
2	QPSK	3/4	2	108	6	648	486	1	12150.0	13500.0
3	16-QAM	1/2	4	108	6	1296	648	1	16200.0	18000.0
4	16-QAM	3/4	4	108	6	1296	972	1	24300.0	27000.0
5	64-QAM	2/3	6	108	6	1944	1296	1	32400.0	36000.0
6	64-QAM	3/4	6	108	6	1944	1458	1	36450.0	40500.0
7	64-QAM	5/6	6	108	6	1944	1620	1	40500.0	45000.0
8	256-QAM	3/4	8	108	6	2592	1944	1	48600.0	54000.0
9	256-QAM	5/6	8	108	6	2592	2160	1	54000.0	60000.0

Table 24-47—S1G MCSs for 4MHz, Nss = 4

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	108	6	432	216	1	5400.0	6000.0
1	QPSK	1/2	2	108	6	864	432	1	10800.0	12000.0
2	QPSK	3/4	2	108	6	864	648	1	16200.0	18000.0
3	16-QAM	1/2	4	108	6	1728	864	1	21600.0	24000.0
4	16-QAM	3/4	4	108	6	1728	1296	1	32400.0	36000.0
5	64-QAM	2/3	6	108	6	2592	1728	1	43200.0	48000.0
6	64-QAM	3/4	6	108	6	2592	1944	1	48600.0	54000.0
7	64-QAM	5/6	6	108	6	2592	2160	1	54000.0	60000.0
8	256-QAM	3/4	8	108	6	3456	2592	2	64800.0	72000.0
9	256-QAM	5/6	8	108	6	3456	2880	2	72000.0	80000.0

Table 24-48—S1G MCSs for 8MHz, Nss = 1

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	234	8	234	117	1	2925.0	3250.0
1	QPSK	1/2	2	234	8	468	234	1	5850.0	6500.0
2	QPSK	3/4	2	234	8	468	351	1	8775.0	9750.0
3	16-QAM	1/2	4	234	8	936	468	1	11700.0	13000.0
4	16-QAM	3/4	4	234	8	936	702	1	17550.0	19500.0
5	64-QAM	2/3	6	234	8	1404	936	1	23400.0	26000.0
6	64-QAM	3/4	6	234	8	1404	1053	1	26325.0	29250.0
7	64-QAM	5/6	6	234	8	1404	1170	1	29250.0	32500.0
8	256-QAM	3/4	8	234	8	1872	1404	1	35100.0	39000.0
9	256-QAM	5/6	8	234	8	1872	1560	1	39000.0	43333.3

Table 24-49—S1G MCSs for 8MHz, Nss = 2

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	234	8	468	234	1	5850.0	6500.0
1	QPSK	1/2	2	234	8	936	468	1	11700.0	13000.0
2	QPSK	3/4	2	234	8	936	702	1	17550.0	19500.0
3	16-QAM	1/2	4	234	8	1872	936	1	23400.0	26000.0
4	16-QAM	3/4	4	234	8	1872	1404	1	35100.0	39000.0
5	64-QAM	2/3	6	234	8	2808	1872	1	46800.0	52000.0
6	64-QAM	3/4	6	234	8	2808	2106	1	52650.0	58500.0
7	64-QAM	5/6	6	234	8	2808	2340	2	58500.0	65000.0
8	256-QAM	3/4	8	234	8	3744	2808	2	70200.0	78000.0
9	256-QAM	5/6	8	234	8	3744	3120	2	78000.0	86666.7

Table 24-50—S1G MCSs for 8MHz, Nss = 3

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	234	8	702	351	1	8775.0	9750.0
1	QPSK	1/2	2	234	8	1404	702	1	17550.0	19500.0
2	QPSK	3/4	2	234	8	1404	1053	1	26325.0	29250.0
3	16-QAM	1/2	4	234	8	2808	1404	1	35100.0	39000.0
4	16-QAM	3/4	4	234	8	2808	2106	1	52650.0	58500.0
5	64-QAM	2/3	6	234	8	4212	2808	2	70200.0	78000.0
6	Not valid									
7	64-QAM	5/6	6	234	8	4212	3510	2	87750.0	97500.0
8	256-QAM	3/4	8	234	8	5616	4212	2	105300.0	117000.0
9	256-QAM	5/6	8	234	8	5616	4680	3	117000.0	130000.0

Table 24-51—S1G MCSs for 8MHz, Nss = 4

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	234	8	936	468	1	11700.0	13000.0
1	QPSK	1/2	2	234	8	1872	936	1	23400.0	26000.0
2	QPSK	3/4	2	234	8	1872	1404	1	35100.0	39000.0
3	16-QAM	1/2	4	234	8	3744	1872	1	46800.0	52000.0
4	16-QAM	3/4	4	234	8	3744	2808	2	70200.0	78000.0
5	64-QAM	2/3	6	234	8	5616	3744	2	93600.0	104000.0
6	64-QAM	3/4	6	234	8	5616	4212	2	105300.0	117000.0
7	64-QAM	5/6	6	234	8	5616	4680	3	117000.0	130000.0
8	256-QAM	3/4	8	234	8	7488	5616	3	140400.0	156000.0
9	256-QAM	5/6	8	234	8	7488	6240	3	156000.0	173333.3

Table 24-52—S1G MCSs for 16MHz, Nss = 1

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	468	16	468	234	1	5850.0	6500.0
1	QPSK	1/2	2	468	16	936	468	1	11700.0	13000.0
2	QPSK	3/4	2	468	16	936	702	1	17550.0	19500.0
3	16-QAM	1/2	4	468	16	1872	936	1	23400.0	26000.0
4	16-QAM	3/4	4	468	16	1872	1404	1	35100.0	39000.0
5	64-QAM	2/3	6	468	16	2808	1872	1	46800.0	52000.0
6	64-QAM	3/4	6	468	16	2808	2106	1	52650.0	58500.0
7	64-QAM	5/6	6	468	16	2808	2340	2	58500.0	65000.0
8	256-QAM	3/4	8	468	16	3744	2808	2	70200.0	78000.0
9	256-QAM	5/6	8	468	16	3744	3120	2	78000.0	86666.7

Table 24-53—S1G MCSs for 16MHz, Nss = 2

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	468	16	936	468	1	11700.0	13000.0
1	QPSK	1/2	2	468	16	1872	936	1	23400.0	26000.0
2	QPSK	3/4	2	468	16	1872	1404	1	35100.0	39000.0
3	16-QAM	1/2	4	468	16	3744	1872	1	46800.0	52000.0
4	16-QAM	3/4	4	468	16	3744	2808	2	70200.0	78000.0
5	64-QAM	2/3	6	468	16	5616	3744	2	93600.0	104000.0
6	64-QAM	3/4	6	468	16	5616	4212	2	105300.0	117000.0
7	64-QAM	5/6	6	468	16	5616	4680	3	117000.0	130000.0
8	256-QAM	3/4	8	468	16	7488	5616	3	140400.0	156000.0
9	256-QAM	5/6	8	468	16	7488	6240	3	156000.0	173333.3

Table 24-54—S1G MCSs for 16MHz, Nss = 3

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	468	16	1404	702	1	17550.0	19500.0
1	QPSK	1/2	2	468	16	2808	1404	1	35100.0	39000.0
2	QPSK	3/4	2	468	16	2808	2106	1	52650.0	58500.0
3	16-QAM	1/2	4	468	16	5616	2808	2	70200.0	78000.0
4	16-QAM	3/4	4	468	16	5616	4212	2	105300.0	117000.0
5	64-QAM	2/3	6	468	16	8424	5616	3	140400.0	156000.0
6	64-QAM	3/4	6	468	16	8424	6318	3	157950.0	175500.0
7	64-QAM	5/6	6	468	16	8424	7020	4	175500.0	195000.0
8	256-QAM	3/4	8	468	16	11232	8424	4	210600.0	234000.0
9	Not valid									

Table 24-55—S1G MCSs for 16MHz, Nss = 4

MCS Idx	Mod	R	N_bpscs	N_sd	N_sp	N_cbps	N_dbps	N_es	Data_rate (Kbps)	
									8us GI	4us GI
0	BPSK	1/2	1	468	16	1872	936	1	23400.0	26000.0
1	QPSK	1/2	2	468	16	3744	1872	1	46800.0	52000.0
2	QPSK	3/4	2	468	16	3744	2808	2	70200.0	78000.0
3	16-QAM	1/2	4	468	16	7488	3744	2	93600.0	104000.0
4	16-QAM	3/4	4	468	16	7488	5616	3	140400.0	156000.0
5	64-QAM	2/3	6	468	16	11232	7488	4	187200.0	208000.0
6	64-QAM	3/4	6	468	16	11232	8424	4	210600.0	234000.0
7	64-QAM	5/6	6	468	16	11232	9360	6	234000.0	260000.0
8	256-QAM	3/4	8	468	16	14976	11232	6	280800.0	312000.0
9	256-QAM	5/6	8	468	16	14976	12480	6	312000.0	346666.7

Annex D

(normative)

Insert or modify the following rows in Table D-1:

Table D-1— Regulatory requirement list

Geographic Area	Approval Standards	Documents	Approval Authority
…	…	…	...
United States	Federal Communications Commission (FCC)	…… Sections TBD	FCC
…	…	…	…
Korea	TBD	TBD	TBD
Singapore	TBD	TBD	TBD
…	…	…	…

Annex E

Country elements and operating classes

E.1 Country information and operating classes

Insert the rows below for Operating classes <ANA> through <ANA+4>:

Table E-1—Operating classes in the United States

Operating class	Global operating class (see E-4)	Channel starting frequency (GHz)	Channel spacing (MHz)	Channel set	Channel center frequency index	Behavior limits set
<ANA>	<ANA>	0.902	1	-	1,3,5,7,9,11,13,15,17,19,21,23,25,27,29,31,33,35,37,39,41,43,45,47,49,51	TBD
<ANA+1>	<ANA+1>	0.902	2	-	2,6,10,14,18,22,26,30,34,38,42,46,50	TBD
<ANA+2>	<ANA+2>	0.902	4	-	8,16,24,32,40,48	TBD
<ANA+3>	<ANA+3>	0.902	8	-	12,28,44	TBD
<ANA+4>	<ANA+4>	0.902	16	-	20	TBD

NOTE—Channel starting frequency is the frequency that results in the regulatory domain's channel number being the RLAN channel number.

Insert the rows below for Operating classes <ANA> through <ANA+1>:

Table E-2—Operating classes in Europe

Operating class	Global operating class (see E-4)	Channel starting frequency (GHz)	Channel spacing (MHz)	Channel set	Channel center frequency index	Behavior limits set
<ANA>	<ANA>	0.863	1	-	1,3,5,7,9	TBD
<ANA+1>	<ANA+1>	0.863	2	-	2,6	TBD

Insert the rows below for Operating classes <ANA> :

Table E-3—Operating classes in Japan

Operating class	**Global operating class (see E-4)**	**Channel starting frequency (GHz)**	**Channel spacing (MHz)**	**Channel set**	**<u>Channel center frequency index</u>**	**Behavior limits set** TBD
<ANA>	<ANA>	0.9165	1	-	1,3,5,7,9,11,13,15,17,19,21	

Insert the rows below for Operating classes <ANA> through <ANA+9>:

Table E-4—Global operating classes

Operating class	Nonglobal operating class(es)	Channel starting fre-quency (GHz)	Channel spacing (MHz)	Channel set	Channel center fre-quency index	Behavior limits set
<ANA>	<ANA>	0.755	1	-	1,3,5,7,9,11, 13,15,17,19, 21,23,25,27, 29,31,33,35, 37,39,41,43, 45,47,49,51, 53,55,57,59, 61,63	TBD (for China)
<ANA+1>	<ANA+1>	0.755	2	-	50,54,58,62	TBD (for China)
<ANA+2>	<ANA+2>	0.755	4	-	52,60	TBD (for China)
<ANA+3>	<ANA+3>	0.755	8	-	56	TBD (for China)
<ANA+4>	<ANA+4>	0.9175	1	-	1,3,5,7,9,11	TBD (for Korea)
<ANA+5>	<ANA+5>	0.9175	2	-	2,6,10	TBD (for Korea)
<ANA+6>	<ANA+6>	0.9175	4	-	8	TBD (for Korea)
<ANA+7>	<ANA+7>	0.866	1	-	1,3,5	TBD (for Singapore)
<ANA+8>	<ANA+8>	0.920	1	-	1,3,5,7,9	TBD (for Singapore)
<ANA+9>	<ANA+9>	0.866	2	-	4	TBD (for Singapore)
<ANA+10>	<ANA+10>	0.920	2	-	2,6	TBD (for Singapore)
<ANA+11>	<ANA+11>	0.920	4	-	4	TBD (for Singapore)

E.2 Band-specific operating requirements