IEEE P802.11  
Wireless LANs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Draft text for additional Beamforming procedures for mmWave Distributed Network | | | | |
| Date: 2018-03-07 | | | | |
| Author(s): | | | | |
| Name | Affiliation | Address | Phone | Email |
| Tony Xiao Han | Huawei |  |  | [tony.hanxiao@huawei.com](mailto:tony.hanxiao@huawei.com) |
| Yan Xin |  |  | [yan.xin@huawei.com](mailto:Yan.Xin@huawei.com) |
| Chenlong Jia |  |  | [jiachenlong@huawei.com](mailto:jiachenlong@huawei.com) |
| Mengyao Ma |  |  | [ma.mengyao@huawei.com](mailto:ma.mengyao@huawei.com) |
| Carlos Cordeiro | Intel |  |  | carlos.cordeiro@intel.com |
| Oren Kedem |  |  | [oren.kedem@intel.com](mailto:oren.kedem@intel.com) |
| George Cherian | Qualcomm |  |  | [gcherian@qti.qualcomm.com](mailto:gcherian@qti.qualcomm.com) |
| Assaf Kasher |  |  | [akasher@qti.qualcomm.com](mailto:akasher@qti.qualcomm.com) |
| Djordje Tujkovic | Facebook |  |  | djordjet@fb.com |
| Krishna Gomadam |  |  | kgomadam@fb.com |
| Payam Torab |  |  | ptorab@fb.com |
| Michael Grigat | Deutsche Telekom AG |  | +49-6151-5833533 | m.grigat@telekom.de |

Abstract

This document proposes revisions to 11ay draft specification text to add support for additional TDD beamforming procedures, namely, TDD Group Beamforming training for TDD Distributed Network as described in 11-18-174-00-00ay-beamforming-training-enhancement-for-mmwave-distribution-networks), and TDD Beam Measurement (Interference Measurement and Periodic Beamforming) as introduced in 11-17-1679-00-00ay-beamforming-protocol-reuse-for-mmwave-distribution-networks.

*Change the following subclause*

**6.3.3.2 MLME-SCAN.request**

**6.3.3.2.2 Semantics of the service primitive**

MLME-SCAN.request(

BSSType,

BSSID,

SSID,

ScanType,

ActiveScanType,

ProbeDelay,

ChannelList,

MinChannelTime,

MaxChannelTime,

RequestInformation,

SSID List,

ChannelUsage,

AccessNetworkType,

HESSID,

MeshID,

DiscoveryMode,

FILSRequestParameters,

ReportingOption,

APConfigurationSequenceNumber,

S1GRelayDiscovery,

PV1ProbeResponseOption,

S1GCapabilities,

ChangeSequence,

ELOperation,

MaxAwayDuration,

ScanSectorList,

SectorDwellTime,

VendorSpecificInfo

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| … |  |  |  |
| ScanType | Enumeration | ACTIVE, PASSIVE, TDD PASSIVE | Indicates active, passive or TDD passive scanning |
| ….. |  |  |  |
|  |  |  |  |
| ScanSectorIDList | List of sector configurations | Each sector configuration is a valid configuration for the scanning STA. | Sector configurations, in no particular order, to be used during the scan using TDD beamforming. |
| SectorDwellTime | Integer | N/A | The time (in microseconds) to dwell on each sector during TDD beamforming. |

*Insert the following subclauses*

**6.3.117 TDD beamforming  
6.3.117.1 General**This subclause describes the management procedures associated with TDD beamforming.

**6.3.117.2 MLME-TDD-BF-TRAINING.request  
6.3.117.2.1 Function**

This primitive requests that TDD beamforming training occur with one or more peer STAs.

**6.3.117.2.2 Semantics of the service primitive**The primitive parameters are as follows:

MLME-TDD-BF-TRAINING.request (

BFType,

PeerSTAAddress,

BeamformingStartTimestamp,

TXSectorIDList,

SectorRepetitions

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| BFType | Enumeration | TDD Individual BF, TDD Group BF | Indicates TDD Individual BF or TDD Group BF |
| PeerSTAAddress | MACAddress | Any valid individual MAC address, or a list of MAC addresses | For TDD Individual BF, specifies the address of the peer MAC entity with which to perform TDD beamforming training, or none if the address of the peer MAC entity is unknown.  For TDD Group BF, specifies the address list of the peer MAC entities with which to perform TDD beamforming training. |
| BeamformingStartTimestamp | Integer | N/A | Timestamp that indicates when the TDD beamforming procedure should be started by the STA |
| TXSectorIDList | List of Sector ID configurations | Each sector configuration is a valid configuration for the transmitting STA. | Sector ID configurations, in no particular order, to be used during the TDD beamforming transmission. |
| SectorRepetitions | Integer | 1 - 1024 | Indicates the number of repetitions for each TX Sector ID being utilized. |

**6.3.117.2.3 When generated**

This primitive is generated by the SME to request that TDD beamforming training be performed with one or more peer STAs.

**6.3.117.2.4 Effect on receipt**On receipt of this primitive, the MLME invokes the MAC sublayer TDD beamforming training procedures  
defined in 10.39.

**6.3.117.3 MLME-TDD-BF-TRAINING.confirm  
6.3.117.3.1 Function**

This primitive reports the outcome of a requested TDD beamforming training procedure.

**6.3.117.3.2 Semantics of the service primitive**The primitive parameters are as follows:

MLME-TDD-BF-TRAINING.confirm (

BFType,

PeerSTAAddress,

NumberOfTDDFeedbackPeers,

TDDFeedbackResults,

ResultCode

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| BFType | Enumeration | TDD Individual BF, TDD Group BF | Indicates TDD Individual BF or TDD Group BF. |
| PeerSTAAddress | MACAddress | Any valid individual MAC address, or a list of MAC addresses | For TDD Individual BF, specifies the address of the peer MAC entity with which TDD beamforming training was performed or attempted.  For TDD Group BF, specifies the address list of the peer MAC entities with which TDD Beamforming training was performed or attempted. |
| NumberOfTDDFeedbackPeers | Integer | 0 - N | Number of peer MAC entities for which a TDD Feedback is available. |
|  |  |  |  |
| TDDFeedbackResults | A set of TDD Feedback Results element, one for each of the peer MAC entities counted in Number of TDDFeedbacks, together with the address of that MAC entitity | As defined in 9.4.2.269 (TDD Route element) | Zero or more tuples in the form of {peer MAC entity address, TDD Feedback Results}. |
| ResultCode | Enumeration | SUCCESS, FAILURE | Indicates the result of the TDD beamforming procedure. |

**6.3.117.3.3 When generated**

This primitive is generated by the MLME to report the result of the TDD beamforming procedure with one or more peer STAs.

**6.3.117.3.4 Effect on receipt**

The SME is notified of the result of the procedure.

**6.3.117.4 MLME-TDD-BF-TRAINING.indication  
6.3.117.4.1 Function**

This primitive indicates that TDD beamforming training with a peer STA, and at the request of that peer STA, has  
completed

.  
**6.3.117.4.2 Semantics of the service primitive**The primitive parameters are as follows:

MLME-BF-TRAINING.indication (

BFType,

PeerSTAAddress,

NumberOfTDDFeedbacks,

TxBeamFeedback,

ResultCode

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| BFType | Enumeration | TDD Individual BF, TDD Group BF | Indicates TDD Individual BF or TDD Group BF. |
| PeerSTAAddress | MACAddress | Any valid individual MAC address | Specifies the address of the peer MAC entity with which TDD beamforming training was performed or attempted. |
| NumberOfTDDFeedbacks | Integer | 0 – 1024 | Indicates the number of TDD Feedbacks included. |
| TxBeamFeedback | Set of Tx Beam Feedback fields | As defined in 9.4.2.269 (TDD Route element) | One or more Tx Beam Feedback fields are present. |
| ResultCode | Enumeration | SUCCESS, FAILURE | Indicates the result of the TDD beamforming procedure. |

**6.3.117.4.3 When generated**

This primitive is generated by the MLME to report the result of TDD beamforming procedure that was initiated by the peer STA.

**6.3.117.4.4 Effect on receipt**The SME is notified of the result of the procedure.

**6.3.118 TDD Beam Measurement  
6.3.118.1 General**This subclause describes the management procedures associated with TDD beam measurement.

**6.3.118.2 MLME-TDD-BEAM-MEASUREMENT.request  
6.3.118.2.1 Function**

This primitive requests that TDD beam measurement occur with one or more peer STAs.

**6.3.118.2.2 Semantics of the service primitive**The primitive parameters are as follows:

MLME-TDD-BEAM-MEASUREMENT.request (

BFRole,

PeerSTAAddress,

BeamMeasurementStartTimestamp,

TXSectorIDList,

SectorRepetitions,

SlotSchedule

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| BFRole | Enumeration | Initiator or Responder | Set to Initiator or Responder. |
| PeerSTAAddress | MACAddress | Any valid individual MAC address, broadcast addresses | Specifies the address of the peer MAC entity with which to perform TDD beam measurement, or none if all MAC entities within reach are targeted. |
| BeamformingStartTimestamp | Integer | N/A | Timestamp that indicates when the TDD beam measurement procedure should be started by the STA. |
| TXSectorIDList | List of Sector ID configurations | Each sector configuration is a valid configuration for the transmitting STA. | Sector ID configurations, in no particular order, to be used by Initiator during TDD beam measurement. Applicable only when BFRole is set to Initiator. |
| SectorRepetitions | Integer | 1 - 1024 | Indicates the number of repetitions for each TX Sector ID being utilized. Applicable only when BFRole is set to Initiator. |
| SlotSchedule | Bitmap |  | Indicates the TDD slots to be used for transmitting TDD SSW frames, or the TDD slots used for measurement. |

**6.3.118.2.3 When generated**

This primitive is generated by the SME to request that TDD beam measurement be performed with one or more peer STAs.

**6.3.118.2.4 Effect on receipt**On receipt of this primitive, the MLME invokes the MAC sublayer TDD beam measurement procedures  
defined in 10.39.

**6.3.118.3 MLME-TDD-BEAM-MEASUREMENT.confirm  
6.3.118.3.1 Function**

This primitive reports the outcome of a requested TDD beam measurement procedure.

**6.3.118.3.2 Semantics of the service primitive**The primitive parameters are as follows:

MLME-TDD-BEAM-MEASUREMENT.confirm (

BFRole,

PeerSTAAddress,

ResultCode

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| BFRole | Enumeration | Initiator or Responder | Set to Initiator or Responder. |
| PeerSTAAddress | MACAddress | Any valid individual MAC address, or a list of MAC addresses | Set to the address of the peer MAC entity specified in request. |
| ResultCode | Enumeration | SUCCESS, FAILURE | Indicates the result of the TDD beam measurement procedure. |

**6.3.118.3.3 When generated**

This primitive is generated by the MLME to report the result of the TDD beam measurement with one or more peer STAs.

**6.3.118.3.4 Effect on receipt**

The SME is notified of the result of the procedure.

**6.3.118.4 MLME-TDD-BEAM-MEASUREMENT.indication  
6.3.118.4.1 Function**

This primitive indicates that TDD beam measurement with a peer STA, and at the request of that peer STA, has  
completed.

.  
**6.3.118.4.2 Semantics of the service primitive**The primitive parameters are as follows:

MLME-BEAM-MEASUREMENT.indication (

PeerSTAAddress,

NumberOfTDDFeedbacks,

TxBeamFeedback,

ResultCode

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| PeerSTAAddress | MACAddress | Any valid individual MAC address | Specifies the address of the peer MAC entity with which TDD beamforming training was performed or attempted. |
| NumberOfTDDFeedbacks | Integer | 0 – 1024 | Indicates the number of TDD Feedbacks included. |
| TxBeamFeedback | Set of Tx Beam Feedback fields | As defined in 9.4.2.269 (TDD Route element) | One or more Tx Beam Feedback fields are present. |
| ResultCode | Enumeration | SUCCESS, FAILURE | Indicates the result of the TDD beamforming procedure. |

**6.3.118.4.3 When generated**

This primitive is generated by the MLME to report the result of TDD beam measurement procedure that was initiated by the peer STA.

**6.3.118.4.4 Effect on receipt**The SME is notified of the result of the procedure.

**6.3.119 TDD Sector Switch   
6.3.119.1 General**

This subclause describes the management procedures associated with TDD sector switch.

**6.3.119.2 MLME-TDD-SECTOR-SWITCH.request  
6.3.119.2.1 Function**

This primitive requests that a sector switch be performed with a peer STA.

**6.3.119.2.2 Semantics of the service primitive**The primitive parameters are as follows:

MLME-TDD-SECTOR-SWITCH.request (

PeerSTAAddress,

SectorSwitchTimestamp,

SectorRevertTimestamp,

InitiatorTXSectorID,

InitiatorRXSectorID,

ResponderTXSectorID,

ResponderRXSectorID

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| PeerSTAAddress | MACAddress | Any valid individual MAC address | Specifies the address of the peer MAC entity with which to perform TDD sector switch procedure. |
| SectorSwitchTimestamp | Integer | N/A | Timestamp that indicates when the sector switch should take effect |
| SectorRevertTimestamp | Integer | N/A | Timestamp that indicates when the sector revert should take effect in case of failure. The timestamp indicated by SectorRevertTimestamp is always later than the timestamp indicated by SectorSwitchTimestamp. |
| InitiatorTXSectorID | Integer | 0 – 1023 | Indicates the TX Sector ID to be utilized by the initiator STA. |
| InitiatorRXSectorID | Integer | 0 – 1023 | Indicates the RX Sector ID to be utilized by the initiator STA. |
| ResponderTXSectorID | Integer | 0 – 1023 | Indicates the TX Sector ID to be utilized by the responder STA. |
| ResponderRXSectorID | Integer | 0 – 1023 | Indicates the RX Sector ID to be utilized by the responder STA. |

**6.3.119.2.3 When generated**

This primitive is generated by the SME to request that a sector switch be performed with a peer STA.

**6.3.119.2.4 Effect on receipt**On receipt of this primitive, the MLME invokes the MAC sublayer sector switch procedure defined in 11.36.

**6.3.119.3 MLME-TDD- SECTOR-SWITCH.confirm  
6.3.119.3.1 Function**

This primitive reports the outcome of a TDD sector switch procedure.

**6.3.119.3.2 Semantics of the service primitive**The primitive parameters are as follows:

MLME-TDD- SECTOR-SWITCH.confirm (

TXSectorID,

RXSectorID,

ResultCode

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| PeerSTAAddress | MACAddress | Any valid individual MAC address | Specifies the address of the peer MAC entity with which to perform TDD sector switch procedure |
| TXSectorID | Integer | 0 – 1023 | Indicates the TX Sector ID to be utilized by the STA. |
| RXSectorID | Integer | 0 – 1023 | Indicates the RX Sector ID to be utilized by the STA. |
| ResultCode | Enumeration | SUCCESS, FAILURE | Indicates the result of the TDD sector switch procedure. |

**6.3.119.3.3 When generated**

This primitive is generated by the MLME to report the result of TDD sector switch with a peer STA.

**6.3.119.3.4 Effect on receipt**

The SME is notified of the result of the procedure.

**6.3.119.4 MLME-TDD- SECTOR-SWITCH.indication  
6.3.119.4.1 Function**

This primitive indicates that a TDD sector switch request or a TDD sector switch acknowledgement has been received successfully.

.  
**6.3.119.4.2 Semantics of the service primitive**The primitive parameters are as follows:

MLME- SECTOR-SWITCH.indication (

PeerSTAAddress,

SectorSwitchTimestamp,

SectorRevertTimestamp,

InitiatorTXSectorID,

InitiatorRXSectorID,

ResponderTXSectorID,

ResponderRXSectorID

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| PeerSTAAddress | MACAddress | Any valid individual MAC address | Specifies the address of the peer MAC entity with the indication was received |
| SectorSwitchTimestamp | Integer | N/A | Future timestamp which indicates when the sector switch should take effect |
| SectorRevertTimestamp | Integer | N/A | Timestamp that indicates when the sector revert should take effect in case of failure. The timestamp indicated by SectorRevertTimestamp is always later than the timestamp indicated by SectorSwitchTimestamp. |
| InitiatorTXSectorID | Integer | 0 – 1023 | Indicates the TX Sector ID to be utilized by the initiator STA. |
| InitiatorRXSectorID | Integer | 0 – 1023 | Indicates the RX Sector ID to be utilized by the initiator STA. |
| ResponderTXSectorID | Integer | 0 – 1023 | Indicates the TX Sector ID to be utilized by the responder STA. |
| ResponderRXSectorID | Integer | 0 – 1023 | Indicates the RX Sector ID to be utilized by the responder STA. |

**6.3.119.4.3 When generated**

This primitive is generated by the MLME to indicate successful reception of a TDD sector switch request or TDD sector switch acknowledgement by a STA.

**6.3.119.4.4 Effect on receipt**The SME is notified of the result of the reception.

9. Frame formats

**9.2 MAC frame formats**

**9.2.4 Frame fields**

**9.2.4.1 Frame Control field**

**9.2.4.1.3 Type and Subtype subfields**

*Change Table 9-2 as follows*

|  |  |  |  |
| --- | --- | --- | --- |
| **Type value B3 B2** | **Subtype value B7 B6 B5 B4** | **Control Frame Extension value B11 B10 B9 B8** | **Description** |
| 01 | 0110 | 0000 | Sector Ack |
| 01 | 0110 | 0001 | Block Ack Schedule |
| 01 | 0110 | 0010 | Poll |
| 01 | 0110 | 0011 | SPR |
| 01 | 0110 | 0100 | Grant |
| 01 | 0110 | 0101 | DMG CTS |
| 01 | 0110 | 0110 | DMG DTS |
| 01 | 0110 | 0111 | Grant Ack |
| 01 | 0110 | 1000 | SSW |
| 01 | 0110 | 1001 | SSW-Feedback |
| 01 | 0110 | 1010 | SSW-Ack |
| 01 | 0110 | 1011 | TDD Beamforming |
| 01 | 0110 | 1100 – 1111 | Reserved |

*Add below sections as follows*

**9.3.1.24 TDD Beamforming frame format**

**9.3.1.24.1 Overview**

The frame format for the TDD Beamforming frame is defined in Figure 12.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
|  | Frame Control | Duration | RA | TA | TDD Beamforming Control | TDD Beamforming Information | FCS |
| Octets : | 2 | 2 | 6 | 6 | 1 | 6 or variable | 4 |

**Figure 12—TDD Beamforming frame format**

The Duration field is set to the time until the end of the current TDD Slot (see 10.36.6.2.2).

The RA field is set to the MAC address of the intended receiver of the TDD Beamforming frame, or to broadcast address when the intended receiver MAC address is unknown, or when there are more than one intended receivers.

The TA field is set to the MAC address of the transmitter STA of the TDD Beamforming frame.

The TDD Beamforming Control field is defined as shown in Figure 13.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |
|  | TDD Group  Beamforming | TDD Beam  Measurement | TDD Beamforming Frame Type | End of Training | Reserved |
| Bits: | 1 | 1 | 2 | 1 | 3 |

**Figure 13—TDD Beamforming Control subfield format**

The TDD Group Beamforming field is set to 1 if the frame is transmitted to perform TDD Group Beamforming, and set to 0 otherwise.

The TDD Beam Measurement field is set to 1 if the transmitted frame is to be used for TDD Beam Measurement procedure, and 0 otherwise.

TDD Group Beamforming, TDD Beam Measurement, and RA field values indicate a TDD Beamforming frame usage, as listed in Table X.

**Table X —TDD Beamforming Frame usage**

|  |  |  |  |
| --- | --- | --- | --- |
| **TDD Group Beamforming** | **TDD Beam Measurement** | **RA field** | **Beamforming procedure** |
| 0 | 0 | Unicast | TDD Individual BF with a known peer |
| 0 | 0 | Broadcast | TDD Individual BF with an unknown peer |
| 0 | 1 | Unicast | TDD Beam measurement with a known peer |
| 0 | 1 | Broadcast | TDD Beam measurement with all neighboring peers |
| 1 | 0 | Unicast | *Reserved* |
| 1 | 0 | Broadcast | TDD Group BF with two or more peers |
| 1 | 1 | Unicast | *Reserved* |
| 1 | 1 | Broadcast | TDD Group BF with two or more peers (per responder list) while other neighboring STAs perform TDD beam measurement under SME command |

For TDD Individual and TDD Group beamforming (TDD Beamforming Operation subfield set to 0 or 1), the TDD Beamforming Frame Type subfield is defined as shown in Table 3.

**Table 3 —TDD Beamforming Frame Type subfield definition**

|  |  |
| --- | --- |
| **Value** | **Meaning** |
| 0 | TDD SSW (Sector Sweep).  The TDD Beamforming Frame Type subfield is set to this value when the sender transmits TDD SSW frame (See 10.39.10). |
| 1 | TDD SSW Feedback.  The TDD Beamforming Frame Type subfield is set to this value when the sender transmits TDD SSW Feedback frame (See 10.39.10). |
| 2 | TDD SSW Ack.  The TDD Beamforming Frame Type subfield is set to this value when the sender transmits TDD SSW Ack frame (See 10.39.10). |
| 3 | Reserved |

* For TDD Individual beamforming, the End of Training subfield is set as following,The End of Training subfield is set to 1 in a TDD SSW frame to indicate that the initiator intend to end the TDD beamforming training after the transmission of the remaining TDD SSW frames with the current Sector ID; this subfield is set to zero otherwise;
* The End of Training subfield is set to 1 in a TDD SSW Feedback frame if the TDD SSW Feedback is sent in response to a TDD SSW frame in which its End of Training subfield was set to 1; this subfield is set to zero otherwise.
* The End of Training subfield is set to 1 in a TDD SSW Ack frame to indicate that the TDD beamforming training has completed; otherwise, this subfield is set to zero.

For TDD Group beamforming the End of Training subfield is reserved.

The content of TDD Beamforming Information field depends on the value of TDD Beamforming Frame Type subfield.

The length of TDD Beamforming Information field is 6 octets when the TDD Group Beamforming is zero, and 5 + 4*R* octets otherwise, where R is the number of target responders.

The length of TDD Beamforming Information shall not change during TDD Group beamforming, even after beamforming training with one or more of target responders has completed.

**9.3.1.24.2 TDD SSW (Sector Sweep)**

The TDD Beamforming Information field of the TDD SSW frame is shown in Figure 14.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
|  | TX Sector ID | Count  Index | Beamforming Time Unit | Transmit Period | Responder Feedback Offset | Initiator Ack Offset | Reserved |
| Bits : | 10 | 3 | 4 | 8 | 10 | 10 | 3 |

**Figure 14a—TDD Beamforming Information field format (TDD SSW frame for** **TDD Individual beamforming)**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | TX Sector ID | Count  Index | Ack Count Index | Beamforming Time Unit | Transmit Period | Number of Responders | Responder Info | … | Responder Info | Reserved |
| Bits : | 10 | 3 | 3 | 4 | 8 | 8 | 32 32 | | | 4 |

**Figure 14b—TDD Beamforming Information field format (TDD SSW frame for** **TDD Group beamforming)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Responder ID | Responder Feedback Offset | | | | Initiator Ack Offset | End of Training | Reserved |
| Bits : | 10 |  | 10 |  |  | 10 | 1 1 | |

**Figure 14-1—Responder Info subfield format (TDD SSW frame for** **TDD Group beamforming)**

The TX Sector ID subfield is set to indicate the antenna sector through which the TDD SSW frame is transmitted.

The Count Index subfield indicates the repetition of the initiator TDD Beamforming frames within a TDD slot, with the subfield set to 0 for the first transmission and increased by one for each successive transmission within a TDD slot.

The Beamforming Time Unit (BTU) subfield is defined in Table 4.

**Table 4 — Beamforming Time Unit subfield**

|  |  |
| --- | --- |
| **Value** | **Time Unit** |
| 0 | 1us |
| 1 | 100us |
| 2 | 400us |
| 3 - 15 | Reserved |

The BTU subfield indicates the beamforming time unit for the Transmit Period, Responder Feedback Offset and Initiator Ack Offset subfields in the TDD Beamforming Information field of TDD SSW frames. This subfield also defines the time unit for the Transmit Period, Initiator Transmit Offset and Responder Transmit Offset subfields in the TDD Beamforming Information field of the TDD SSW Ack frames.

The Transmit Period subfield indicates the offset, in units of BTUs, between TDD SSW transmissions with the same Count Index subfield value in different TDD slots.

For all beamforming operations the Responder Feedback Offset subfield indicates the offset, in units of BTUs, beginning immediately after the end of the TDD SSW frame, the TDD slot in which the TDD SSW Feedback frame is to be transmitted by the responder. The subfield is reserved when TDD SSW frame is transmitted exclusively for beam measurement,

For all beamforming operations the Initiator Ack Offset subfield indicates the offset, in units of BTUs, beginning immediately after the end of the TDD SSW frame of when the TDD slot in which the TDD SSW Ack frame is to be transmitted by the initiator. The subfield is reserved when TDD SSW frame is transmitted exclusively for beam measurement,

The Ack Count Index subfield indicates the number of the TDD SSW Ack frames that have been sent before the current TDD SSW frame within the same TDD slot. The Ack Count Index subfield is set to 0 if no TDD SSW Ack frame is transmitted before the current TDD SSW frame in the same TDD slot, and increases by one for each transmission of the TDD SSW Ack frame within the same TDD slot.

The Number of Responders subfield indicates the number of responders with which the initiator intends to do TDD beamforming.

The Responder Info subfield is defined in Figure 14-1 (Responder Info subfield).

The Responder ID subfield indicates the ID of the responder. The 10-bit Responder ID is derived from the responder’s MAC address, based on the scheme in 10.39.10.4, which is similar as the scheme in 30.9.1.2.

The End of Training subfield set to 1 in the Responder Info subfield of a TDD SSW frame for TDD Group beamforming training indicates that the initiator intends to end the TDD beamforming training with the corresponding responder after the transmission of the remaining TDD SSW frames with the current Sector ID; this subfield is set to zero otherwise.

**9.3.1.24.3 TDD SSW Feedback**

The TDD Beamforming Information field of the TDD SSW Feedback frame is shown in Figure 15.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  | TX Sector ID | Decoded TX Sector ID | SNR Report | Reserved |
| Bits : | 10 | 10 | 8 | 20 |

**Figure 15—TDD Beamforming Information field format**

The TX Sector ID subfield is set to indicate the sector through which the TDD SSW Feedback frame is transmitted.

The Decoded TX Sector ID subfield contains the value of the TX Sector ID subfield from the TDD SSW frame that the feedback frame is sent in response to and that the TDD SSW frame was received from the initiator with the best quality.

The SNR Report subfield is set to the value of the SNR achieved while decoding the TDD SSW frame received with the best quality and which is indicated in the Decoded TX Sector ID subfield. The value of SNR Report subfield is an unsigned integer referenced to a level of –8 dB. Each step is 0.25 dB. SNR values less than or equal to –8 dB are represented as 0. SNR values greater than or equal to 55.75 dB are represented as 0xFF.

**9.3.1.24.4 TDD SSW Ack**

The TDD Beamforming Information field of the TDD SSW Ack frame is shown in Figure 16.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
|  | Decoded TX Sector ID | Count Index | Transmit Period | SNR Report | Initiator Transmit  Offset | Responder Transmit  Offset | Reserved |
| Bits : | 10 | 3 | 8 | 8 | 8 | 8 | 3 |

**Figure 16—TDD Beamforming Information field format**

The Decoded TX Sector ID subfield contains the value of the TX Sector ID subfield of the TDD SSW Feedback frame that was received from the responder.

The Count Index subfield indicates the index of the frame transmission within a TDD slot, with the subfield set to 0 for the first frame transmission and increased by one for each successive frame transmission within a TDD slot.

The Transmit Period subfield indicates the interval, in units of BTUs, between successive TDD SSW transmissions with the same Count Index subfield value in different TDD slots.

The SNR Report subfield is set to the value of the SNR achieved while decoding the TDD SSW Feedback frame. The SNR Report subfield is unsigned integers referenced to a level of –8 dB. Each step is 0.25 dB. SNR values less than or equal to –8 dB are represented as 0. SNR values greater than or equal to 55.75 dB are represented as 0xFF.

The Initiator Transmit Offset subfield indicates the offset, in units of BTUs, beginning immediately after the end of the TDD SSW Ack frame, the TDD slot in which the initiator is expected to transmit additional frame, such as announce frame carrying the network configuration, to the responder. When the Initiator Transmit Offset subfield is set to zero, no time offset indication is specified by the initiator.

The Responder Transmit Offset subfield indicates the offset, in units of BTUs, beginning immediately after the TDD SSW Ack frame, the TDD slot in which the responder is expected to respond to frames sent by the initiator. When the Responder Transmit Offset subfield is set to zero, no time offset indication is specified by the initiator.

*Add below sections as follows*

**9.4.2.269 TDD Route element**

The TDD Route element is used to communicate TDD beamforming results and sector switch configuration as described in 10.39.10 and 11.36. The format of the TDD Route element is shown in Figure 83.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  | Element ID | Length | Element ID Extension | TDD Route Subelements |
| Octets : | 1 | 1 | 1 | Variable |

**Figure 83---TDD Route element format**

The Element ID, Length and Element ID Extension fields are defined in 9.4.2.1.

The TDD Route Subelements field is defined in Table 18. The TDD Route element contains one or more of the subelements defined in Table 18.

**Table 18 — TDD Route subelement IDs**

|  |  |  |
| --- | --- | --- |
| **Subelement ID** | **Name** | **Length** |
| 0 | TDD Feedback Results | Variable |
| 1 | TDD Sector Setting | 24 |
| 2-220 | Reserved |  |
| 221 | Vendor specific |  |
| 222-225 | Reserved |  |

The TDD Feedback Results subelement is used to communicate all the initiator TX Sector IDs as received by the responder during a TDD beamforming training procedure as described in 10.39.10. The format of the TDD Feedback Results element is shown in Figure 84.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |
|  | Subelement ID | Length | Number of Tx Beams | Tx Beam Feedback 1 | …. | Tx Beam Feedback N |
| Octets : | 1 | 1 | 2 | Variable |  | Variable |

**Figure 84---TDD Feedback Results subelement format**

The Subelement ID field is defined in Table 18.

The Length field is defined in 9.4.2.1.

The Number of Tx Beams subfield indicates the number of Tx Beam Feedback fields included in the TDD Route element.

The TDD TX Beam Feedback field is defined in Figure 85.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |
|  | TX Sector ID | Number of Decoded RX Sectors | Decoded RX Sector Information 1 | …….. | Decoded RX Sector Information M |
| Bits : | 10 | 8 | 32 |  | 32 |

**Figure 85--- TDD Tx Beam Feedback field format**

The TX Sector ID subfield contains the value of the TX Sector ID subfield of the TDD SSW frame that were sent by the initiator and that the information in the TDD Feedback field relate to.

The Decoded RX Sectors Information field is defined in Figure 86.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | B0 B9 | B10 B15 | B16 B23 | B24 B32 |
|  | Decoded RX Sector ID | Reserved | SNR Report | RSSI Report |
| Bits : | 10 | 6 | 8 | 8 |

**Figure 86---Decoded RX Beam Information subfield format**

The Decoded RX Sector ID subfield indicates the receive sector index used by the responder while it decoded the respective TDD SSW frame transmitted in the respective TX Sector ID.

The SNR Report subfield is set to the value of the SNR achieved while decoding the TDD SSW frame with the respective TX Sector ID and RX Decoded Sector ID. The SNR Report subfield is 8 bit unsigned integers referenced to a level of –8 dB. Each step is 0.25 dB. SNR values less than or equal to –8 dB are represented as 0. SNR values greater than or equal to 55.75 dB are represented as 0xFF.

The RSSI Report subfield is set to the value of the received power while receiving the L-STF field of the TDD SSW frame with the respective TX Sector ID and RX Decoded Sector ID. RSSI Report is an 8-bit signed integer in the range -128 dBm to 127 dBm and is measured by the PHY of the power observed at the input of the antennas plus the antenna gain, or equivalent antenna gain for a phased-array antenna, used to receive the current PPDU

The TDD Sector Setting subelement is used to request the peer to configure its antenna to a specific receive and transmit sector combination as described in 11.36. The format of the TDD Sector Setting subelement is shown in Figure 87.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |
|  | Subelement ID | Length | TDD Sector Setting Control | Switch Timestamp | Revert Timestamp | TDD Switch Sectors |
| Octets : | 1 | 1 | 1 | 8 | 8 | 5 |

**Figure 87---TDD Sector Setting subelement format**

The Subelement ID field is defined in Table 18.

The Length field is defined in 9.4.2.1.

The TDD Sector Setting Control field is defined in Figure 88

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | B0 | B1 | B2 | B3 – B7 |
|  | Set Sector  Request | Set Sector  Response | Set Sector Acknowledge | Reserved |
| Bits : | 1 | 1 | 1 | 5 |

**Figure 88---TDD Sector Setting Control field format**

The Set Sector Request subfield set to 1 by the initiator to indicate the responder to change its receiver sector setting according to the Responder RX Sector ID subfield and its transmitter sector setting according to Responder TX Sector ID subfield in the TDD Switch Sectors field.

The Set Sector Response subfield set to 1 by the responder to indicate the reception of a successful TDD Sector Setting subelement with Set Sector Request subfield set to 1.

The Set Sector Acknowledge subfield set to 1 by the initiator to acknowledge the reception of a successful TDD Sector Setting subelement with Sector Response subfield set to 1.

The Reserved subfield should be set to 0.

The Switch Timestamp subfield indicates the future TSF timer value (see 9.4.1.10) in which the new sector configuration setting is to take effect.

The Revert Timestamp subfield indicates the future TSF timer value (see 9.4.1.10) in which the previous sector configuration will be reverted to in case sector switching fails.

The TDD Switch Sectors field is defined in Figure 89

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | B0 B9 | B10 B19 | B20 B29 | B30 B39 |
|  | Responder RX Sector ID | Responder TX Sector ID | Initiator RX Sector ID | Initiator TX Sector ID |
| Bits : | 10 | 10 | 10 | 10 |

**Figure 89---TDD Switch Sectors field format**

The Responder RX Sector ID subfield contains the value of the sector ID the responder uses to set its receive sector.

The Responder TX Sector ID subfield contains the value of the sector ID the responder uses to set its transmit sector.

The Initiator RX Sector ID subfield contains the value of the sector index the initiator uses to set its receive sector.

The Initiator TX Sector ID subfield contains the value of the sector index the initiator uses to set its transmit sector.

**9.6.22.2 Announce frame format**

*Change Table 9-416 as follows*

**Table 9-416—Announce frame Action field format *(continued)***

|  |  |  |
| --- | --- | --- |
| **Order** | **Information** | **Notes** |
| 9 | Multiple BSSID | The Multiple BSSID element is defined in 9.4.2.46. The Multiple BSSID element is optionally present. If present, the Multiple BSSID element signals all the BSSIDs in use by the BSS. |
| . | . | . |
| . | . | . |
| 22 | UPSIM | The UPSIM element is defined in 9.4.2.167. The UPSIM element is optionally present. |
| 23 | TDD Route | The TDD Route element is defined in 9.4.2.269. The TDD Route element is optionally present. |

**10.7.7.1 Usage of DMG Control modulation class***Change below sections as follows*

The DMG Control modulation class has only one MCS, which is DMG MCS 0 defined in Clause 20. The  
DMG Beacon, SSW-Feedback, SSW-Ack, RTS, DMG CTS, DMG CTS-to-self, DMG DTS, CF-End,  
Grant, SPR, Poll, TDD Beamforming type frames (i.e. TDD SSW, TDD SSW Feedback and TDD SSW Ack) and first BRP packet in beam refinement shall be transmitted using the DMG Control modulation class.

**10.36.6.2.2 SP with TDD channel access**

*Change below sections as follows*

Except for the transmission of a TDD Beamforming frame prior to association, A DMG STA shall not transmit during a TDD SP unless it receives a TDD Slot Schedule element that indicates it is assigned to at least one TDD slot within the TDD SP by the DMG AP or DMG PCP. The DMG AP or DMG PCP shall transmit the TDD Slot Schedule element to each DMG STA that is assigned to access the TDD SP through an Announce frame or Association Response frame before the time indicated by the value of the Slot Schedule Start Time within the element. Upon reception of a TDD Slot Schedule element corresponding to allocations identified by the Allocation ID subfield value within the element, a DMG STA shall adopt the schedule within the element at the time indicated by the value of the Slot  
Schedule Start Time subfield within the element

*Add below sections as follows*

10.39 DMG Beamforming

10.39.10 TDD Beamforming

**10.39.10.1 General**

Three TDD beamforming procedures are defined in this section,

* In TDD Individual beamforming, a single STA (initiator) transmits a series of TDD SSW frames (see 9.3.1.24.2) through its different sectors while a target STA (responder) sweeps generally a subset of its receive sectors. If the responder receives at least one TDD SSW frame, through exchanging additional frames both initiator and responder are made aware of one or more combinations of transmit beam on the initiator side and receive beam on the responder side that enable communication between the two STAs.
* In TDD Group beamforming, a single STA (initiator) transmits a series of TDD SSW frames through its different sectors while two or more target STAs (responders) sweep generally a subset of their respective receive sectors. For each responder that receives at least one TDD SSW frame, through exchanging additional frames both initiator and responder are made aware of one or more combinations of transmit beam on the initiator side and receive beam on the responder side.
* In TDD beam measurement, a single STA (initiator) transmits a series of TDD SSW frames while a single target STA (responder) or alternatively a group of target STAs (responders) sweep their respective receive sectors. The primary difference between TDD beam measurement and other TDD beamforming procedures is that responders do not transmit any frame to the initiator during the procedure, and all responders report the measurement results to SME instead.

All TDD beamforming procedures are performed during a TDD SP.

TDD individual and TDD group beamforming procedures assumes antenna reciprocity for both the initiator and responder STAs. A TDD beamforming frame is a TDD SSW frame, a TDD SSW-Feedback frame or a TDD SSW-Ack frame.

Figure 124a shows an example of the TDD Individual beamforming training procedure.



**Figure 124a—An example of TDD Individual beamforming training**

During TDD Individual beamforming training, a STA that has not established a DMG control mode connection with an intended peer, switches its antenna configuration through all its receive sectors. In order to establish a DMG control mode connection, an initiator sends multiple TDD SSW frames during its assigned TDD slots. A TDD SSW frame indicates to the responder the TX Sector ID used by the initiator for the transmission of the TDD SSW frames, the time offset for which the responder should send its TDD SSW Feedback frame as response and the time offset the responder shall be ready to get the TDD SSW Ack frame. The responder sends its TDD SSW Feedback frame with the same sector it received the TDD SSW with the best quality. Following the reception of a TDD SSW Feedback frame, the initiator sends a TDD SSW Ack frame that acknowledges the received configuration. During the TDD Individual beamforming training, the TDD SSW frame is sent periodically and will be repeated multiple times for each TX Sector ID. The TDD Individual BF training sequence is continued until the initiator sets the End of Training subfield in the TDD SSW Ack frame to 1 in which will includes also the time offsets indication in the Initiator Transmit Offset subfield on when the responder obtains the network configuration parameters and time offset indication in the Responder Transmit Offset on when the responder sends the total results of the TDD Individual beamforming procedure.

Figure 124b gives an example of the TDD Group beamforming training procedure.



**Figure 124b—An example of TDD Group beamforming training**

During TDD Group beamforming training, a STA that has not established a DMG control mode connection with an intended peer, switches its antenna configuration through all its receive sectors. In order to establish a DMG control mode connection, an initiator sends multiple TDD SSW frames during its assigned TDD slots. A TDD SSW frame indicates to the responders the TX Sector ID used by the initiator for the transmission of the TDD SSW frames, the time offset for which each responder should send its TDD SSW Feedback frame as response and the time offset each responder shall be ready to get the TDD SSW Ack frame. Each responder sends its TDD SSW Feedback frame with the same sector it received the TDD SSW frame with the best quality. Following the reception of a TDD SSW Feedback frame, the initiator sends a TDD SSW Ack frame to each responder that acknowledges the received configuration.

During the TDD Group beamforming training, the TDD SSW frame is sent periodically and will be repeated multiple times for each TX Sector ID. The TDD Group BF training sequence for each responder is continued until the initiator sets the End of Training subfield in the TDD SSW Ack frame to 1 for the corresponding responder in which will includes also the time offsets indication in the Initiator Transmit Offset subfield on when the corresponding responder obtains the network configuration parameters and time offset indication in the Responder Transmit Offset on when the corresponding responder sends the total results of the TDD Group beamforming procedure. The initiator could end the BF training with the responders simultaneously or individually. This is implementation dependent, and out of scope of this standard.

**10.39.10.2 Initiator Operation for TDD Individual Beamforming**

For TDD Individual Beamforming, the BFType parameter is set to TDD Individual BF in the MLME-TDD-BF-TRAINING.request primitive.

To initiate TDD Individual beamforming, the initiator shall send multiple TDD SSW frames with the RA field set to the Responder STA’s MAC Address as indicated by the PeerSTAAddress parameter of the MLME-TDD-BF-TRAINING.request primitive.

TDD SSW frames that are sent from the same transmit antenna sector shall have the same TX Sector ID subfield value; frames shall be transmitted at the same transmit power and shall not include BRP training fields.

Initiator shall send TDD SSW frames with the same TX Sector ID subfield for multiple number of times as indicated in the SectorRepetitions parameter of the MLME-TDD-BF-TRAINING.request primitive.

Initiator shall send the TDD SSW frames with the TX Sector ID values as indicted in the TXSectorIDList parameter of the MLME-TDD-BF-TRAINING.request primitive.

TDD SSW and TDD SSW Ack frames transmitted in the same TDD slot shall be be separated with SBIFS interval and shall have a strictly increasing Count Index subfield value with the first transmitted TDD SSW frame or TDD SSW Ack frame in the TDD slot has this subfield equal to zero.

NOTE- It is recommended to transmit all TDD SSW frames at the beginning of a TDD slot and before TDD SSW ACK frames that are sent in the same TDD slot.

The initiator shall set its receive antenna to the same sector as was indicated in the TX Sector ID subfield of the respective TDD SSW frames to receive the responder TDD SSW Feedback frame at the time offset indicated by the below equation:

*ResponderFeedbackOffset – [(CountIndex+1) x TXTIME(TDD SSW) + (Count Index x SBIFS)]*  (1)

Where:

*ResponderFeedbackOffset*  is the Responder Feedback Offset subfield value in the TDD SSW frame with the same TX Sector ID within the same TDD slot (in microsecond). This value is the summation of two factors. The first factor is the duration from the end of the first TDD SSW or TDD SSW Ack frame to the start of the corresponding TDD SSW Feedback frame. The second factor is one *TXTIME(TDD SSW) which is a constant value for* *TDD Individual Beamforming.*

*CountIndex*  is the Count Index subfield value from the respective TDD SSW or TDD SSW Ack (integer)

Figure 125 depict the calculation of time to transmit the TDD SSW feedback for TDD Individual BF.



**Figure 125—TDD SSW feedback transmit time for TDD Individual BF**

If the initiator received a TDD SSW Feedback frame, after the time offset indicated by the following equation, the initiator shall set its DMG antenna to the same sector that was used to transmit the respective TDD SSW frame to transmit a TDD SSW Ack frame to the responder.

*InitiatorAckOffset – [(CountIndex+1) x TXTIME(TDD SSW) + (Count Index x SBIFS)]*  (2)

Where:

*InitiatorAckOffset*  is the Initiator Ack Offset subfield value in the TDD SSW frame with the same TX Sector ID within the same TDD slot (in microsecond). This value is the summation of two factors. The first factor is the duration from the end of the first TDD SSW or TDD SSW Ack frame to the start of the corresponding TDD SSW Ack frame. The second factor is one *TXTIME(TDD SSW) which is a constant value for* *TDD Individual Beamforming.*

*CountIndex*  is the Count Index subfield value from the received TDD SSW or TDD SSW Ack (integer)

The TDD SSW Ack frame shall include the sector used by the initiator to transmit the TDD SSW Ack in the TX Sector ID subfield, the sector used by the responder to transmit the TDD SSW Feedback frame in the Decoded TX Sector ID subfield, the measured SNR of the decoded TDD SSW Feedback frame in the SNR Report subfield and the time offsets to exchange announce frames with STA capabilities and network configuration.

For TDD Individual Beamforming, an initiator may request the responder to stop its receive sector sweeping by setting End of Training subfield to 1 in the TDD SSW frames. Upon reception of TDD SSW Feedback frame with End of Training subfield set to 1, the initiator should send the TDD SSW Ack frame to the responder with End of Training subfield set to 1, at the time offset indicated by (2). After sending TDD SSW Ack frame with End of Training subfield equal to 1, the initiator shall configure its DMG antenna to the sector index as indicated in the Decoded TX Sector ID subfield of the TDD SSW Feedback frame received from the responder during the respective TDD beamforming training in which its End of Training subfield was set to 1. The initiator shall use this sector for its subsequent transmissions and receptions with the responder, until another sector is negotiated.

If the initiator sent TDD SSW Ack frame with the End Of Training subfield set to 1, after the time offset indicated by the following equation, the initiator shall set its DMG antenna to the same sector that was used to transmit the respective TDD SSW Ack frame to transmit an announce frame to the responder.

*InitiatorTransmitOffset – [(CountIndex+1) x TXTIME(TDD SSW) + (Count Index x SBIFS)]*  (3)

Where:

*InitiatorTransmitOffset*  is the Initiator Transmit Offset subfield value in the TDD SSW Ack frame with the End of Training subfield set to 1 (in microsecond). This value is the summation of two factors. The first factor is the duration from the end of the first TDD SSW or TDD SSW Ack frame to the start of the corresponding announce frame. The second factor is one *TXTIME(TDD SSW) which is a constant value for* *TDD Individual Beamforming.*

*CountIndex*  is the Count Index subfield value from the received TDD SSW or TDD SSW Ack (integer)

The initiator shall set its receive antenna to the same sector as was indicated in the TX Sector ID subfield of the respective TDD SSW Ack frame with the End Of Training subfield set to 1, in order to receive the responder announce frame at the time offset indicated by the below equation:

*ResponderTransmitOffset – [(CountIndex+1) x TXTIME(TDD SSW) + (Count Index x SBIFS)]*  (4)

Where:

*ResponderTransmitOffset*  is the Responder Transmit Offset subfield value in the TDD SSW Ack frame with the End of Training subfield set to 1 (in microsecond). This value is the summation of two factors. The first factor is the duration from the end of the first TDD SSW or TDD SSW Ack frame to the start of the corresponding announce frame. The second factor is one *TXTIME(TDD SSW) which is a constant value for* *TDD Individual Beamforming.*

*CountIndex*  is the Count Index subfield value from the respective TDD SSW or TDD SSW Ack (integer)

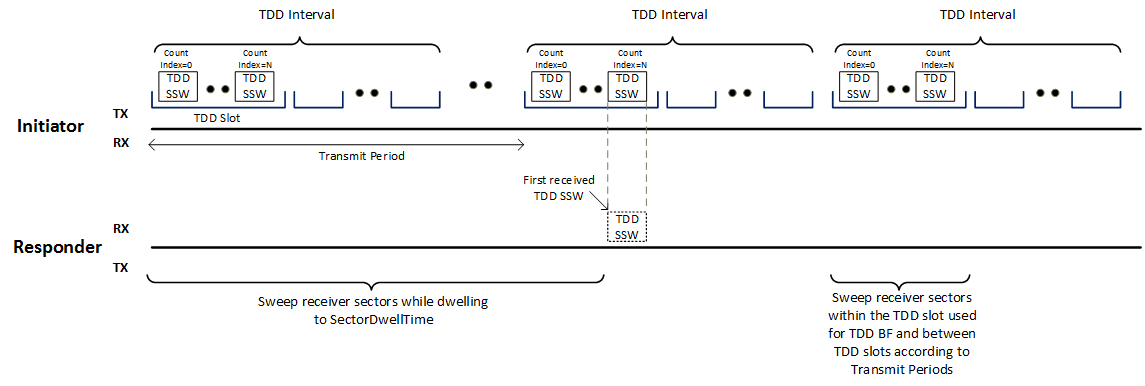
**10.39.10.3 Responder Operation for TDD Individual Beamforming**

A responder STA that has lost its network configuration or has not yet receive TDD SSW frame or has not yet acquired the TDD Slot Structure element used by the BSS shall sweep its receiver antenna through all its receive sectors while dwelling on each sector for a time equal to SectorDwellTime as indicted by the MLME-TDD-BF-SCAN.request primitive

NOTE – To increase the likelihood of detecting initiator’s TDD SSW frame, the responder SME can set SectorDwellTime to at least [2 × TXTIME (TDD SSW) + SBIFS].

A responder STA that has received TDD SSW frame shall sweep its receiver antenna configuration through its receive sectors between TDD beamforming frames received in a TDD slot and between TDD slots used for BF training according to the period as indicated by the Transmit Period subfield of the received TDD SSW frame.

Figure 126 gives an example of the Responder receiver sweeping procedure for TDD Individual BF.



**Figure 126—Responder Receiver Sweeping for TDD Individual BF**

Once the first TDD SSW frame is received, the responder proceeds with the following operation.

Upon reception of one or more TDD SSW frames on single receive sector, the responder shall switch to its next receive sector to be ready to receive the next TDD SSW frame transmission within SBIFS interval or at the time instant specified by the Transmit Period in the TDD SSW frame. While sweeping through its receive sectors, the responder shall continue decoding all the received TDD SSW frames.

The responder shall transmit a TDD SSW Feedback frame using the sector from which the responder received the TDD SSW with the best link quality at the time indicated by equation (1). The TDD SSW Feedback frame shall include the sector index used by the initiator to transmit the TDD SSW frame in the Decoded TX Sector ID subfield, the sector index used by the responder to transmit the TDD SSW Feedback frame in the TX Sector ID subfield, and the SNR of the TDD SSW frame received with best quality in the SNR Report subfield.

At the time offset indicated by equation (2) of the decoded TDD SSW frame, the responder shall set its receive DMG antenna to the same sector that was indicated in the TX Sector ID subfield of the TDD SSW Feedback in order to be ready to receive a TDD SSW Ack frame from the initiator.

The responder shall continue sweeping through its receive sectors until successfully receiving and decoding a TDD SSW Ack frame with End of Training subfield equal to 1. Upon the reception of TDD SSW Ack frame with End of Training subfield equal to 1, the responder shall stop its receive sweeping and shall configure its DMG antenna to the sector as indicated in the Decoded TX Sector ID subfield of the TDD SSW Ack frame received from the initiator and which its End of Training subfield is set to 1. The responder shall use this sector for its subsequent transmissions and receptions with the initiator, until another sector is negotiated.

Responder that transmits TDD SSW Feedback frame in response to TDD SSW frames sent with End of Training subfield set to 1 shall set the End of Training subfield in the TDD SSW Feedback frame to 1.

Upon reception of TDD SSW Ack with End of Training subfield set to 1, the responder shall be ready to receive an announce frame from the initiator at the time offset indicated by (3) and shall transmit to the initiator an announce frame containing a TDD Route element listing the ordered pairs of TX Sector IDs and Decoded TX Sector IDs obtained from the TDD beamforming training transmitted at the time offset indicated by (4).

**10.39.10.4 Initiator Operation for TDD Group Beamforming**

For TDD Group Beamforming, the BFType parameter is set to TDD Group BF in the MLME-TDD-BF-TRAINING.request primitive.

To initiate TDD Group beamforming, the initiator shall send multiple TDD SSW frames. For each TDD SSW frame, the RA field is set to the Broadcast MAC Address, and the MAC address of each responder is indicated by the PeerSTAAddress parameter of the MLME-TDD-BF-TRAINING-START.request primitive.

The Responder ID subfield of each responder is set to be the value derived from the responder’s MAC address, based on the following scheme, which is similar as the scheme in 30.9.1.2.

The process for generating Responder ID subfield from the responder’s MAC address is depicted in the following Figure.



**Figure 127—** **Generation of** **Responder ID subfield**

The process starts by using the MAC address of the responder to generate the scrambled MAC address. The MAC address is divided into three words, *wordi* (0 ≤ *i* ≤ 2), of 16 bits each, where *word0* is the 16 MSB of the MAC address and *word2* is the 16 LSB of the MAC address. For each *wordi*, a scrambled\_*wordi* is created as follows:

*Scrambled*\_*wordi* = (*wordi* + *scramble* \_ *pattern*) mod 216 (5)

where:

*wordi* is the corresponding 16 bit word from the MAC address.

*scramble\_pattern* is ((0x5795×*seed\_value*) mod 215), where *seed\_value* is the value of the Scrambler Initialization field in the L-Header of the PPDU carrying the TDD SSW frame.

The scrambled MAC address is generated by the consecutive concatenation of *scrambled\_word0*,  
*scrambled\_word1* and *scrambled\_word2*.

Finally, the Short Scrambled MAC address field is generated by taking the 10 MSBs of CRC-16-CCITT computed over the scrambled MAC address.

TDD SSW frames that are sent from the same transmit antenna sector shall have the same TX Sector ID subfield value; frames shall be transmitted at the same transmit power and shall not include BRP training fields.

Initiator shall send TDD SSW frames with the same TX Sector ID subfield for multiple number of times as indicated in the SectorRepetitions parameter of the MLME-TDD-BF-TRAINING.request primitive.

Initiator shall send the TDD SSW frames with the TX Sector ID values as indicted in the TXSectorIDList parameter of the MLME-TDD-BF-TRAINING.request primitive.

TDD SSW and TDD SSW Ack frames transmitted in the same TDD slot shall be be separated with SBIFS interval and shall have a strictly increasing Count Index subfield value with the first transmitted TDD SSW frame or TDD SSW Ack frame in the TDD slot has this subfield equal to zero.

The initiator shall set its receive antenna to the same sector as was indicated in the TX Sector ID subfield of the respective TDD SSW frames to receive the responder TDD SSW Feedback frame of each responder at the time offset indicated by the below equation:

*ResponderFeedbackOffsetn – [AckCountIndex* × *TXTIME(TDD Ack)  + (CountIndex+1-* *AckCountIndex)* × *TXTIME(TDD SSW) + (CountIndex* × *SBIFS)]*  (6)

Where:

*ResponderFeedbackOffsetn*  is the Responder Feedback Offset subfield value in the *n*th responder’s Responder Info subfield in the TDD SSW frame with the same TX Sector ID within the same TDD slot (in microsecond). This value is the summation of two factors. The first factor is the duration from the end of the first TDD SSW or TDD SSW Ack frame to the start of the corresponding TDD SSW Feedback frame. The second factor is one *TXTIME(TDD SSW) which is a variable for* *TDD Group Beamforming.* In order to avoid collision of the TDD SSW Feedback frame transmission for responders, different ResponderFeedbackOffset should be set for different Responders.

*CountIndex*  is the Count Index subfield value from the respective TDD SSW or TDD SSW Ack (integer)

*AckCountIndex*  is the Ack Count Index subfield value from the respective TDD SSW frame. This value is the number of TDD SSW Ack frames which have been sent before this TDD SSW frame within a TDD slot (integer).

Figure 128 depict the calculation of time to transmit the TDD SSW feedback for TDD Group BF.



**Figure 128—TDD SSW feedback transmit time for TDD Group BF**

If the initiator received a TDD SSW Feedback frame, after the time offset indicated by the below equation, the initiator shall set its DMG antenna to the same sector that was used to transmit the respective TDD SSW frame to transmit a TDD SSW Ack frame to the responder.

*InitiatorAckOffsetn – [AckCountIndex* × *TXTIME(TDD Ack)  + (CountIndex+1- AckCountIndex)* × *TXTIME(TDD SSW) + (Count Index* × *SBIFS)]*  (7)

Where:

*InitiatorAckOffsetn*  is the Initiator Ack Offset subfield value in the *n*th responder’s Responder Info subfield in the TDD SSW frame with the same TX Sector ID within the same TDD slot (in microsecond). This value is the summation of two factors. The first factor is the duration from the end of the first TDD SSW or TDD SSW Ack frame to the start of the corresponding TDD SSW Ack frame. The second factor is one *TXTIME(TDD SSW) which is a variable for* *TDD Group Beamforming.* Different ResponderAckOffset should be set for each Responder.

*CountIndex*  is the Count Index subfield value from the received TDD SSW or TDD SSW Ack (integer)

*AckCountIndex*  is the Ack Count Index subfield value from the respective TDD SSW frame. This value is the number of TDD SSW Ack frames which have been sent before this TDD SSW frame within a TDD slot (integer).

The TDD SSW Ack frame shall include the sector used by the initiator to transmit the TDD SSW Ack in the TX Sector ID subfield, the sector used by the responder to transmit the TDD SSW Feedback frame in the Decoded TX Sector ID subfield, the measured SNR of the decoded TDD SSW Feedback frame in the SNR Report subfield and the time offsets to exchange announce frames with STA capabilities and network configuration.

For TDD Group Beamforming, an initiator may request one or more responders in the group to stop its receive sector sweeping by setting the End of Training subfield to 1 in the corresponding Responder Info subfield of the TDD SSW frames. Upon reception of TDD SSW Feedback frame with End of Training subfield set to 1, the initiator should send the TDD SSW Ack frame to the corresponding responder with End of Training subfield set to 1, at the time offset indicated by (7). After sending TDD SSW Ack frame with End of Training subfield equal to 1, the initiator shall configure its DMG antenna to the sector index as indicated in the Decoded TX Sector ID subfield of the TDD SSW Feedback frame received from the corresponding responder during the respective TDD beamforming training in which its End of Training subfield was set to 1. The initiator shall use this sector for its subsequent transmissions and receptions with the corresponding responder, until another sector is negotiated. The length of the TDD SSW frame stays the same during TDD Group beamforming. For each target responder that has completed beamforming training the corresponding Responder ID field is set to 0.

Once the initiator sends a TDD SSW Ack frame with the End of Training subfield set to 1 to a target responder, after the time offset indicated by the below equation, the initiator shall set its DMG antenna to the same sector that was used to transmit the respective TDD SSW Ack frame to transmit an Announce frame to the responder.

*InitiatorTransmitOffset – [AckCountIndex* × *TXTIME(TDD Ack)  + (CountIndex+1- AckCountIndex)* × *TXTIME(TDD SSW) + (Count Index* × *SBIFS)]*  (8)

Where:

*InitiatorTransmitOffset*  is the Initiator Transmit Offset subfield value in the TDD SSW Ack frame with the End of Training subfield set to 1 (in microsecond). This value is the summation of two factors. The first factor is the duration from the end of the first TDD SSW or TDD SSW Ack frame to the start of the corresponding announce frame. The second factor is one *TXTIME(TDD SSW) which is a variable for* *TDD Group Beamforming.*

*CountIndex*  is the Count Index subfield value from the received TDD SSW or TDD SSW Ack (integer)

*AckCountIndex*   is the Ack Count Index subfield value from the respective TDD SSW frame. This value is the number of TDD SSW Ack frames which have been sent before this TDD SSW frame within a TDD slot (integer).

The initiator shall set its receive antenna to the same sector as was indicated in the TX Sector ID subfield of the respective TDD SSW Ack frame with the End Of Training subfield set to 1, in order to receive the responder announce frame at the time offset indicated by the below equation:

*ResponderTransmitOffset – [AckCountIndex* × *TXTIME(TDD Ack)  + (CountIndex+1- AckCountIndex)* × *TXTIME(TDD SSW) + (Count Index* × *SBIFS)]*  (9)

Where:

*ResponderTransmitOffset*  is the Responder Transmit Offset subfield value in the TDD SSW Ack frame with the End of Training subfield set to 1 (in microsecond). This value is the summation of two factors. The first factor is the duration from the end of the first TDD SSW or TDD SSW Ack frame to the start of the corresponding announce frame. The second factor is one *TXTIME(TDD SSW) which is a variable for* *TDD Group Beamforming.*

*CountIndex*  is the Count Index subfield value from the respective TDD SSW or TDD SSW Ack (integer)

*AckCountIndex*   is the Ack Count Index subfield value from the respective TDD SSW frame. This value is the number of TDD SSW Ack frames which have been sent before this TDD SSW frame within a TDD slot (integer).

NOTE- It is recommended to transmit all TDD SSW frames at the beginning of a TDD slot and before TDD SSW ACK frames that are sent in the same TDD slot.

**10.39.10.5 Responder Operation for TDD Group Beamforming**

A responder STA that has lost its network configuration or has not yet receive TDD SSW frame or has not yet acquired the TDD Slot Structure element used by the BSS shall sweep its receiver antenna through all its receive sectors while dwelling on each sector for a time equal to SectorDwellTime as indicted by the MLME-TDD-BF-SCAN.request primitive

NOTE – To increase the likelihood of detecting initiator’s TDD SSW frame, the responder SME can set SectorDwellTime to at least [2 × TXTIME (TDD SSW) + SBIFS]. The best value of SectorDwellTime is implementation dependent, and out of scope of this standard.

A responder STA that has received TDD SSW frame shall sweep its receiver antenna configuration through its receive sectors between TDD beamforming frames received in a TDD slot and between TDD slots used for BF training according to the period as indicated by the Transmit Period subfield of the received TDD SSW frame.

Figure 129 gives an example of the Responder receiver sweeping procedure for TDD Group BF.



**Figure 129—Responder Receiver Sweeping for TDD Group BF**

Once the first TDD SSW frame is received, the responder proceeds with the following operation.

Upon reception of one or more TDD SSW frames on single receive sector, the responder shall switch to its next receive sector to be ready to receive the next TDD SSW frame transmission within SBIFS interval or at the time instant specified by the Transmit Period in the TDD SSW frame. While sweeping through its receive sectors, the responder shall continue decoding all the received TDD SSW frames.

The responder shall transmit a TDD SSW Feedback frame using the sector from which the responder received the TDD SSW with the best link quality at the time indicated by equation (6). The TDD SSW Feedback frame shall include the sector index used by the initiator to transmit the TDD SSW frame in the Decoded TX Sector ID subfield, the sector index used by the responder to transmit the TDD SSW Feedback frame in the TX Sector ID subfield, and the SNR of the TDD SSW frame received with best quality in the SNR Report subfield.

At the time offset indicated by equation (7) of the decoded TDD SSW frame, the responder shall set its receive DMG antenna to the same sector that was indicated in the TX Sector ID subfield of the TDD SSW Feedback in order to be ready to receive a TDD SSW Ack frame from the initiator.

The responder shall continue sweeping through its receive sectors until successfully receiving and decoding a TDD SSW Ack frame with End of Training subfield equal to 1. Upon the reception of TDD SSW Ack frame with End of Training subfield equal to 1, the responder shall stop its receive sweeping and shall configure its DMG antenna to the sector as indicated in the Decoded TX Sector ID subfield of the TDD SSW Ack frame received from the initiator and which its End of Training subfield is set to 1. The responder shall use this sector for its subsequent transmissions and receptions with the initiator, until another sector is negotiated.

Responder that transmits TDD SSW Feedback frame in response to TDD SSW frames sent with End of Training subfield set to 1 shall set the End of Training subfield in the TDD SSW Feedback frame to 1.

Upon reception of TDD SSW Ack with End of Training subfield set to 1, the responder shall be ready to receive an announce frame from the initiator at the time offset indicated by (8) and shall transmit to the initiator an announce frame containing a TDD Route element listing the ordered pairs of TX Sector IDs and Decoded TX Sector IDs obtained from the TDD beamforming training transmitted at the time offset indicated by (9).

**10.39.10.6 Initiator operation for TDD beam measurement**

Initiator operation during TDD beam measurement is mostly the same as initiator operation during TDD beamforming training, with the following differences,

* TDD Beam measurement is started upon receiving an MLME-TDD-BEAM-MEASUREMENT.request primitive with BFRole parameter set to Initiator.
* The Responder Feedback Offset and Initiator Ack Offset fields are set to zero in all TDD SSW frames transmitted exclusively for TDD Beam Measurement, i.e., TDD SSW frames with TDD Group Beamforming field set to 0 and TDD Beam Measurement field set to 1
* No TDD SSW Ack is transmitted

**10.39.10.7 Responder operation for TDD beam measurement**

Responder’s operation during the TDD Beam Measurement procedure is the same responder operation during TDD beamforming training, with the following differences,

* TDD Beam measurement is started upon receiving an MLME-TDD-BEAM-MEASUREMENT.request primitive with BFRole parameter set to Responder.
* Responder does not transmit any frames to the initiator and reports the measurement results to SME instead.

*Add below sections as follows*

**11.36.2 TDD beamforming**

Upon receipt of an MLME-TDD-BF-TRAINING.request primitive, a DMG STA shall assume the role of TDD beamforming initiator, andbased on the BFType parameter, the initiator shall undertake TDD Individual beamforming training or TDD Group Beamforming training with the STA(s) indicated by the PeerSTAAddress parameter according to the procedures defined in 10.39.10. The beamforming procedure shall start at the time indicated by the BeamformingStartTimestamp parameter.

Upon receipt of the MLME-SCAN.request primitive with the ScanType parameter set to TDD passive, a DMG

STA shall passively scan for TDD SSW frames by sweeping its receiver antenna through all the receive sectors specified in ScanSectorIDList parameter while dwelling on each sector for a time equal to SectorDwellTime and shall be performed through all channels specified within the ChannelList parameter.

A STA that receives the MLME-TDD-BF-TRAINING.request primitive with BFRole parameter set to initiator and BFType parameter set to TDD Individual beamforming or TDD Group beamforming shall assume the initiator role and perform the TDD Individual or TDD Group BF procedure defined in 10.39.10. The STA shall issue an MLME-TDD-BF-TRAINING.confirm primitive on completion of the requested TDD beamforming procedure after transmitting the last TDD SSW Ack frame with End of Training field set to 1.

A STA that performs a TDD beamforming procedure with a peer STA at the request of the peer STA shall issue an  
MLME-TDD-BF-TRAINING.indication primitive on completion of the beamforming procedure as specified in 10.39.10 after receiving a TDD SSW Ack frame with RA field set to the STA MAC address and with End of Training subfield set to 1. The STA shall add the parameters RXSectorID and SNR according to the received RX Sector ID and SNR from the respective TDD SSW Ack received from the initiator.

Figure 129a illustrates an example of the TDD Individual beamforming training procedure.



**Figure 129a— TDD Individual Beamforming training procedure.**

Figure 129b illustrates an example of the TDD Group beamforming training procedure.



**Figure 129b— TDD Group Beamforming training procedure.**

**11.36.3 TDD beam measurement**

Upon receipt of an MLME-TDD-BEAM-MEASUREMENT.request primitive, a DMG STA shall assume the role of initiator or responder and shall perform the beam measurement procedure with the STA(s) indicated by the PeerSTAAddress parameter according to the procedures defined in 10.39.10. The beamforming procedure shall start at the time indicated by the BeamformingStartTimestamp parameter.

A STA that receives the MLME-TDD-BEAM-MEASUREMENT.request primitive with BFRole parameter set to responder shall issue an MLME-TDD-BF-TRAINING.confirm primitive on completion of the beamforming procedure, which happens according to the TDD slot schedule provided by the MLME-TDD-BF-TRAINING.request primitive. The STA shall add the parameters RXSectorID and SNR according to the received TDD SSW frames received from the initiator.

**11.36.4 TDD Sector Switch procedure**

The TDD sector switch procedure allows a pair of DMG STAs operating in an SP with TDD channel access to synchronize switch of transmit and receive sectors for communication between them. Only a PCP or AP shall initiate the TDD sector switch procedure. An AP or PCP can make use of the information in TDD Feedback Results subelements and the results of measurements undertaken by STAs in the BSS to determine when to invoke a TDD sector switch procedure.

Upon receipt of an MLME-TDD-SECTOR-SWITCH.request primitive, a DMG STA shall send the peer STA indicated by the PeerSTAAddress parameter an Announce frame of subtype Action with a TDD Route element that includes a TDD Sector Setting subelement with the Set Sector Request subfield set to 1. This is referred to as a TDD sector switch request message. Messages with Set Sector Response subfield set to 1 and messages with Set Sector Acknowledge subfield set to 1 are referred as TDD sector response and TDD sector acknowledge messages, respectively. STA shall not set to ‘1’ more than one bit of the TDD Sector Setting Control field in a given transmitted element.

The Responder TX Sector ID, Responder RX Sector ID, Initiator TX Sector ID and Initiator RX Sector ID subfields in the TDD Sector Setting subelement shall be set to, respectively, the ResponderTXSectorID, ResponderRXSectorID, InitiatorTXSectorID and InitiatorRXSectorID parameters of the request primitive. The Set Sector Request subfield in the TDD Sector Setting subelement shall be set to 1.

The Switch Timestamp subfield in the TDD Sector Setting subelement shall be set to the value of the SectorSwitchTimestamp parameter of the request primitive. The Switch Timestamp subfield value shall be set to a time value that allow at least three retransmissions of the Announce frame and the corresponding Ack frame sent in response.

The Revert Timestamp subfield in the TDD Sector Setting subelement shall be set to the value of the SectorRevertTimestamp parameter of the request primitive. The Revert Timestamp subfield value shall be set to a time value that allows the responder at least three retransmissions of a TDD sector response message, for the case the responder does not receive the TDD sector acknowledge message from the initiator, plus time to allow the initiator at least three retransmissions of a TDD sector acknowledge message, for the case the initiator does not receive the Ack frame from the responder.

An initiator STA that does not receive an Ack frame in response to a TDD sector switch request message should retransmit the message until the time indicated by the Switch Timestamp subfield.

A MLME-TDD-SECTOR-SWITCH.request primitive incorporating a new SectorSwitchTimestamp value shall not be issued until the SectorRevertTimestamp of the previous request primitive has been elapsed.

A responder shall send an Ack frame in response to the reception of a TDD sector switch request message and perform the following:

* Issue an MLME-TDD-SECTOR-SWITCH.indication primitive with the PeerSTAAddress parameter set to the TA of the received message, and the ResponderTXSectorID, ResponderRXSectorID, InitiatorTXSectorID and InitiatorRXSectorID parameters of the primitive set to, respectively, the Responder TX Sector ID, Responder RX Sector ID, Initiator TX Sector ID and Initiator RX Sector ID subfields of the TDD Sector Setting subelement within the received message.
* Respond with an Ack frame to any TDD sector switch request messages that arrive before the time indicated by the Switch Timestamp subfield value within the message.
* Set its receive and transmit antenna configuration corresponding to the Responder RX Sector ID and Responder TX Sector ID subfield values in the TDD sector switch request message, respectively, at the time indicated by the Switch Timestamp subfield.
* Send to the initiator a TDD sector switch response message by transmitting an Announce frame of subtype Action No Ack with the same Sector Setting subelement that was received by the responder, except that the Set Sector Request subfield shall be set to 0 and the Set Sector Response subfield shall be set to 1. The TDD sector switch message should be sent at the earliest TDD slot occurring after the time indicated by the value of the Switch Timestamp subfield.

An initiator receiving an Ack frame to a transmitted TDD sector switch request message shall perform the following:

* Issue an MLME-TDD-SECTOR-SWITCH.indication primitive with the ResponderTXSectorID, ResponderRXSectorID, InitiatorTXSectorID and InitiatorRXSectorID parameters of the primitive set to the Responder TX Sector ID, Responder RX Sector ID, Initiator TX Sector ID and Initiator RX Sector ID subfields in the TDD Sector Setting subelement as was sent in the respective TDD sector switch request.
* Set its receive and transmit antenna configuration corresponding to the Initiator TX Sector ID and Initiator RX Sector ID subfield values, respectively, at the time indicated by the value of the Switch Timestamp subfield.

An initiator receiving a TDD sector switch response message shall send the responder a TDD sector switch acknowledge message by transmitting an Announce frame of subtype Action with the same Sector Setting subelement that was received by the initiator, except that the Set Sector Response subfield shall be set to 0 and the Set Sector Acknowledge subfield shall be set to 1. The TDD sector switch acknowledge message should be sent at the earliest TDD slot occurring after the time indicated by the value of the Switch Timestamp subfield.

A responder sending an Ack frame in response to a TDD sector switch acknowledge message received before the time indicated by the Revert Timestamp value shall issue an MLME-TDD-SECTOR-SWITCH.confirm primitive. The TXSectorID and RXSectorID parameters of the primitive shall be set to the new transmit sector index and receive sector indexes, respectively, and the ResultCode parameter shall be set to SUCCESS.

An initiator receiving an Ack frame in response to a transmitted TDD sector switch acknowledge message before the time indicated by the Revert Timestamp value shall issue MLME-TDD-SECTOR-SWITCH.confirm primitive. The TXSectorID and RXSectorID parameters of the primitive shall be set to the new transmit sector index and receive sector indexes, respectively, and the ResultCode parameter shall be set to SUCCESS.

A responder that did not receive a TDD sector switch acknowledge message in response to a transmitted TDD sector switch response message should retransmit the TDD sector switch message until the time indicated by the Revert Timestamp subfield value.

An initiator STA that did not receive an Ack frame in response to a transmitted TDD sector switch acknowledge message should retransmit the TDD sector switch acknowledge message until the time indicated by the Revert Timestamp subfield value.

A responder that did not send an Ack frame in response to a received TDD sector switch acknowledge message by the time indicated by the Revert Timestamp subfield value shall issue an MLME-TDD-SECTOR-SWITCH.confirm primitive with the ResultCode parameter set to FAILURE and shall revert to the antenna configuration used atthe start of the TDD sector switch procedure.

An initiator STA that did not receive an Ack frame in response to a transmitted TDD sector switch acknowledge message by the time indicated by the Revert Timestamp subfield value shall issue an MLME-TDD-SECTOR-SWITCH.confirm primitive with the ResultCode parameter shall be set to FAILURE and shall revert to the antenna configuration used at the start of the TDD sector switch procedure.

An initiator STA that reverted to the previous antenna configuration at the time indicated by the Revert Timestamp subfield value, shall send a PPDU that requires Ack frame at the earliest TDD slots occurring after the Revert Timestamp subfield value. An initiator STA receiving an Ack frame in response to the PPDU it transmitted after the time indicated by the Revert Timestamp subfield shall issue an MLME-TDD-SECTOR-SWITCH.indication primitive. The TXSectorID and RXSectorID parameters of the primitive shall be set to the sectors used at the start of the TDD sector switch procedure and the ResultCode parameter shall be set to SUCCESS.

A responder sending an Ack frame in response to a PPDU it received after the time indicated by the Revert Timestamp subfield value shall issue an MLME-TDD-SECTOR-SWITCH.indication primitive. The TXSectorID and RXSectorID parameters of the primitive shall be set to the sectors used at the start of the TDD sector switch procedure and the ResultCode parameter shall be set to SUCCESS.

A TDD initiator that did not receive an Ack frame in response to a transmitted PPDU shall initiate the TDD beamforming procedure as described in 10.39.10.

A responder that reverted to the antenna configuration at the time indicated by the Revert Timestamp subfield value and that did not receive a PPDU from the initiator at a TDD slot occurring after the Revert Timestamp subfield value shall start the TDD beamforming procedure as a responder as described in 10.39.10.

Figure 130 illustrates an example of successful TDD sector switch procedure.



**Figure 130— TDD Sector Switch procedure.**

**References:**

1. Draft P802.11ay\_D1.1.pdf
2. IEEE Std 802.11-2016