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Wireless LANs

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| **Specification Framework for TGbp** |
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Abstract

This document provides the framework from which the draft TGbp amendment will be developed. The document provides an outline of each the functional blocks that will be a part of the final amendment. The document is intended to reflect the working consensus of the group on the broad outline for the draft specification. As such it is expected to begin with minimal detail reflecting agreement on specific techniques and highlighting areas on which agreement is still required. It may also begin with an incomplete feature list with additional features added as they are justified. The document will evolve over time until it includes sufficient detail on all the functional blocks and their inter-dependencies so that work can begin on the draft amendment itself.

# Revision history

|  |  |  |
| --- | --- | --- |
| Revision | Date | Changes |
| 0 | Sep 09, 2024 | Initial version |
| 1 | Sep 19, 2024 | Add motions passed in 2024 September meeting |
| 2 | Sep 25, 2024 | Revised version based on the comments from task group members |
| 3 | Nov 21, 2024 | Add motions passed in 2024 November meeting |
| 4 | Feb 01, 2025 | Add motions passed in 2025 January meeting |
| 5 | Mar 06, 2025 | Revised version based on the comments from task group members |
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| 8 | May 22, 2025 | Add motions passed in 2025 May meeting |
| 9 | June 06, 2025 | Revised version based on the comments from task group memebers |
| 10 | July 17, 2025 | Revised version based on the comments from task group memebers |

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# Abbreviations and acronyms

AMP ambient power

WPT wireless power transfer

OOK on-off keying

# AMP architecture

1.
2.

## General

* **AM-1**: 11bp defines an “AMP AP STA”
	+ AMP non AP STAs may or may not communicate with AMP AP STA without association
	+ The AMP AP STA may or may not provide access to the DS for the AMP non AP STA
	+ Note: the AMP AP STA may be part of an access point.

[Motion #22, [1], [16] and [17]]

* **AM-2**:
	+ Backscatter non-AP AMP STA: A non-AP AMP STA that is capable of receiving only AMP Downlink PPDUs and supports uplink backscatter transmission.
	+ Active Tx non-AP AMP STA: A non-AP AMP STA that is capable of receiving only AMP Downlink PPDUs and supports active transmission of AMP Uplink PPDUs.
	+ AMP Enabled non-AP STA: A non-AP STA (e.g. non-HT, HT or HE STA) that is also capable of receiving AMP Downlink PPDUs.

[Motion #29, [1] and [18]]

* **AM-3**:
	+ IEEE 802.11bp defines an AMP Energizer that contains an Energizing Function, which is capable of transmitting WPT waveform and/or excitation waveform for backscattering operation. Additionally, the AMP Energizer may contain or be co-located (which one is TBD) with an IEEE 802.11 non-AMP non-AP STA.
	+ Note: WPT waveform is transmitted over sub1-GHz. Depending on whether the backscattering operation happens in sub1-GHz or 2.4GHz, accordingly the excitation waveform will be transmitted in the same band.

[Motion #34, [1], [30] and [31]]

## Architecture feature #1

Description for Architecture feature #1

## Architecture feature #2

Description for Architecture feature #2

# AMP MAC

1.

## General

This section describes the functional blocks in the AMP MAC.

## AMP TSF

* **MM-1**: If AMP device is able to support AMP TSF, the maximum timing offset is ±104 ppm.

[Motion #13, [1] and [2]]

* **MM-23**: 802.11bp defines short timestamp to enable AMP NON-AP STA to monitor DL frames in duty-cycle operation.
	+ The length of short timestamp is TBD..

[Motion #82, [1], [63], [78] and [79]]

## UL access

* **MM-2**: 11bp defines a mechanism to allow an AP to solicit AMP uplink PPDU(s) from one or more 802.11bp clients.

[Motion #24, [1] and [19]]

* **MM-6**: 802.11bp to define a slot-based procedure to enable one or more clients to access the medium to send uplink AMP PPDU(s).

[Motion #45, [1] and [19]]

* **MM-7**:
	+ An 802.11bp client may use the receive time of the AMP Trigger frame, which solicits UL AMP PPDUs from the client, to determine the timing for transmitting UL AMP PPDUs in the same TXOP
	+ The definition of receive time is TBD.

[Motion #47, [1], [53]]

* **MM-8**: 802.11bp supports a time-slot based random access mechanism for Active Tx non-AP AMP STAs:
	+ AMP AP transmits an AMP frame that indicates one or more time-slots.
	+ Further details (e.g., frame formats, how a STA chooses a random access time-slot etc.) are TBD.

[Motion #50, [1], [54], [55], [56] and [57]]

* **MM-9**: 802.11bp supports a time-slot based scheduled access mechanism for Active Tx non-AP AMP STAs:
	+ AMP AP transmits an AMP frame to assign one or more transmission time-slots.
	+ Further details (e.g., frame formats, how the time-slots are assigned etc.) are TBD.

[Motion #51, [1], [54], [55], [56] and [57]]

## Power management for AMP non-AP STA

### Duty-cycle operation

* **MM-4**: If an AMP device is able to support TSF, it can monitor AMP DL Frame in a duty-cycle manner.

[Motion #32, [1], [21] and [22]]

### Service period

* **MM-22**: IEEE 802.11bp defines an AMP Service Period, that allows an Active Tx non-AP AMP STA to enter doze state after a minimum wake up time since the start of the AMP Service Period, if the Active Tx non-AP AMP STA does not receive any AMP DL PPDU from the AMP AP.

[Motion #75, [1], [22], [74] and [75]]

## Secure communication

### General

* **MM-3**: 11bp defines a mechanism to support secure communications for 802.11bp clients.

[Motion #26, [1] and [20]]

* **MM-5**:
	+ IEEE 802.11bp will specify secure data communication methods that do not require maintaining security associations.
	+ Note:
		- The methods are based on existing 802.11 security protocols.
		- The security for backscattering AMP devices are TBD.
		- The details are TBD.

[Motion #44, [1], [47], [48], [49], [50] and [51]]

* **MM-21**:
	+ 11bp uses short local addresses for AMP non-AP STAs in secure AMP communications.
	+ Note—Whether to include backscatter non-AP STAs in this procedure is TBD

[Motion #68, [1], [67] and [68]]

### Key generation

* **MM-14**: 802.11bp defines for AMP-enabled non-AP STA:
	+ AMP temporal key (ATK) to protect individually addressed AMP frames
	+ AMP integrity group temporal key (AIGTK) to protect group addressed AMP frames

[Motion #61, [1], [64]]

* **MM-15**: 802.11bp uses the baseline authentication procedure for AMP-enabled non-AP STA to generate AMP temporal key(s) to protect individually and group addressed AMP frames.

[Motion #62, [1], [64]]

* **MM-17**: 802.11bp defines a mechanism to generate a transient key for an AMP non-AP STA that supports secure communication, where:
	+ An AMP AP transmits a downlink frame containing an ANonce.
	+ After receiving the downlink AMP frame from the AMP AP that contains an ANonce, an AMP non-AP STA generates an SNonce.
	+ The AMP non-AP STA generates a transient key using the ANonce, the SNonce, the Authenticator Address (AA), the Supplicant Address (SA), and a Pairwise Master Key (PMK) between the AP and the client.
	+ Note—Whether to include backscatter non-AP STAs in this procedure is TBD.

[Motion #64, [1], [50], [20], [65] and [66]]

* **MM-18**: 802.11bp defines a mechanism to generate a transient key for an AMP AP that supports secure communication, where:
	+ In response to the DL AMP frame from the AMP AP that contains an ANonce, the AMP AP receives an UL AMP frame from an AMP non-AP STA that carries the SNonce and a MIC.
		- The AMP non-AP STA generates the MIC using the derived transient key at the AMP non-AP STA.
		- If the uplink AMP frame is carrying any UL data, the data payload portion of the uplink AMP frame may be encrypted using the transient key generated at the AMP non-AP STA.
	+ If the MIC is verified:
		- The AP uses the ANonce it transmitted in the previous downlink AMP frame, the SNonce, the Authenticator Address (AA), the Supplicant Address (SA), and the PMK to generate the transient key.
		- Using the generated transient key, the AMP AP decrypts the UL data payload (if the payload was encrypted).
	+ Note—Whether to include backscatter non-AP STAs in this procedure is TBD.

[Motion #65, [1], [50], [20], [65] and [66]]

### Secured data communication

* **MM-19**: the transient key generation at the AP and the AMP client in 802.11bp may occur concurrently with AMP downlink and uplink data communication:
	+ The downlink AMP frame from the AP carries ANonce along with downlink data from the AP (e.g., AMP trigger).
	+ The uplink AMP frame from the AMP client carries SNonce and MIC along with the UL data (e.g., UL response to the AMP trigger).
		- The UL data may be encrypted using the transient key generated at the AMP non-AP STA.
	+ Note—Whether to include backscatter non-AP STAs in this procedure is TBD.

[Motion #66, [1], [50], [20], [65] and [66]]

* **MM-20**: the transient key generation at the AP and the AMP client in 802.11bp may be performed immediately before AMP downlink and uplink data communication:
	+ Once the transient key is derived at both the AP and the AMP client, subsequent AMP data communication between the AP and the client can be secured using MIC and/or encryption based on the generated transient key.
	+ Note—Whether to include backscatter non-AP STAs in this procedure is TBD.

[Motion #67, [1] and [20]]

## Support of UHF RFID logic interface

* **MM-10**: 11bp supports a mode of operation in which a sub-set of the logical interface of the UHF RFID Standard is used for backscattering communication.
	+ Applicable UHF commands are carried in 802.11bp frames.
	+ Applicable to both mono-static & bi-static backscattering.
	+ The sub-set of the logical interface to be reused is TBD.
	+ NOTE – The logical interface of the UHF RFID Standard is defined by the EPC® Radio-Frequency Identity Generation-2 UHF RFID Standard.

[Motion #52, [1], [54], [55], [56] and [57]]

## Power management for AMP-enabled non-AP STA

* **MM-11**: 802.11bp defines an AMP duty cycle operation for an AMP-enabled non-AP STA, which follows the state transition diagram shown in the figure.
	+ AMP duty cycle operation follows the negotiation procedure defined for WUR in the baseline



[Motion #58, [1], [64]]

* **MM-12**: If an AMP-enabled non-AP STA successfully receives an AMP Wake-Up frame from the associated AMP AP, the non-AP STA should transition to the Awake State and transmit a PS-Poll/UL frame to the AP to indicate that it is in the Awake State (PS/Active mode).

[Motion #59, [1], [64]]

* **MM-13**: If the non-AP STA transmits a frame with PM = 1 to the associated AP, then the non-AP may transition to the Doze state, and the AMP-enabled non-AP STA shall enter the AMP mode.

[Motion #60, [1], [64]]

* **MM-16**: an AMP-enabled non-AP STA and the associated AMP AP use AMP mode setup to exchange AMP capabilities
	+ AMP mode setup may occur during the association procedure or post-association.

[Motion #63, [1], [64]]

## MAC feature #7

Description for MAC feature #7

# AMP PHY

1.

## General

* **PM-1**: 11bp supports a mode to enable AMP devices to operate in legacy WLAN network by defining AMP DL and required control/signaling.

[Motion #7, [1] and [3]]

* **PM-2**: 11bp defines at least one mode of MAC/PHY that allows an AMP-only device with active uplink communication in 2.4GHz subject to the following requirements:
	+ clock accuracy requirement is relaxed compared to legacy 802.11 devices;
	+ the active uplink communication can only be sent in response to being polled by the AP.

[Motion #14, [1] and [4]]

* **PM-3**: 11bp defines at least one mode of MAC/PHY that supports close-range mono-static backscattering communication in 2.4 GHz.

[Motion #15, [1] and [5]]

* **PM-4**: 11bp defines at least one mode of MAC/PHY that supports bi-static backscattering communication in 2.4 GHz.

[Motion #15, [1] and [6]]

* **PM-29**: 11bp defines at least one mode of MAC/PHY that supports mono-static backscattering communication in sub-1 GHz.

[Motion #73, [1] and [72]]

## AMP clock accuracy

* **PM-12**: When performing transmission, the maximum clock offset is ± 103 ppm for AMP Non-AP STA supporting active transmission.

[Motion #20, [1], [12] and [13]]

* **PM-28**: The maximum allowed clock inaccuracy for the backscattering tag using OOK modulation is 100,000 ppm for both receive mode and backscattering transmit mode.

[Motion #72, [1], [15] and [71]]

## DL PPDU

### General

This section describes DL PPDU design.

### DL PPDU format

* **PM-5**: IEEE 802.11bp will specify, in 2.4 GHz, an AMP Downlink PPDU containing at least an 802.11 preamble field, an AMP-Sync field and an AMP-Data field. Inclusion of an AMP-SIG field is TBD.
	+ The details of the 802.11 preamble field are TBD.
	+ Additionally, for transmission to backscatter STAs there will be one or more Excitation fields
	+ Additionally, for transmission to backscatter STAs there may be more than one AMP-Data field
		- Additionally, AMP-Sync and AMP-SIG field may precede each AMP-Data field
	+ Name of this Downlink PPDU is TBD.

[Motion #8, [1] and [7]]

* **PM-15**: The preamble of an AMP DL PPDU includes L-STF, L-LTF, L-SIG, RL-SIG, and U-SIGs for AMP enabled non-AP STA and active TX non-AP AMP STA in 2.4 GHz.

[Motion #28, [1] and [23]]

* **PM-16**: The (3dB) bandwidth of the AMP DL PPDU in 2.4 GHz is at least 10 MHz for backscattering communication. The transmit spectrum mask is TBD.

[Motion #30, [1], [24] and [25]]

### Waveform generation

* **PM-21**:
	+ The carrier waveform for AMP Downlink PPDU is constructed by repeating one predefined base waveform of TBD micro-second, and additional pseudo-random phase is applied to each base waveform
	+ The base waveform definition is TBD.
	+ Note:
		- The SYNC and Data fields are OOK modulated on the carrier waveform.
		- The Excitation field is not OOK modulated.

[Motion #39, [1], [40], [41], [42] and [43]]

* **PM-26**:
	+ The SYNC, Data field and Excitation field of 11bp DL PPDU use OFDM symbol as base carrier waveform for OOK modulated AMP communication.

[Motion #70, [1], [41], [42] and [70]]

* **PM-27**:
	+ The base OFDM symbol is defined as 4us OFDM symbol, and generated by performing 64-point IFFT of the predefined sequence and pre-append the last 0.8us waveform as the cyclic prefix.

[Motion #71, [1], [41], [42] and [70]]

### AMP-Sync field

* **PM-10**: The AMP-Sync field in AMP Downlink PPDU in 2.4 GHz is defined with chip duration of 2µs for backscattering case.

[Motion #18, [1] and [10]]

* **PM-18**: IEEE 802.11bp defines at least one AMP-Sync in the AMP Downlink PPDU in 2.4 GHz for backscatter communication, and at least one AMP-Sync in the AMP Downlink PPDU in 2.4 GHz for non-backscatter communication. The AMP-Sync is independent of the integrated and non-integrated deployment.

[Motion #33, [1] and [26]]

* **PM-25**:
	+ IEEE 802.11bp defines 4 base sequences used for AMP DL/UL SYNC field in 2.4GHz frequency band.
		- 1 base sequences, S1, for DL non-backscatter SYNC field.  S1 and a function of S1, are used for different DL data rate.
		- 1 sequence, S2,  for DL backscatter SYNC field.
		- 1 base sequence, S3, for UL active transmission SYNC field.
		- 1 sequence, S4, for UL backscatter SYNC field.
		- Detailed SYNC sequence designs are TBD
	+ Besides the above 4 base sequences, the need of additional sequence S5 is TBD if mono-static and bi-static backscattering UL SYNC field design is different.

[Motion #69, [1] and [69]]

* **PM-30**: IEEE 802.11bp will specify, in 2.4 GHz, DL synchronization sequence with the same chip duration for all data rates for non-backscatter case.

[Motion #76, [1] and [76]]

### Modulation, coding and data rates

* **PM-6**: The AMP Downlink PPDU AMP-Sync field and the AMP-Data field will use On-Off Keying (OOK) modulation.

[Motion #9, [1] and [7]]

* **PM-7**: The AMP Downlink PPDU AMP-Data field will use Manchester encoding for non-backscatter operation.
	+ For the Backscatter case, the AMP-Data field encoding scheme is TBD.

[Motion #10, [1] and [7]]

* **PM-9**: The AMP Downlink PPDU in 2.4 GHz shall support the following data rates:
	+ 1 Mb/s (for non-Backscatter STAs only)
	+ 250 kb/s.

[Motion #16, [1] and [9]]

* **PM-19**: The AMP-Data field of AMP DL PPDU for backscatter communication uses Manchester encoding.

[Motion #37, [1] and [40]]

* **PM-22**: For DL PPDU and UL PPDU for backscattering:
	+ For AMP Manchester encoded OOK of rate 250kbps, each data bit is encoded based on the chip duration of 2us.
	+ For AMP Manchester encoded OOK of rate 1Mbps, each data bit is encoded based on the chip duration of 0.5us.

[Motion #40, [1], [40], [41], [42] and [43]]

* **PM-23**: For DL PPDU and UL PPDU:
	+ For AMP Manchester encoded OOK, data bit 1 is encoded as chip bits “01” and data bit 0 is encoded as chip bits“10”
	+ Note: same definition as WUR HDR definition.

[Motion #41 and #79, [1], [40], [41], [42] and [43]]

* **PM-31**: For DL PPDU for non backscattering case:
	+ For AMP Manchester encoded OOK of rate 250kbps, each data bit is encoded based on the chip duration of 2us.
	+ For AMP Manchester encoded OOK of rate 1Mbps, each data bit is encoded based on the chip duration of 0.5us..

[Motion #77, [1], [44] and [76]]

## UL PPDU

### General

* **PM-14**: 11bp defines one mode of backscattering without carrier center frequency shift.

[Motion #27, [1] and [27]]

### UL PPDU format

* **PM-8**: IEEE 802.11bp shall specify, in 2.4 GHz, an AMP uplink PPDU for AMP STA supporting active transmission that contains an AMP-Sync field and AMP-Data field. Inclusion of an AMP-SIG field in the AMP uplink PPDU is TBD.
	+ The bandwidth of the AMP uplink PPDU is less than 20 MHz.

[Motion #11, [1] and [8]]

* **PM-24**:
	+ 11bp shall specify, in 2.4 GHz, an AMP UL PPDU for backscatter non-AP AMP STAs that contains an AMP-Sync field and an AMP-Data field.
	+ Note: This AMP UL PPDU is within one excitation field of an AMP DL PPDU.

[Motion #42, [1], [44], [45] and [46]]

### Modulation, coding and data rates

* **PM-11**: 11bp defines Manchester encoding for the data portion of UL transmission in 2.4 GHz, including both backscattering and active transmission.

[Motion #19, [1] and [11]]

* **PM-13**: 11bp will define On-Off Keying (OOK) modulation for AMP-Sync field and the AMP-Data field in an AMP Uplink PPDU for Active Transmission.

[Motion #21, [1], [14] and [15]]

* **PM-17**: 11bp defines the following data rates for AMP uplink transmissions at 2.4GHz
	+ 250kbps and 1Mbps for both backscatter and non-backscatter uplink transmission;
	+ 4Mbps for non-backscatter uplink transmission only.
		- Mandatory or optional is TBD

[Motion #31, [1], [28] and [29]]

* **PM-20**: The AMP-Sync field and the AMP-Data field of AMP UL PPDU for backscatter communication use OOK modulation.

[Motion #38, [1], [40]]

* **PM-25**:
	+ The PHY parameters (at least data rate) for AMP UL transmission are indicated by the AMP AP.
	+ Other PHY parameters TBD.

[Motion #43, [1], [44]]

* **PM-32**:
	+ For UL PPDU for non backscattering case, for AMP Manchester encoded OOK  the chip duration of data portion is different for different data rates. The exact chip duration is TBD.
		- 4Mbps is TBD.

[Motion #78, [1], [44] and [76]]

## PHY feature #3

Description for PHY feature #3

# AMP WPT

1.

## General

This section describes the functional blocks in the AMP MAC.

## Energizer control

* **WM-1**: IEEE 802.11bp defines a mechanism that allows control information to be sent by AMP AP STA to the AMP Energizer. The control information is TBD.

[Motion #35, [1], [31], [32] and [33]]

* **WM-3**:
	+ Control information that is sent from the AMP AP to the AMP Energizer relating to the WPT waveform may include at least one or more of the following: Start Time, Duration, Interval, Transmit Power, and frequency related parameters.
	+ The frequency related parameters may include central frequency information, bandwidth information, etc.
	+ Note: Interval refers to a repetition of the WPT waveform.

[Motion #53, [1], [31], [32], [33], [35], [58] and [59]]

* **WM-5**: Energizer should report its WPT and excitation related capability to the AMP AP. The parameters to be reported are TBD.

[Motion #55, [1], [58]]

* **WM-6**:
	+ Control information that may be sent from the AMP AP to the AMP Energizer relating to the excitation signal includes one or more of the following: Start Time, Duration, Transmit Power and frequency related parameters.
	+ The frequency related parameters may include central frequency information, etc.

[Motion #74, [1], [31] and [73]]

* **WM-8**: IEEE 802.11bp defines at least the following capability parameters to be reported by the energizer to the AMP AP.
	+ Whether or not support S1G WPT transmission
		- If supported, frequency related parameters for WPT. The frequency related parameters may include central frequency information, bandwidth information, etc.
	+ Whether or not support 2.4G excitation waveform transmission.
	+ Maximum Tx power.
	+ Note: The energizer should at least support one of the following transmissions: S1G WPT transmission or 2.4G excitation waveform transmission.

[Motion #81, [1], [58] and [77]]

## AMP non-AP STA reporting

* **WM-2**: IEEE 802.11bp defines a mechanism that allows an AMP non-AP STA to report its energy harvesting and power related information to AMP AP STA. The parameters that are included in the report and how to report such information is TBD.

[Motion #36, [1], [32]-[39]]

## WPT coexistence

* **WM-4**: WPT signals from two or more transmitters in S1GHz are allowed to occupy the same channel simultaneously.

[Motion #54, [1], [60] and [61]]

* **WM-7**: Energizer may perform LBT before transmitting WPT signals in S1G. The details of LBT are TBD.

[Motion #80, [1], [60], [61] and [77]]

## WPT feature #4

Description for WPT feature #2

# AMP frame format

1.

## General

* **FM-1**: 11bp defines communication between AMP non AP STA and AMP AP STA through 11bp frames.

[Motion #23, [1], [16] and [17]]

## AMP Trigger frame

* **FM-2**: 802.11bp defines an AMP Trigger frame that an AP transmits to solicit UL AMP PPDU(s) from one or more 802.11bp clients and may carry the following content
	+ Transmitter ID
	+ Receiver ID(s)
	+ FCS
	+ Other parameters TBD.

[Motion #46, [1], [20] and [52]]

* **FM-3**: When the AP solicits UL AMP PPDUs from 802.11bp clients using a slot-based procedure, the AMP Trigger frame shall carry the following parameters
	+ Number of slots for UL PPDU transmissions in that TXOP
	+ Other parameters TBD.

[Motion #48, [1], [19] and [53]]

* **MM-5**: AMP trigger frame may indicate parameters for a slot-based procedure of time slots to AMP non-AP STA(s).
	+ The exact parameters are TBD.

[Motion #56, [1], [62] and [63]]

## AMP Ack frame

* **FM-4**: 802.11bp defines an AMP Ack frame that an AMP AP transmits to acknowledge the received UL AMP frame(s).

[Motion #49, [1], [52]]

## AMP Wake-Up frame

* **FM-6**: 802.11bp defines an AMP Wake-Up frame, which an AMP AP transmits to AMP-enabled non-AP STA(s) to indicate that the AP intends to exchange non-AMP frames with the non-AP STA
	+ The expectation is to reuse WUR frame format for the AMP Wake-Up frame and to carry it in an AMP PPDU

[Motion #57, [1], [64]]

## Field #4

Description for field #3

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