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

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

Amendment 3: Enhancements for Very High Throughput to Support Chinese Millimeter Wave Frequency Bands (60 GHz and 45 GHz)

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 802.11aj™-2018
(Amendment to IEEE Std 802.11™-2016
as amended by IEEE Std 802.11ai™-2016
and IEEE Std 802.11ah™-2016)

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Approved 15 February 2018

IEEE-SA Standards Board

Abstract: The IEEE 802.11™ directional multi-gigabit (DMG) physical layer (PHY) and the medium access control (MAC) layer are modified by this amendment to IEEE Std 802.11™-2016 to enable operation in the Chinese millimeter wave frequency band around 60 GHz. This amendment also defines modifications to the IEEE 802.11 PHY and MAC layer to enable operation in the Chinese millimeter wave frequency band around 45 GHz.

Keywords: beamforming, CDMG, China directional multi-gigabit, China millimeter-wave multi-gigabit, CMMG, DBC, DCS, dynamic bandwidth control, dynamic channel selection, IEEE 802.11™, IEEE 802.11aj™, opportunistic transmission, spatial sharing

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Introduction

This introduction is not part of IEEE Std 802.11aj-2018, IEEE Standard for Information technology—Local and metropolitan area networks—Specific requirements—Part 11: Wireless LAN MAC and PHY Specifications—Amendment 3: Enhancements for Very High Throughput to Support Chinese Millimeter Wave Frequency Bands (60 GHz and 45 GHz).

The purpose of this amendment is to support operation in the Chinese millimeter wave frequency bands (60 GHz and 45 GHz) to enable multi-Gb/s throughput.

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

Amendment 3: Enhancements for Very High Throughput to Support Chinese Millimeter Wave Frequency Bands (60 GHz and 45 GHz)

(This amendment is based on IEEE Std 802.11™-2016 as amended by IEEE Std 802.11ai™-2016 and IEEE Std 802.11ah™-2016.)

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1. Overview

1.3 Supplementary information on purpose

Insert the following item at the end of the dashed list in 1.3:

— Defines the PHY and MAC enhancements to enable operation in the Chinese millimeter wave frequency bands (60 GHz and 45 GHz).

[1] Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

3. Definitions, acronyms, and abbreviations

3.2 Definitions specific to IEEE Std 802.11

Insert the following definitions into 3.2 in alphabetical order:

China directional multi-gigabit (CDMG): Pertaining to operation in DMG and where the channel is contained within the Chinese 60 GHz frequency band.

NOTE—The Chinese 60 GHz channel set is defined in Table E-5 in Annex E.

China directional multi-gigabit small band beacon interval (CDMG SBBI): A value, in units of TUs, represents the length of a beacon interval (BI) operating on a 1.08 GHz channel.

China millimeter-wave multi-gigabit (CMMG): Pertaining to operation in a frequency band containing a channel in 42.3 GHz to 47.3 GHz or 47.2 GHz to 48.4 GHz frequency bands.

NOTE—The Chinese 45 GHz channel set is defined in Table E-5 in Annex E.

China millimeter-wave multi-gigabit (CMMG) basic service set (BSS): A BSS in which DMG Beacon frames are transmitted by CMMG stations (STAs).

China millimeter-wave multi-gigabit (CMMG) duplicate physical layer (PHY) protocol data unit (PPDU) format: The data transmission (TXVECTOR parameter CH_BANDWIDTH equal to CBW1080) duplicates the transmission of a 540 MHz signal over every 540 MHz frequency segment.

China millimeter-wave multi-gigabit (CMMG) physical layer (PHY) protocol data unit (PPDU): A Clause 26 PPDU transmitted or received using the Clause 26 physical layer (PHY).

China millimeter-wave multi-gigabit (CMMG) beamformee: A CMMG station (STA) that receives a CMMG physical layer (PHY) protocol data unit (PPDU) that was transmitted using a beamforming steering matrix and that supports the CMMG transmit beamforming feedback mechanism as described in 10.34a.

China millimeter-wave multi-gigabit (CMMG) beamformer: A CMMG station (STA) that transmits a CMMG physical layer (PHY) protocol data unit (PPDU) using a beamforming steering matrix.

China millimeter-wave multi-gigabit (CMMG) single medium access control (MAC) protocol data unit (CMMG single MPDU): An MPDU that is the only MPDU in an aggregate MPDU (A-MPDU) carried in a CMMG physical layer (PHY) protocol data unit (PPDU) and that is carried in an A-MPDU subframe with the EOF subfield of the MPDU delimiter field equal to 1.

synchronizing access point (AP) or personal basic service set (PBSS) control point (PCP): A CDMG AP or PCP that is operating on a 1.08 GHz channel but still transmitting its DMG Beacon frames on the relevant 2.16 GHz channel with the AP or PCP Role subfield of the Dynamic Bandwidth Control element (9.4.2.218) set to 0 and providing synchronization service to a synchronized AP or PCP on the relevant 2.16 GHz channel.

synchronized access point (AP) or personal basic service set (PBSS) control point (PCP): A CDMG AP or PCP that is operating on a 1.08 GHz channel but still transmitting its DMG Beacon frames on the relevant 2.16 GHz channel with the AP or PCP Role subfield of the Dynamic Bandwidth Control element (9.4.2.218) set to 1 and synchronizing with the synchronizing AP or PCP on the relevant 2.16 GHz channel.

3.4 Abbreviations and acronyms

Insert the following abbreviations into 3.4 in alphabetical order:

CEF	channel estimation field
CDMG	China directional multi-gigabit
DBC	dynamic bandwidth control
DCS	dynamic channel selection
OCEF	OFDM channel estimation field
CMMG	China millimeter-wave multi-gigabit
SBBI	small band beacon interval
SCEF	single carrier channel estimation field
OSTF	OFDM short training field
ZCZ	zero correlation zone

4. General description

4.3 Components of the IEEE 802.11 architecture

Insert the following subclauses, 4.3.25 and 4.3.26, after 4.3.24:

4.3.25 CDMG STA

The IEEE 802.11 CDMG STA is a DMG STA that supports CDMG operation in Chinese 60 GHz frequency band when dot11CDMGOptionImplemented is true. In addition to CDMG features, a CDMG STA supports DMG features as described in 4.3.21. A CDMG STA also supports CDMG features as identified in Clause 10, Clause 11, and Clause 24. A CDMG STA supports transmission and reception of frames that are compliant with PHY specifications as defined in Clause 24. A CDMG STA is also a QoS STA. The basic channel access of a CDMG STA (see 10.36 and 10.60) allows it to operate in an Infrastructure BSS or in an IBSS or in a PBSS.

Besides supporting DMG PHY features defined in Clause 20, a CDMG STA also supports the PHY signaling as described in 24.4, 24.5, and 24.6. At a minimum, a CDMG STA supports the mandatory modulation and coding scheme (MCS) and PHY protocol data unit (PPDU) formats described in 24.4 and 24.5.

4.3.26 CMMG STA

The IEEE 802.11 CMMG STA operates in 42.3 GHz to 47.3 GHz or 47.2 GHz to 48.4 GHz frequency bands.

The main PHY features in a CMMG STA are the following:

— 540 MHz channel width
— Control mode and SC mode (directional transmit and receive)
— Single spatial stream MCS 0 (control mode transmit and receive) in all supported channel widths
— Single spatial stream MCSs 1 to 3 (SC mode transmit and receive) in all supported channel widths
— LDPC coding with length 672
— Normal guard interval as defined in Table 25-3
— Optional support for 1080 MHz channel width
— Optional support for CMMG MCSs 4 to 8 (SC mode transmit and receive)
— Optional support for CMMG MCSs 9 to 16 (OFDM mode transmit and receive)
— Optional support for short guard interval (transmit and receive)
— Optional support for LDPC coding with length 2016
— Optional support MIMO transmission (SC mode and OFDM mode transmit and receive)
— Optional support for STBC (transmit and receive)
— Optional support for transmit beamforming sounding (by sending a CMMG NDP)
— Optional support for responding to transmit beamforming sounding

The CMMG STA provides PHY and MAC features that can support a throughput of 1 Gb/s and greater, as measured at the MAC data service access point (SAP). A CMMG STA supports CMMG features as identified in Clause 10, Clause 11, and Clause 25. A CMMG STA operates in a CMMG BSS and supports transmission and reception of frames that are compliant with PHY specifications as defined in Clause 25. A CMMG STA is also a QoS STA. The basic channel access of a CMMG STA (see 10.36) allows it to operate in an Infrastructure BSS, in an IBSS, or in a PBSS. Certain CMMG features such as service period allocation are available only to CMMG STAs that are associated with an AP or with a PCP, while other

CMMG features such as EDCA operation in a PBSS do not require association. A CMMG STA supports beamforming (BF) as described in 10.38 and 20.10 and GCM encryption as described in 12.5.5.

A CMMG STA supports the PHY signaling as described in 25.4, 25.5, and 25.6. At a minimum, a CMMG STA supports the mandatory modulation and coding scheme (MCS) and PHY protocol data unit (PPDU) formats described in 25.4 and 25.5. A CMMG STA has PHY features that include a low-density parity check (LDPC) encoding, a preamble making use of zero correlation zone (ZCZ) sequences, and beamforming. The PPDUs are always transmitted with the same channel spacing as described in Annex E.

A CMMG STA supports MAC features that provide channel access in an environment in which transmissions use a directional antenna pattern or use multiple input multiple output antenna pattern. A CMMG STA has MAC features that include frame aggregation, block ack features, service periods, contention based access periods, CMMG protected period, AP or PCP clustering, dynamic channel time management, reverse direction, spatial sharing, beamforming, and fast session transfer in a multi-band device. A CMMG STA is not a mesh STA. A CMMG STA follows the same channel access rules irrespective of the type of BSS in which it operates.

6. Layer management

6.3 MLME SAP interface

6.3.3 Scan

6.3.3.3 MLME-SCAN.confirm

6.3.3.3.2 Semantics of the service primitive

Insert the following rows at the end of the untitled table describing BSSDescriptions in 6.3.3.3.2:

Name	Type	Valid range	Description	IBSS adoption
CDMG Capabilities	CDMG Capabilities element	As defined in 9.4.2.217.	Specifies the parameters within the CDMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CDMGOptionImplemented is true; otherwise not present.	Do not adopt.
CMMG Capabilities	CMMG Capabilities element	As defined in 9.4.2.227.	Specifies the parameters within the CMMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CMMGOptionImplemented is true; otherwise not present.	Do not adopt.
CMMG Operation	CMMG Operation element	As defined in 9.4.2.228.	Specifies the parameters within the CMMG Operation element that are supported by the MAC entity. The parameter is present if dot11CMMGOptionImplemented is true; otherwise not present.	Do not adopt.

6.3.7 Associate

6.3.7.2 MLME-ASSOCIATE.request

6.3.7.2.2 Semantics of the service primitive

Insert the following parameters in the primitive parameters list in 6.3.7.2.2:

```
MLME-ASSOCIATE.request(
                        ...
                        CDMG Capabilities,
                        CMMG Capabilities,
                        VendorSpecificInfo
                        )
```

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.7.2.2:

Name	Type	Valid range	Description
CDMG Capabilities	CDMG Capabilities element	As defined in 9.4.2.217.	Specifies the parameters within the CDMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CDMGOptionImplemented is true; otherwise not present.
CMMG Capabilities	CMMG Capabilities element	As defined in 9.4.2.227.	Specifies the parameters within the CMMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CMMGOptionImplemented is true; otherwise not present.

6.3.7.3 MLME-ASSOCIATE.confirm

6.3.7.3.2 Semantics of the service primitive

Insert the following parameters in the primitive parameters list in 6.3.7.3.2:

The primitive parameters are as follows:

MLME-ASSOCIATE.confirm(
...
<u>CDMG Capabilities</u>,
<u>CMMG Capabilities</u>,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.7.3.2:

Name	Type	Valid range	Description
CDMG Capabilities	CDMG Capabilities element	As defined in 9.4.2.217.	Specifies the parameters within the CDMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CDMGOptionImplemented is true; otherwise not present.
CMMG Capabilities	CMMG Capabilities element	As defined in 9.4.2.227.	Specifies the parameters within the CMMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CMMGOptionImplemented is true; otherwise not present.

6.3.7.4 MLME-ASSOCIATE.indication

6.3.7.4.2 Semantics of the service primitive

Insert the following parameters in the primitive parameters list in 6.3.7.4.2:

The primitive parameters are as follows:

MLME-ASSOCIATE.indication(
...
CDMG Capabilities,
CMMG Capabilities,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.7.4.2:

Name	Type	Valid range	Description
CDMG Capabilities	CDMG Capabilities element	As defined in 9.4.2.217.	Specifies the parameters within the CDMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CDMGOptionImplemented is true; otherwise not present.
CMMG Capabilities	CMMG Capabilities element	As defined in 9.4.2.227.	Specifies the parameters within the CMMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CMMGOptionImplemented is true; otherwise not present.

6.3.7.5 MLME-ASSOCIATE.response

6.3.7.5.2 Semantics of the service primitive

Insert the following parameters in the primitive parameters list in 6.3.7.5.2:

The primitive parameters are as follows:
MLME-ASSOCIATE.response(
...
CDMG Capabilities,
CMMG Capabilities,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.7.5.2:

Name	Type	Valid range	Description
CDMG Capabilities	CDMG Capabilities element	As defined in 9.4.2.217.	Specifies the parameters within the CDMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CDMGOptionImplemented is true; otherwise not present.
CMMG Capabilities	CMMG Capabilities element	As defined in 9.4.2.227.	Specifies the parameters within the CMMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CMMGOptionImplemented is true; otherwise not present.

6.3.8 Reassociate

6.3.8.2 MLME-REASSOCIATE.request

6.3.8.2.2 Semantics of the service primitive

Insert the following parameters in the primitive parameters list in 6.3.8.2.2:

The primitive parameters are as follows:
MLME-REASSOCIATE.request(
...
CDMG Capabilities,
CMMG Capabilities,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.8.2.2:

Name	Type	Valid range	Description
CDMG Capabilities	CDMG Capabilities element	As defined in 9.4.2.217.	Specifies the parameters within the CDMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CDMGOptionImplemented is true; otherwise not present.
CMMG Capabilities	CMMG Capabilities element	As defined in 9.4.2.227.	Specifies the parameters within the CMMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CMMGOptionImplemented is true; otherwise not present.

6.3.8.3 MLME-REASSOCIATE.confirm

6.3.8.3.2 Semantics of the service primitive

Insert the following parameters in the primitive parameters list in 6.3.8.3.2:

The primitive parameters are as follows:
MLME-REASSOCIATE.confirm(
...
CDMG Capabilities,
CMMG Capabilities,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.8.3.2:

Name	Type	Valid range	Description
CDMG Capabilities	CDMG Capabilities element	As defined in 9.4.2.217.	Specifies the parameters within the CDMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CDMGOptionImplemented is true; otherwise not present.
CMMG Capabilities	CMMG Capabilities element	As defined in 9.4.2.227.	Specifies the parameters within the CMMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CMMGOptionImplemented is true; otherwise not present.

6.3.8.4 MLME-REASSOCIATE.indication

6.3.8.4.2 Semantics of the service primitive

Insert the following parameters in the primitive parameters list in 6.3.8.4.2:

The primitive parameters are as follows:

MLME-REASSOCIATE.indication(
...
<u>CDMG Capabilities</u>,
<u>CMMG Capabilities</u>,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.8.4.2:

Name	Type	Valid range	Description
CDMG Capabilities	CDMG Capabilities element	As defined in 9.4.2.217.	Specifies the parameters within the CDMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CDMGOptionImplemented is true; otherwise not present.
CMMG Capabilities	CMMG Capabilities element	As defined in 9.4.2.227.	Specifies the parameters within the CMMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CMMGOptionImplemented is true; otherwise not present.

6.3.8.5 MLME-REASSOCIATE.response

6.3.8.5.2 Semantics of the service primitive

Insert the following parameters in the primitive parameters list in 6.3.8.5.2:

The primitive parameters are as follows:

MLME-REASSOCIATE.response(
...
CDMG Capabilities,
CMMG Capabilities,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.8.5.2:

Name	Type	Valid range	Description
CDMG Capabilities	CDMG Capabilities element	As defined in 9.4.2.217.	Specifies the parameters within the CDMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CDMGOptionImplemented is true; otherwise not present.
CMMG Capabilities	CMMG Capabilities element	As defined in 9.4.2.227.	Specifies the parameters within the CMMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CMMGOptionImplemented is true; otherwise not present.

6.3.11 Start

6.3.11.2 MLME-START.request

6.3.11.2.2 Semantics of the service primitive

Insert the following parameters in the primitive parameters list in 6.3.11.2.2:

The primitive parameters are as follows:

MLME-START.request(
...
CDMG Capabilities,
CMMG Capabilities,
CMMG Operation,
VendorSpecificInfo
)

Insert the following rows before the VendorSpecificInfo row in the untitled table in 6.3.11.2.2:

Name	Type	Valid range	Description
CDMG Capabilities	CDMG Capabilities element	As defined in 9.4.2.217.	Specifies the parameters within the CDMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CDMGOptionImplemented is true.
CMMG Capabilities	CMMG Capabilities element	As defined in 9.4.2.227.	Specifies the parameters within the CMMG Capabilities element that are supported by the MAC entity. The parameter is present if dot11CMMGOptionImplemented is true and is absent otherwise.
CMMG Operation	CMMG Operation element	As defined in 9.4.2.228.	Specifies the parameters within the CMMG Operation element that are supported by the MAC entity. The parameter is present if dot11CMMGOptionImplemented is true; otherwise not present.

6.3.11.2.4 Effect of receipt

Insert the following paragraph before the last paragraph of 6.3.11.2.4:

If the MLME of a CMMG STA receives an MLME-START.request primitive with a Basic CMMG MCS and NSS Set field in the CMMG Operation parameter containing any unsupported <CMMG MCS, NSS> tuple, the MLME response in the resulting MLME-START.confirm primitive contains a ResultCode parameter that is not set to the value SUCCESS.

6.3.26 TS management interface

6.3.26.1 General

Change Table 6-1 as follows:

Table 6-1—Supported TS management primitives

Primitive	Request	Confirm	Indication	Response
ADDTS (in the context of establishing a TS)	DMG STA CMMG STA non-AP QoS STA	DMG STA CMMG STA non-AP QoS STA	DMG STA CMMG STA HC	DMG STA CMMG STA HC
ADDTS (in the context of requesting an allocation)	Non-AP and non-PCP DMG STA CMMG STA	Non-AP and non-PCP DMG STA CMMG STA	DMG AP or PCP CMMG AP or PCP	DMG AP or PCP CMMG AP or PCP
DELTS	DMG STA CMMG STA non-AP QoS STA HC	DMG STA CMMG STA non-AP QoS STA HC	DMG STA CMMG STA non-AP QoS STA HC	—
ADDTSRESERVE	HC	HC	non-AP QoS STA	non-AP QoS STA

6.3.26.2 MLME-ADDTS.request

6.3.26.2.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.26.2.2 as follows:

The primitive parameters are as follows:

MLME-ADDTS.request (
DialogToken,
TSPEC,
TCLAS,
TCLASProcessing,
U-APSD Coexistence,
EBR,
IntraAccessCategoryPriority,
HigherLayerStreamID,
STAAddress,
DMG TSPEC,
CMMG TSPEC,
Multi-band,
U-PID,
MMS,
VendorSpecificInfo
)

Insert the following row after the 'DMG TSPEC' row in the untitled table in 6.3.26.2.2:

Name	Type	Valid range	Description
CMMG TSPEC	CMMG TSPEC element	As defined in 9.4.2.134a.	Specifies the characteristics and QoS scheduling requirements of the CMMG allocation request.

6.3.26.3 MLME-ADDTS.confirm

6.3.26.3.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.26.3.2 as follows:

The primitive parameters are as follows:

MLME-ADDTS.confirm(
ResultCode,
DialogToken,
TSDelay,
TSPEC,
Schedule,
TCLAS,
TCLASProcessing,
EBR,
HigherLayerStreamID
STAAddress,
DMG TSPEC,

CMMG TSPEC,
Multi-band,
U-PID,
MMS,
VendorSpecificInfo
)

Insert the following rows after the 'DMG TSPEC' row in the untitled table in 6.3.26.3.2:

Name	Type	Valid range	Description
CMMG TSPEC	CMMG TSPEC element	As defined in 9.4.2.228.	Specifies the characteristics and QoS scheduling requirements of the CMMG allocation request.

Change the first two paragraphs after the untitled table in 6.3.26.3.2 as follows:

For the ResultCode value of SUCCESS received by a non-DMG STA or a non-CMMG STA, the TSPEC and the optional TCLAS parameters describe the characteristics of the TS that has been created (or modified); and the specified (nonzero) parameters [with the exception of Service Start Time, Medium Time, and any possibly unspecified minimum set of parameters (see 10.22.4.3) in the TSPEC element in an ADDTS Request frame] exactly match those of the matching MLME-ADDTS.request primitive.

For other values of ResultCode received by a non-DMG STA or a non-CMMG STA, no new TS has been created. In the case of REJECTED_WITH_ SUGGESTED_CHANGES, the TSPEC represents an alternative proposal by the HC based on information about the current status of the MAC entity. In the case of REJECTED_HOME_WITH_SUGGESTED_CHANGES, the TSPEC represents an alternative proposal by the HC based on information received from the SSPN interface. A TS is not created with this definition. If the suggested changes are acceptable to the STA, it is the responsibility of the STA to set up the TS with the suggested changes.

6.3.26.3.3 When generated

Change the second paragraph of 6.3.26.3.3 as follows:

This primitive is generated when that MLME-ADDTS.request primitive is found to contain invalid parameters, when a timeout occurs, or when the STA receives a response in the form of an ADDTS Response frame in the corresponding QoS Action frame from the HC, ~~or~~ DMG STA, or CMMG STA.

6.3.26.4 MLME-ADDTS.indication

6.3.26.4.1 Function

Change 6.3.26.4.1 as follows:

This primitive reports to the DMG STA's SME, CMMG STA's SME, or HC's SME the request for adding (or modifying) a TS.

6.3.26.4.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.26.4.2 as follows:

MLME-ADDTS.indication (
DialogToken,
STAAddress,
TSPEC,
TCLAS,
TCLASProcessing,
U-APSD Coexistence,
EBR,
IntraAccessCategoryPriority,
HigherLayerStreamID,
DMG TSPEC,
CMMG TSPEC,
Multi-band,
U-PID,
MMS,
VendorSpecificInfo
)

Insert the following row after the 'DMG TSPEC' row in the untitled table in 6.3.26.4.2:

Name	Type	Valid range	Description
CMMG TSPEC	CMMG TSPEC element	As defined in 9.4.2.134a.	Specifies the characteristics and QoS (scheduling) requirements of the CMMG allocation request.

6.3.26.5 MLME-ADDTS.response

6.3.26.5.2 Semantics of the service primitive

Change the primitive parameter list in 6.3.26.5.2 as follows:

The primitive parameters are as follows:
MLME-ADDTS.response (
ResultCode,
DialogToken,
STAAddress,
TSDelay,
TSPEC,
Schedule,
TCLAS,
TCLASProcessing,
U-APSD Coexistence,
EBR,
HigherLayerStreamID,
DMG TSPEC,
CMMG TSPEC,
Multi-band,

U-PID,
MMS,
VendorSpecificInfo
)

Insert the following row after the 'DMG TSPEC' row in the untitled table in 6.3.26.5.2:

Name	Type	Valid range	Description
CMMG TSPEC	CMMG TSPEC element	As defined in 9.4.2.134a.	Specifies the characteristics and QoS (scheduling) requirements of the CMMG allocation request.

Insert the following subclause, 6.3.118, after 6.3.117.5.4:

6.3.118 DCS procedure

6.3.118.1 General

This subclause describes the management procedures associated with the dynamic channel selection mechanism.

6.3.118.2 MLME-DCSMEASUREMENT.request

6.3.118.2.1 Function

This primitive requests transmission of a DCS Measurement Request frame to the DCS responder AP or PCP with which to perform the DCS procedure.

6.3.118.2.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-DCSMEASUREMENT.request (
DCSResponderAddress,
DCSMeasurementRequest
)

Name	Type	Valid range	Description
DCSResponderAddress	MAC Address	Any valid individual MAC address.	Specifies the MAC address of the AP or PCP to which the DCS Measurement Request frame is transmitted.
DCSMeasurement Request	DCS Measurement Request Action field	As defined in 9.6.8.37.	Specifies the parameters of the DCS measurement request.

6.3.118.2.3 When generated

This primitive is generated by the SME to request that a DCS Measurement Request frame be sent to the DCS responder AP or PCP with which to perform the DCS procedure.

6.3.118.2.4 Effect on receipt

On receipt of this primitive, the MLME indicates the MAC sublayer to construct and attempt to transmit a DCS Measurement Request frame.

6.3.118.3 MLME-DCSMEASUREMENT.indication

6.3.118.3.1 Function

This primitive indicates that a DCS Measurement Request frame is received.

6.3.118.3.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-DCSMEASUREMENT.indication (
                                 DCSRequesterAddress,
                                 DCSMeasurementRequest
                                 )
```

Name	Type	Valid range	Description
DCSRequesterAddress	MAC Address	Any valid individual MAC address.	Specifies the MAC address of the AP or PCP from which the DCS Measurement Request frame is received.
DCSMeasurement Request	DCS Measurement Request Action field	As defined in 9.6.8.37.	Specifies the parameters of the DCS measurement request.

6.3.118.3.3 When generated

This primitive is generated by the MLME when a valid DCS Measurement Request frame is received.

6.3.118.3.4 Effect on receipt

Once the SME receives this primitive, the STA operates according to the procedure defined in 11.49.

6.3.118.4 MLME-DCSMEASUREMENT.response

6.3.118.4.1 Function

This primitive requests transmission of a DCS Measurement Report frame to the DCS requester AP or PCP with which to perform the DCS procedure.

6.3.118.4.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-DCSMEASUREMENT.response (
                              DCSRequesterAddress,
                              DCSMeasurementReport
                              )
```

Name	Type	Valid range	Description
DCSRequesterAddress	MAC Address	Any valid individual MAC address.	Specifies the MAC address of the AP or PCP to which the DCS Measurement Report frame is transmitted.
DCSMeasurementReport	DCS Measurement Report Action field	As defined in 9.6.8.40.	Specifies the parameters of the DCS measurement response.

6.3.118.4.3 When generated

This primitive is generated by the SME to request that a DCS Measurement Report frame be sent to the DCS requester AP or PCP with which to perform the DCS procedure.

6.3.118.4.4 Effect on receipt

On receipt of this primitive, the MLME indicates the MAC sublayer to construct and attempt to transmit a DCS Measurement Report frame.

6.3.118.5 MLME-DCSMEASUREMENT.confirm

6.3.118.5.1 Function

This primitive indicates that a DCS Measurement Report frame was received.

6.3.118.5.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-DCSMEASUREMENT.confirm (
                DCSResponderAddress,
                DCSMeasurementReport
                )
```

Name	Type	Valid range	Description
DCSResponderAddress	MAC Address	Any valid individual MAC address.	Specifies the MAC address of the AP or PCP from which the DCS Measurement Report frame was received.
DCSMeasurementReport	DCS Measurement Report Action field	As defined in 9.6.8.40.	Specifies the parameters of the DCS measurement response.

6.3.118.5.3 When generated

This primitive is generated by the MLME when a valid DCS Measurement Report frame is received.

6.3.118.5.4 Effect on receipt

Once the SME receives this primitive, the STA operates according to the procedure defined in 11.49.

6.3.118.6 MLME-DCS.request

6.3.118.6.1 Function

This primitive requests transmission of a DCS Request frame to the DCS responder AP or PCP with which to perform the DCS procedure.

6.3.118.6.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-DCS.request (
DCSResponderAddress,
DCSRequest
)

Name	Type	Valid range	Description
DCSResponderAddress	MAC Address	Any valid individual MAC address.	Specifies the MAC address of the AP or PCP to which the DCS Request frame is transmitted.
DCSRequest	DCS Request Action field	As defined in 9.6.8.39.	Specifies the parameters of the DCS request.

6.3.118.6.3 When generated

This primitive is generated by the SME to request that a DCS Request frame be sent to the DCS responder AP or PCP with which to perform the DCS procedure.

6.3.118.6.4 Effect on receipt

On receipt of this primitive, the MLME indicates the MAC sublayer to construct and attempt to transmit a DCS Request frame.

6.3.118.7 MLME-DCS.indication

6.3.118.7.1 Function

This primitive indicates that a DCS Request frame is received.

6.3.118.7.2 Semantics of the service primitive

The primitive parameters are as follows:

MLME-DCS.indication (
DCSRequesterAddress,
DCSRequest
)

Name	Type	Valid range	Description
DCSRequesterAddress	MAC Address	Any valid individual MAC address.	Specifies the MAC address of the AP or PCP from which the DCS Request frame is received.
DCSRequest	DCS Request Action field	As defined in 9.6.8.39.	Specifies the parameters of the DCS request.

6.3.118.7.3 When generated

This primitive is generated by the MLME when a valid DCS Request frame is received.

6.3.118.7.4 Effect on receipt

Once the SME receives this primitive, the STA operates according to the procedure defined in 11.49.

6.3.118.8 MLME-DCS.response

6.3.118.8.1 Function

This primitive requests transmission of a DCS Response frame to the DCS requester AP or PCP with which to perform the DCS procedure.

6.3.118.8.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-DCS. Response (
                    DCSRequesterAddress,
                    DCSResponse
                    )
```

Name	Type	Valid range	Description
DCSRequesterAddress	MAC Address	Any valid individual MAC address.	Specifies the MAC address of the AP or PCP to which the DCS Measurement Report frame is transmitted.
DCS Response	DCS Response Action field	As defined in 9.6.8.40.	Specifies the parameters of the DCS response.

6.3.118.8.3 When generated

This primitive is generated by the SME to provide the results of a DCS request.

6.3.118.8.4 Effect on receipt

On receipt of this primitive, the MLME indicates the MAC layer to construct and attempt to transmit a DCS Response frame.

6.3.118.9 MLME-DCS.confirm

6.3.118.9.1 Function

This primitive indicates that a DCS Response frame was received.

6.3.118.9.2 Semantics of the service primitive

The primitive parameters are as follows:

```
MLME-DCS.confirm (
                  DCSResponderAddress,
                  DCSResponse
                  )
```

Name	Type	Valid range	Description
DCSResponderAddress	MAC Address	Any valid individual MAC address.	Specifies the MAC address of the AP or PCP from which the DCS Measurement Report frame was received.
DCSResponse	DCS Response Action field	As defined in 9.6.8.40.	Specifies the parameters of the DCS response.

6.3.118.9.3 When generated

This primitive is generated by the MLME when a valid DCS Measurement Report frame is received.

6.3.118.9.4 Effect on receipt

Once the SME receives this primitive, the STA operates according to the procedure defined in 11.49.

9. Frame formats

9.2 MAC frame formats

9.2.3 General frame format

Change the second paragraph of 9.2.3 as follows:

For PV0 MPDUs, the first three fields (Frame Control, Duration/ID, and Address 1) and the last field (FCS) in Figure 9-1 constitute the minimal frame format and are present in all these frames, including reserved types and subtypes. The fields Address 2, Address 3, Sequence Control, Address 4, QoS Control, HT Control, CMMG Control, and Frame Body are present only in certain frame types and subtypes. Each field is defined in 9.2.4. For PV1 MPDUs, the fields constituting the minimal frame format are defined in 9.8. The format of each of the individual subtypes of each PV0 frame type is defined in 9.3, the format of each PV1 frame type is defined in 9.8, and the format of NDP CMAC frames is defined in 9.9. The components of management frame bodies are defined in 9.4. The formats of Action frame bodies (PV0 and PV1) are defined in 9.6.

Change Figure 9-1 as follows:

Octets: 2	2	6	0 or 6	0 or 6	0 or 2	0 or 6	0 or 2	0 or 4	0 or 4	variable	4
Frame Control	Duration /ID	Address 1	Address 2	Address 3	Sequence Control	Address 4	QoS Control	HT Control	CMMG Control	Frame Body	FCS

MAC Header

Figure 9-1—MAC frame format

9.2.4 Frame fields

9.2.4.1 Frame Control field

9.2.4.1.8 More Data field

Insert the following paragraph at the end of 9.2.4.1.8:

The More Data subfield is set to 1 in individually addressed frames transmitted by a CMMG AP to a CMMG STA when both support the CMMG TXOP power save feature (as determined from their CMMG Capabilities elements) to indicate that at least one additional buffered BU is present for the STA, see 11.2.3.21.

9.2.4.1.10 +HTC/Order subfield

Insert the following item at the end of the dashed list of the first paragraph of 9.2.4.1.10:

— It is set to 1 in a QoS Data or Management frame transmitted by a QoS CMMG STA to indicate that the frame contains a CMMG Control field.

Insert the following subclause, 9.2.4.6a (including Figure 9-15b, Figure 9-15c, Figure 9-15d, Table 9-18a, and Table 9-18b), after 9.2.4.6.3:

9.2.4.6a CMMG Control field

The format of the 4-octet CMMG Control field is shown in Figure 9-15b.

	B0	B1 B14	B15 B17	B18 B20	B21	B22
	MRQ	MFB	MFSI	MSI/STBC	FB Tx Type	Unsolicited MFB
Bits:	1	14	3	3	1	1

	B23 B24	B25	B26	B27 B28	B29 B31
	CSI/Steering	CMMG NDP Announcement	CMMG AC Constraints	RDG/More PPDU	Reserved
Bits:	2	1	1	2	3

Figure 9-15b—CMMG Control field

The link adaptation related subfields including the first six subfields are defined in Table 9-18a.

Table 9-18a—Subfields corresponding to link adaptation

Subfield	Meaning	Definition
MRQ	CMMG MCS Feedback request	Set to 1 to request CMMG MCS feedback (solicited MFB); otherwise, set to 0.
MFB	NUM_STS, CMMG MCS, BW and SNR feedback	MFB subfield is interpreted as defined in 9-18b. This subfield contains the recommended MFB. The combination of CMMG MCS=31 and NUM_STS=3 indicates that no feedback is present.
MFSI	MFB sequence identifier	Set to the received value of MSI contained in the frame to which the MFB information refers. Set to 7 for unsolicited MFB.
MSI/STBC	MSI/STBC	If the Unsolicited MFB subfield is 0 and the MRQ subfield is 1, the MSI/STBC subfield contains a sequence number in the range 0 to 6 that identifies the specific MCS feedback request. If the Unsolicited MFB subfield is 0 and the MRQ subfield is 0, the MSI/STBC subfield is reserved. If the Unsolicited MFB subfield is 1 and the MFB does not contain the value representing “no feedback is present,” the MSI/STBC field contains the Compressed MSI and STBC Indication subfields as shown in Figure 9-15d. The STBC Indication subfield indicates whether the estimate in the MFB subfield is computed based on a PPDU using STBC encoding: Set to 0 if the PPDU was not STBC encoded. Set to 1 if the PPDU was STBC encoded. The Compressed MSI subfield contains a sequence number that identifies the specific MCS feedback request. It is in the range 0 to 3 if STBC Indication equals 0 or in the range 0 to 2 if STBC Indication equals 1. Otherwise, the MSI/STBC subfield is reserved.

Table 9-18a—Subfields corresponding to link adaptation *(continued)*

Subfield	Meaning	Definition
FB Tx Type	Transmission type of the measured PPDU	If the Unsolicited MFB subfield is 1 and FB Tx Type subfield is 0, then the unsolicited MFB is estimated from a CMMG PPDU with RXVECTOR parameter BEAMFORMED equal to 0. If the Unsolicited MFB subfield is 1, the MFB does not contain the value representing “no feedback is present,” and the FB Tx Type subfield is 1, then the unsolicited MFB is estimated from a CMMG PPDU with RXVECTOR parameter BEAMFORMED equal to 1. Otherwise, this subfield is reserved.
Unsolicited MFB	Unsolicited CMMG MCS feedback indicator	Set to 1 if the MFB is not a response to an MRQ. Set to 0 if the MFB is a response to an MRQ.

The format of the MFB subfield in the CMMG Control field is shown in Figure 9-15c.

	B1 B2	B3 B7	B8	B9 B14
	NUM_STS	CMMG MCS	BW	SNR
Bit:	2	5	1	6

Figure 9-15c—MFB subfield in the CMMG Control field

The subfields of the MFB subfield in the CMMG Control field are defined in Table 9-18b.

Table 9-18b—MFB subfield in the CMMG Control field

Subfield	Meaning	Definition
NUM_STS	Recommended NUM_STS	Indicates the recommended NUM_STS as defined in 10.31.4. The NUM_STS subfield contains an unsigned integer representing the number of space-time streams minus 1.
CMMG MCS	Recommended CMMG MCS	Indicates the recommended CMMG MCS as defined in 10.31.4. The CMMG MCS subfield contains an unsigned integer in the range 0 to 31 representing a CMMG MCS Index value (defined in 25.15).
BW	Bandwidth of the recommended CMMG MCS	If the Unsolicited MFB subfield is 1, the BW subfield indicates the bandwidth for which the recommended CMMG MCS is intended, as defined in 10.31.4: Set to 0 for 540 MHz. Set to 1 for 1080 MHz. If the Unsolicited MFB subfield is 0, the BW subfield is reserved.
SNR	Average SNR	The SNR subfield of the MFB subfield in the CMMG Control field is defined in Table 9-18.

The format of the MSI/STBC subfield when the Unsolicited MFB subfield is 1 is shown in Figure 9-15d.

	B18 B19	B20
	Compressed MSI	STBC Indication
Bits:	2	1

Figure 9-15d—MSI/STBC subfield when the Unsolicited MFB subfield is 1

The CSI/Steering subfield of the CMMG Control field is defined in Table 9-16.

The CMMG NDP Announcement subfield of the CMMG Control field indicates that an NDP will be transmitted after the frame (according to the rules described in 10.34a). It is set to 1 to indicate that an NDP follows; otherwise, it is set to 0.

The CMMG AC Constraint subfield of the CMMG Control field is the same as defined in Table 9-10.

The RDG/More PPDU subfield of the CMMG control field is defined in Table 9-11.

9.3 Format of individual frame types

9.3.3 Management frames

9.3.3.6 Association Request frame format

Insert the following rows into Table 9-29 in numeric order:

Table 9-29—Association Request frame body

Order	Information	Notes
39	CDMG Capabilities	The CDMG Capabilities element is present if dot11CDMGOptionImplemented is true; otherwise not present.
40	CMMG Capabilities	The CMMG Capabilities element is present when the dot11CMMGOptionImplemented is true; otherwise not present.

9.3.3.7 Association Response frame format

Insert the following rows into Table 9-30 in numeric order:

Table 9-30—Association Response frame body

Order	Information	Notes
50	CDMG Capabilities	The CDMG Capabilities element is present if dot11CDMGOptionImplemented is true; otherwise not present.
51	CMMG Capabilities	The CMMG Capabilities element is present when the dot11CMMGOptionImplemented is true; otherwise not present.
52	CMMG Operation	The CMMG Operation element is present when the dot11CMMGOptionImplemented is true; otherwise not present.

9.3.3.8 Reassociation Request frame format

Insert the following rows into Table 9-31 in numeric order:

Table 9-31—Reassociation Request frame body

Order	Information	Notes
44	CDMG Capabilities	The CDMG Capabilities element is present if dot11CDMGOptionImplemented is true; otherwise not present.
45	CMMG Capabilities	The CMMG Capabilities element is present when the dot11CMMGOptionImplemented is true; otherwise not present.

9.3.3.9 Reassociation Response frame format

Insert the following rows into Table 9-32 in numeric order:

Table 9-32—Reassociation Response frame body

Order	Information	Notes
53	CDMG Capabilities	The CDMG Capabilities element is present if dot11CDMGOptionImplemented is true; otherwise not present.
54	CMMG Capabilities	The CMMG Capabilities element is present when the dot11CMMGOptionImplemented is true; otherwise not present.
55	CMMG Operation	The CMMG Operation element is present when the dot11CMMGOptionImplemented is true; otherwise not present.

9.3.3.10 Probe Request frame format

Insert the following rows into Table 9-33 in numeric order:

Table 9-33—Probe Request frame body

Order	Information	Notes
28	CDMG Capabilities	The CDMG Capabilities element is present if dot11CDMGOptionImplemented is true; otherwise not present.
29	Cluster Probe	The Cluster Probe element is optionally present if dot11ClusteringActivated is true; otherwise not present.
30	CMMG Capabilities	The CMMG Capabilities element is present when the dot11CMMGOptionImplemented is true; otherwise not present.

9.3.3.11 Probe Response frame format

Insert the following rows into Table 9-34 in numeric order:

Table 9-34—Probe Response frame body

Order	Information	Notes
85	CDMG Capabilities	The CDMG Capabilities element is present if dot11CDMGOptionImplemented is true; otherwise not present.
86	Extended Cluster Report	The Extended Cluster Report element is optionally present if dot11ClusteringActivated is true; otherwise not present.
87	CMMG Capabilities	The CMMG Capabilities element is present when the dot11CMMGOptionImplemented is true; otherwise not present.
88	CMMG Operation	The CMMG Operation element is present when the dot11CMMGOptionImplemented is true; otherwise not present.

9.3.4 Extension frames

9.3.4.2 DMG Beacon

Insert the following rows into Table 9-41 in numeric order:

Table 9-41—DMG Beacon frame body

Order	Information	Notes
40	CDMG Capabilities	The CDMG Capabilities element is present if dot11CDMGOptionImplemented is true; otherwise not present.
41	Dynamic Bandwidth Control	The Dynamic Bandwidth Control element is optionally present if a STA operates as an AP or PCP and dot11CDMGOptionImplemented is true; otherwise not present.
42	Cluster Probe	The Cluster Probe element is optionally present if dot11ClusteringActivated is true; otherwise not present.
43	Extended Cluster Report	The Extended Cluster Report element is optionally present if dot11ClusteringActivated is true; otherwise not present.
44	Cluster Switch Announcement	The Cluster Switch Announcement element is optionally present if dot11ClusteringActivated is true; otherwise not present.
45	Extended Cluster Report	The Extended Cluster Report element is optionally present if dot11ClusteringActivated is true; otherwise not present.
46	Cluster Switch Announcement	The Cluster Switch Announcement element is optionally present if dot11ClusteringActivated is true; otherwise not present.
47	SPSH Report	The SPSH Report element is optionally present if dot11ClusteringActivated is true; otherwise not present.
48	Clustering Interference Assessment	The Clustering Interference Assessment element is optionally present if dot11ClusteringActivated is true; otherwise not present.

Table 9-41—DMG Beacon frame body *(continued)*

Order	Information	Notes
49	CMMG Capabilities	The CMMG Capabilities element is present when dot11CMMGOptionImplemented is true; otherwise not present.
50	CMMG Operation	The CMMG Operation element is present if dot11CMMG OptionImplemented is true; otherwise not present.
51	Power Constraint	The Power Constraint element is present if dot11SpectrumManagementRequired is true and is optionally present if dot11RadioMeasurementActivated is true; otherwise not present.
52	TPC Report	The TPC Report element is present if dot11SpectrumManagementRequired is true or dot11RadioMeasurementActivated is true; otherwise not present.
53	BSS Load	The BSS Load element is present if dot11QosOptionImplemented and dot11QBSSLoadImplemented are both true; otherwise not present.

Change Figure 9-62 as follows:

	B0 B7	B8 B55	B56 B57	B58 B62	B63
	Beacon SP Duration	Cluster ID	Cluster Member Role	ClusterMaxMem	~~Reserved~~ SPSH Measurement Enabled
Bits:	8	48	2	5	1

Figure 9-62—Clustering Control field format if the Discovery Mode field is 0

Insert the following paragraph before the last paragraph ("The A-BFT Responder Address subfield ....") of 9.3.4.2:

The SPSH Measurement Enabled subfield is used by a CDMG S-AP or S-PCP to indicate whether the member APs or member PCPs in an AP or PCP cluster are allowed to perform channel measurement to achieve spatial sharing. If the SPSH Measurement Enabled subfield is 1, a SPSH measurement period starts. In this period, the member APs or member PCPs in an AP or PCP cluster can perform channel measurement in its BSS and spatial reuse is not allowed. If the SPSH Measurement Enabled subfield is 0, SPSH measurement terminates and SP reuse is conducted in the following time interval, i.e., APs or PCPs of the AP or PCP cluster are allowed to allocate time-overlapping SPs among different BSSs. In a DMG Beacon frame transmitted by a non-CDMG S-AP or S-PCP, the SPSH Measurement Enabled subfield is reserved.

9.4 Management and Extension frame body components

9.4.1 Fields that are not elements

9.4.1.7 Reason Code field

Insert the following rows into Table 9-45 in numeric order, and change the Reserved row accordingly:

Table 9-45—Reason codes

Reason code	Name	Meaning
67	TRANSMISSION_LINK_ESTABLISHMENT_ FAILED	Transmission link establishment in alternative channel failed.
68	ALTERATIVE_ CHANNEL_OCCUPIED	The alterative channel is occupied.

9.4.1.9 Status Code field

Insert the following rows into Table 9-46 in numeric order, and change the Reserved row accordingly:

Table 9-46—Status codes

Status code	Name	Meaning
116	DENIED_NOTIFICATION_PERIOD_ALLOCATION	Request denied because the allocation of notification period is failed.
117	DENIED_CHANNEL_SPLITTING	Request denied because the request of channel splitting is failed.
118	DENIED_ALLOCATION	Request denied because the allocation request is failed.
119	CMMG_FEATURES_NOT_SUPPORTED	Association denied because the requesting STA does not support CMMG features.

9.4.1.11 Action field

Insert the following rows into Table 9-47 in numeric order, and change the Reserved row accordingly:

Table 9-47—Category values

Code	Meaning	See subclause	Robust	Group addressed privacy
27	CDMG	9.6.29	Yes	No
28	CMMG	9.6.30	Yes	No

9.4.1.46 Band ID field

Insert the following row into Table 9-63 in numeric order, and change the Reserved row accordingly:

Table 9-63—Band ID field

Band ID value	Meaning
6	45 GHz

Insert the following subclause, 9.4.1.47a, after 9.4.1.47:

9.4.1.47a CMMG Parameters field

The definition of the CMMG parameters field is the same as the definition of the DMG parameters field.

Insert the following subclauses, 9.4.1.61 to 9.4.1.63 (including Figure 9-121d, Figure 9-121e, and Table 9-76c through Table 9-76i), after 9.4.1.60:

9.4.1.61 CMMG MIMO Control field

The CMMG MIMO Control field is used to manage the exchange of CMMG MIMO channel state or transmit beamforming feedback information. It is used in the CMMG Compressed Beamforming (see 9.6.30.2) frame.

The CMMG MIMO Control field is defined in Figure 9-121d.

	B0B1	B2B3	B4	B5 B6	B7 B8	B9 B11	B12 B13	B14 B37	B38 B39
	Nc Index	Nr Index	Channel Width	Grouping	Codebook Information	Remaining Matrix Segment	Reserved	Sounding Timestamp	Reserved
Bits:	2	2	1	2	2	3	2	24	2

Figure 9-121d—CMMG MIMO Control field

The subfields of the CMMG MIMO Control field are defined in Table 9-76c.

Table 9-76c—Subfields of the CMMG MIMO Control field

Subfield	Description
N_c Index	Indicates the number of columns in a matrix minus 1: Set to 0 for $N_c = 1$ Set to 1 for $N_c = 2$ Set to 2 for $N_c = 3$ Set to 3 for $N_c = 4$
N_r Index	Indicates the number of rows in a matrix minus 1: Set to 0 for $N_r = 1$ Set to 1 for $N_r = 2$ Set to 2 for $N_r = 3$ Set to 3 for $N_r = 4$

Table 9-76c—Subfields of the CMMG MIMO Control field *(continued)*

Subfield	Description
Channel Width	Indicates the width of the channel in which a measurement was made: Set to 0 for 540 MHz Set to 1 for 1080 MHz
Grouping	Indicates the number of subcarriers grouped into one: Set to 0 for $N_g = 1$ (No grouping) Set to 1 for $N_g = 2$ Set to 2 for $N_g = 4$ Set to 3 for $N_g = 6$
Codebook Information	Indicates the size of codebook entries: Set to 0 for 2 bits for ψ, 4 bits for ϕ Set to 1 for 3 bits for ψ, 5 bits for ϕ The value 2 and 3 are reserved.
Remaining Matrix Segments	Contains the remaining segment number for the associated measurement report. Valid range: 0 to 7. Set to 0 for the last segment of a segmented report or the only segment of an unsegmented report.
Sounding Timestamp	Contains the lower 3 octets of the TSF timer value sampled at the instant that the MAC received the PHY-CCA.indication(IDLE) primitive that corresponds to the end of the reception of the sounding packet that was used to generate feedback information contained in the frame.

9.4.1.62 CMMG Compressed Beamforming Report field

The CMMG Compressed Beamforming Report field is used by the CMMG Compressed Beamforming frame (see 9.6.30.2) to carry explicit feedback information in the form of angles representing compressed beamforming feedback matrices V for use by a transmit CMMG beamformer to determine steering matrices Q, as described in 10.32.5 and 25.6.8.13.

The size of the CMMG Compressed Beamforming Report field depends on the values in the CMMG MIMO Control field.

The CMMG Compressed Beamforming Report field contains the channel matrix elements indexed, first, by matrix angles in the order shown in Table 9-76d, second, by data subcarrier index from lowest frequency to highest frequency. The explanation of how these angles are generated from the beamforming feedback matrix V is given in 25.6.8.13.2.

Table 9-76d—Order of angles in the CMMG Compressed Beamforming Report field

Size of V ($N_r \times N_c$)	Number of angles (N_a)	The order of angles in the Compressed Beamforming Feedback Matrix subfield
2×1	2	$\varphi_{1,1}, \psi_{2,1}$
2×2	2	$\varphi_{1,1}, \psi_{2,1}$
3×1	4	$\varphi_{1,1}, \varphi_{2,1}, \psi_{2,1}, \psi_{3,1}$
3×2	6	$\varphi_{1,1}, \varphi_{2,1}, \psi_{2,1}, \psi_{3,1}, \varphi_{2,2}, \psi_{3,2}$
3×3	6	$\varphi_{1,1}, \varphi_{2,1}, \psi_{2,1}, \psi_{3,1}, \varphi_{2,2}, \psi_{3,2}$

Table 9-76d—Order of angles in the CMMG Compressed Beamforming Report field *(continued)*

Size of V ($N_r \times N_c$)	Number of angles (N_a)	The order of angles in the Compressed Beamforming Feedback Matrix subfield
4×1	6	$\varphi_{1,1}, \varphi_{2,1}, \varphi_{3,1}, \psi_{2,1}, \psi_{3,1}, \psi_{4,1}$
4×2	10	$\varphi_{1,1}, \varphi_{2,1}, \varphi_{3,1}, \psi_{2,1}, \psi_{3,1}, \psi_{4,1}, \varphi_{2,2}, \varphi_{3,2}, \psi_{3,2}, \psi_{4,2}$
4×3	12	$\varphi_{1,1}, \varphi_{2,1}, \varphi_{3,1}, \psi_{2,1}, \psi_{3,1}, \psi_{4,1}, \varphi_{2,2}, \varphi_{3,2}, \psi_{3,2}, \psi_{4,2}, \varphi_{3,3}, \psi_{4,3}$
4×4	12	$\varphi_{1,1}, \varphi_{2,1}, \varphi_{3,1}, \psi_{2,1}, \psi_{3,1}, \psi_{4,1}, \varphi_{2,2}, \varphi_{3,2}, \psi_{3,2}, \psi_{4,2}, \varphi_{3,3}, \psi_{4,3}$

The angles are quantized as defined in Table 9-76e. All angles are transmitted LSB to MSB.

Table 9-76e—Quantization of angles

Quantized ψ	Quantized φ
$\psi = \frac{k\pi}{2^{b_\psi+1}} + \frac{\pi}{2^{b_\psi+2}}$ radians where $k = 0, 1, \ldots, 2^{b_\psi} - 1$ b_ψ is the number of bits used to quantize ψ defined by the Codebook Information field of the CMMG MIMO Control field	$\varphi = \frac{k\pi}{2^{b_\varphi+1}} + \frac{\pi}{2^{b_\varphi+2}}$ radians where $k = 0, 1, \ldots, 2^{b_\varphi} - 1$ b_φ is the number of bits used to quantize φ defined by the Codebook Information field of the CMMG MIMO Control field

The Compressed Beamforming Report field has the structure and order defined in Table 9-76f, where N_a is the number of angles used for the CMMG compressed beamforming feedback matrix subfield.

Table 9-76f—Compressed Beamforming Report field

Field	Size (bits)	Meaning
Average SNR of Space-Time Stream 1	8	Signal-to-noise ratio at the beamformee for space-time stream 1 averaged over all data subcarriers
...	...	...
Average SNR of Space-Time Stream N_c	8	Signal-to-noise ratio at the beamformee for space-time stream N_c averaged over all data subcarriers.
Compressed Beamforming Feedback Matrix V for Subcarrier $k = scidx(0)$	$N_a \times (b_\varphi + b_\psi)/2$	Compressed beamforming feedback matrix
Compressed Beamforming Feedback Matrix V for Subcarrier $k = scidx(1)$	$N_a \times (b_\varphi + b_\psi)/2$	Compressed beamforming feedback matrix
Compressed Beamforming Feedback Matrix V for Subcarrier $k = scidx(2)$	$N_a \times (b_\varphi + b_\psi)/2$	Compressed beamforming feedback matrix
...	...	...
Compressed Beamforming Feedback Matrix V for Subcarrier $k = scidx(N_s - 1)$	$N_a \times (b_\varphi + b_\psi)/2$	Compressed beamforming feedback matrix
NOTE—The *scidx()* is defined in Table 9-76g.		

N_S is the number of subcarriers for which the CMMG Compressed Beamforming Feedback Matrix subfield is sent back to the CMMG beamformer. N_S is a function of the Channel Width and Grouping subfields in the CMMG MIMO Control field. Table 9-76g lists N_S, the exact subcarrier indices and their order for which the Matrix subfield is sent back. No padding is present between angles in the CMMG compressed beamforming report information, even if they correspond to different subcarriers. If the length of the CMMG Compressed Beamforming Report field is not an integral multiple of 8 bits, up to 7 0s are appended to the end of the field to make its size an integral multiple of 8 bits.

Table 9-76g—Subcarriers for which a Matrix subfield is sent back

Channel width	N_g	N_s	Subcarriers for which Matrix subfield is sent: scidx(0), scidx(1), …, scidx(N_s–1)
540 MHz	1	168	–89, –88, –87, –86, –85, –84, –83, –82, –81, –80, –79, –78, –76, –75, –74, –73, –72, –71, –70, –69, –68, –67, –66, –65, –64, –63, –62, –61, –60, –59, –58, –57, –56, –54, –53, –52, –51, –50, –49, –48, –47, –46, –45, –44, –43, –42, –41, –40, –39, –38, –37, –36, –35, –34, –32, –31, –30, –29, –28, –27, –26, –25, –24, –23, –22, –21, –20, –19, –18, –17, –16, –15, –14, –13, –12, –10, –9, –8, –7, –6, –5, –4, –3, –2, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89 NOTE—Pilot subcarriers (±77, ±55, ±33, ±11) and DC subcarriers (0, ±1) are skipped
	2	90	–89, –88, –86, –84, –82, –80, –78, –76, –74, –72, –70, –68, –66, –64, –62, –60, –58, –56 ,–54, –52, –50, –48, –46, –44, –42, –40, –38, –36, –34, –32, –30, –28, –26, –24, –22, –20, –18, –16, –14, –12, –10, –8, –6, –4, –2, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, 89
	4	46	–89, –86, –82, –78, –74, –70, –66, –62, –58, –54, –50, –46, –42, –38, –34, –30, –26, –22, –18, –14, –10, –6, –2, 2, 6, 10, 14, 18, 22, 26, 30, 34, 38, 42, 46, 50, 54, 58, 62, 66, 70, 74, 78, 82, 86, 89
	6	32	–89, –86, –80, –74, –68, –62, –56, –50, –44, –38, –32, –26, –20, –14, –8, –2, 2, 8, 14, 20, 26, 32, 38, 44, 50, 56, 62, 68, 74, 80, 86, 89
1080 MHz	1	336	–177, –176, –175, –174, –173, –172, –171, –170, –169, –168, –167, –166, –164, –163, –162, –161, –160, –159, –158, –157, –156, –155, –154, –153, –152, –151, –150, –149, –148, –147, –146, –145, –144, –142, –141, –140, –139, –138, –137, –136, –135, –134, –133, –132, –131, –130, –126, –125, –124, –123, –122, –120, –119, –118, –117, –116, –115, –114, –113, –112, –111, –110, –109, –108, –107, –106, –105, –104, –103, –102, –101, –100, –98, –97, –96, –95, –94, –93, –92, –91, –90, –89, –88, –87, –86, –85, –84, –83, –82, –81, –80, –79, –78, –76, –75, –74, –73, –72, –71, –70, –69, –68, –67, –66, –65, –64, –63, –62, –61, –60, –59, –58, –57, –56, –54, –53, –52, –51, –50,–49, –48, –47, –46, –45, –44, –43, –42, –41, –40, –39, –38, –37, –36, –35, –34, –32, –31, –30, –29, –28, –27, –26, –25, –24, –23, –22, –21, –20, –19, –18, –17,–16, –15, –14, –13, –12, –10, –9, –8, –7, –6, –5, –4, –3, –2, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 56, 57, 58, 59, 60, 61,62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 78, 79, 80, 81, 82, 83,84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 122, 123, 124, 125, 126, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177 NOTE—Pilot subcarriers (±165, ±143, ±121, ±99, ±77, ±55, ±33, ±11) and DC subcarriers (0, ±1) are skipped

Table 9-76g—Subcarriers for which a Matrix subfield is sent back *(continued)*

Channel width	N_g	N_s	Subcarriers for which Matrix subfield is sent: scidx(0), scidx(1), …, scidx(N_s–1)
1080 MHz	2	170	–177, –176, –174, –172, –170, –168, –166, –164, –162, –160, –158, –156, –154, –152, –150, –148, –146, –144, –142, –140, –138, –136, –134, –132, –130, –128, –126, –124, –122, –120, –118, –116, –114, –112, –110, –108, –106, –104, –102, –100, –98, –96, –94, –92, –90, –88, –86, –84, –82, –80, –78, –76, –74, –72, –70, –68, –66, –64, –62, –60, –58, –56, –54, –52, –50, –48, –46, –44, –42, –40, –38, –36, –34, –32, –30, –28, –26, –24, –22, –20, –18, –16, –14, –12, –10, –8, –6, –4, –2, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110, 112, 114, 116, 118, 120, 122, 124, 126, 128, 130, 132,134, 136, 138, 140, 142, 144, 146, 148, 150, 152, 154, 156, 158, 160, 162, 164, 166, 168, 170, 172, 174, 176, 177
	4	90	–177, –174, –170, –166, –162, –158, –154, –150, –146, –142, –138, –134, –130, –126, –122, –118, –114, –110, –106, –102, –98, –94, –90, –86, –82, –78, –74, –70, –66, –62, –58, –54, –50, –46, –42, –38, –34, –30, –26, –22, –18, –14, –10, –6, –2, 2, 6, 10, 14, 18, 22, 26, 30, 34, 38, 42, 46, 50, 54, 58, 62, 66, 70, 74, 78, 82, 86, 90, 94, 98, 102, 106, 110, 114, 118, 122, 126, 130, 134, 138, 142, 146, 150, 154, 158, 162, 166, 170, 174, 177
	6	62	–177, –176, –170, –164, –158, –152, –146, –140, –134, –128, –122, –116, –110, –104, –98, –92, –86, –80,–74,–68, –62, –56, –50, –44, –38, –32, –26, –20, –14, –8, –2, 2, 8, 14, 20, 26, 32, 38, 44, 50, 56, 62, 68, 74, 80, 86, 92, 98, 104, 110, 116, 122, 128, 134, 140, 146, 152, 158, 164, 170, 176, 177

The SNR values are encoded as an 8-bit 2s complement value of 4×(SNR_average-22), where SNR_average is the sum of the values of SNR per tone (in decibels) divided by the number of tones represented.

The Average SNR of Space-Time Stream *i* subfield is an 8-bit 2s complement integer whose definition is shown in Table 9-76h.

Table 9-76h—Average SNR of Space-Time Stream *i* subfield

Average SNR of Space-Time Stream *i* subfield	AvgSNR_i (dB)
–128	≤ –10
–127	–9.75
–126	–9.5
…	…
+126	53.5
+127	53.75

9.4.1.63 CMMG Operating Mode field

The CMMG Operating Mode field is present in the Operating Mode Notification frame (see 9.6.30.3) and Operating Mode Notification element (see 9.4.2.229).

The CMMG Operating Mode field is shown in Figure 9-121e.

	B0	B1 B4	B5 B6	B7
	Channel Width	Reserved	RX NSS	RX NSS Type
Bits:	1	4	2	1

Figure 9-121e—CMMG Operating Mode field

The STA transmitting this field indicates its current operating channel width and the number of spatial streams it can receive using the settings defined in Table 9-76i.

Table 9-76i—Subfield values of the CMMG Operating Mode field

Subfield	Description
Channel Width	If the Rx NSS Type subfield is 0, indicates the supported channel width: Set to 0 for 540 MHz Set to 1 for 1080 MHz Reserved if the Rx NSS Type subfield is 1
RX NSS	If the Rx NSS Type subfield is 0, indicates the maximum number of spatial streams that the STA can receive. If the Rx NSS Type subfield is 1, indicates the maximum number of spatial streams that the STA can receive as a beamformee in an SU PPDU using a beamforming steering matrix derived from a CMMG Compressed Beamforming report with the Feedback Type subfield indicating SU in the corresponding CMMG Compressed Beamforming frame sent by the STA. Set to 0 for NSS = 1 Set to 1 for NSS = 2 … Set to 3 for NSS = 4
RX NSS Type	Set to 0 to indicate that the Rx NSS subfield carries the maximum number of spatial streams that the STA can receive. Set to 1 to indicate that the Rx NSS subfield carries the maximum number of spatial streams that the STA can receive in an SU PPDU using a beamforming steering matrix derived from a CMMG Compressed Beamforming report with the Feedback Type subfield indicating SU in the corresponding CMMG Compressed Beamforming frame sent by the STA. NOTE—An AP always sets this field to 0.

9.4.2 Elements

9.4.2.1 General

Insert the following rows into Table 9-77 in numeric order:

Table 9-77— Element IDs

Element	Element ID	Element ID Extension	Extensible	Fragmentable
CDMG Capabilities (see 9.4.2.217)	255	17	Yes	No
Dynamic Bandwidth Control (see 9.4.2.218)	255	18	Yes	No
CDMG Extended Schedule (see 9.4.2.219)	255	19	Yes	Yes
SSW Report (see 9.4.2.220)	255	20	Yes	Yes
Cluster Probe (see 9.4.2.221)	255	21	Yes	No
Extended Cluster Report (see 9.4.2.222)	255	22	Yes	No
Cluster Switch Announcement (see 9.4.2.223)	255	23	Yes	No
Enhanced Beam Tracking (see 9.4.2.224)	255	24	Yes	No
SPSH Report (see 9.4.2.225)	255	25	Yes	Yes
Clustering Interference Assessment (see 9.4.2.226)	255	26	Yes	No
CMMG Capabilities (see 9.4.2.227)	255	27	Yes	No
CMMG Operation (see 9.4.2.228)	255	28	Yes	No
CMMG Operating Mode Notification (see 9.4.2.229)	255	29	Yes	No
CMMG Link Margin (see 9.4.2.230)	255	30	Yes	No
CMMG Link Adaptation Acknowledgment (see 9.4.2.231)	255	31	Yes	No

9.4.2.132 Extended Schedule element

Change the fourth paragraph of 9.4.2.132 as follows:

The Allocation Control subfield is defined in Figure 9-518 for a DMG STA and in Figure 9-518a for a CDMG STA.

Change the title of Figure 9-518 as follows:

Figure 9-518—Allocation control subfield format (DMG)

Insert the following figure, Figure 9-518a, after Figure 9-518:

	B0 B3	B4 B6	B7	B8	B9	B10
	Allocation ID	AllocationType	Pseudo-static	Truncatable	Extendable	PCP Active
Bits:	4	3	1	1	1	1

B11	B12	B13 B14	B15
LP SC Used	Truncation Type	Protected Period	Reserved
1	1	2	1

Figure 9-518a—Allocation Control subfield format (CDMG)

Change Table 9-236 as follows:

Table 9-236—AllocationType subfield values

Bit 4	Bit 5	Bit 6	Meaning
0	0	0	SP allocation
1	0	0	CBAP allocation
0	1	0	SP allocation on a 1.08 GHz channel
1	1	0	CBAP allocation on a 1.08 GHz channel
All other combinations			Reserved

Insert the following paragraph after the eighth paragraph ("For an SP allocation, the Truncatable subfield ....") of 9.4.2.132:

For an SP allocation, the Truncatable subfield is set to 1 to indicate that the source CDMG STA and destination CDMG STA can request SP truncation, and the SP truncation type is determined by the Truncation Type subfield. Otherwise, it is set to 0, and the Truncation Type subfield is reserved. For a CBAP allocation, the Truncatable subfield is reserved.

Change the now 11th paragraph of 9.4.2.132 as follows (the dashed list remains unchanged):

For a PCP in active mode (see 11.2.7), or when applied to a CBAP or SP in a PCP Awake BI, a value of 1 for the PCP Active subfield indicates that the PCP is available to transmit or receive during the CBAP or SP, and a value of 0 indicates the PCP unavailability to transmit or receive. For a DMG PCP, the PCP Active subfield is set to 1 at least in the following cases:

Insert the following paragraph after the now 11th paragraph of 9.4.2.132:

For a CDMG PCP, the PCP Active subfield is set to 1 at least in the following cases:

- The PCP transmitting the field is the source or destination of the CBAP or SP.
- The Truncatable subfield is equal to 1, and the Truncation Type subfield is equal to 0.
- The Extendable subfield is equal to 1.
- The subfield is transmitted by an AP.

Insert the following paragraphs (including Table 9-236a and Table 9-236b) at the end of 9.4.2.132:

If the Truncatable subfield is equal to 0, the Truncation Type subfield is reserved. Otherwise, a CDMG AP or a CDMG PCP sets the Truncation Type subfield to 0 to indicate that the CDMG STA is to return the time left in the SP to the CDMG AP or PCP, and it sets the Truncation Type subfield to 1 to indicate that the CDMG STA allocates any portion of its SP as a CBAP.

For CDMG STAs, the Protected Period subfield is used to indicate whether the source and destination STAs of the allocated SP are required to establish a protected period and on which channels the protected period is established. The Protected Period subfield is set to 0 to indicate the source and destination STAs of the SP are allowed to create a protected period, and the STA determines whether to establish a protected period. The Protected Period subfield is set to a nonzero value to indicate the source and destination STAs of the SP are required to create a protected period on the indicated channel(s). The values of the Protected Period subfield for a CDMG STA operating on a 2.16 GHz channel or a 1.08 GHz are listed in Table 9-236a and Table 9-236b, respectively. For a CBAP allocation, the Protected Period subfield is reserved.

Table 9-236a—Protected Period subfield value for a CDMG STA operating on a 2.16 GHz channel

Value	Meaning
0	The STA determines whether to establish a protected period.
1	The current channel needs a protected period.
2	Both the current 2.16 GHz channel and the low-frequency channel 35 or channel 37 need a protected period.
3	Both the current 2.16 GHz channel and the high-frequency channel 36 or channel 38 need a protected period.

Table 9-236b—Protected Period subfield value for a CDMG STA operating on a 1.08 GHz channel

Value	Meaning
0	The STA determines whether to establish a protected period.
1	The current channel needs a protected period.
2	The current 1.08 GHz channel and the overlapping 2.16 GHz channel need a protected period.
3	Reserved.

Insert the following subclause, 9.4.2.134a (including Figure 9-524a and Figure 9-524b), after 9.4.2.134:

9.4.2.134a CMMG TSPEC element

The definition of the CMMG TSPEC element is similar with the definition of the DMG TSPEC element except for the specific change defined by Figure 9-524a and Figure 9-524b.

The Constraint subfield is defined as illustrated in Figure 9-524a for CMMG STAs.

	TSCONST Start Time	TSCONST Duration	TSCONST Period	Interferer MAC Address	Interferer Channel Bandwidth
Octets:	4	2	2	6	1

Figure 9-524a—Constraint subfield format for CMMG STAs

The Interference Channel Bandwidth subfield is defined in Figure 9-524b.

	B0 B1	B2 B7
	Interferer Channel Bandwidth Indication	Reserved
Bits:	2	6

Figure 9-524b—Interferer Channel Bandwidth subfield format

The Interferer Channel Bandwidth Indication subfield is present only when the operating channel bandwidth of the CMMG STA is 1080 MHz. The Interferer Channel Bandwidth Indication subfield indicates which part of the operating channel was interfered during the time interval indicated by the TSCONST subfields. If the Interferer Channel Bandwidth Indication subfield is 0, interference occurred in the upper 540 MHz of the 1080 MHz operating channel. If the Interferer Channel Bandwidth Indication subfield is 1, interference occurred in the lower 540 MHz of the 1080 MHz operating channel. If the Interferer Channel Bandwidth Indication subfield is 2, interference occurred in over the total operating channel. A value of 3 for the Interferer Channel Bandwidth Indication subfield is reserved.

9.4.2.147 Cluster Report element

Change the Figure 9-541 as follows:

	B0	B1	B2	B3	B4	B5	B6 B7
	Cluster Request	Cluster Report	Schedule Present	TSCONST Present	ECAPC Policy Enforced	ECAPC Policy Present	~~Reserved~~ Cluster Channel Number
Bits:	1	1	1	1	1	1	2

Figure 9-541—Cluster Report Control field format

Insert the following paragraph after the ninth paragraph ("The ECAPC Policy Present subfield ....") of 9.4.2.147:

The Cluster Channel Number subfield is set to 0 to indicate that the operating channel of the reported cluster is the common 2.16 GHz channel; it is set to 1 to indicate that the operating channel of the reported AP or PCP cluster is the low frequency 1.08 GHz channel 35 or 37 (see Annex E); it is set to 2 to indicate the operating channel of the reported AP or PCP cluster is the high frequency 1.08 GHz channel 36 or 38; and the value 3 is reserved.

Insert the following subclauses, 9.4.2.217 to 9.4.2.231 (including Figure 9-589cj through Figure 9-589dr and Table 9-262z through Table 9-262af), after 9.4.2.216:

9.4.2.217 CDMG Capabilities element

9.4.2.217.1 General

The capabilities of a CDMG STA include the capabilities indicated by both the DMG Capabilities element (9.4.2.128) and the CDMG Capabilities element (9.4.2.217). The CDMG Capabilities element contains a STA identifier and several fields to indicate the capabilities that are applicable for a CDMG STA; they are not applicable for a DMG STA. A CDMG STA uses the CDMG Capabilities element to advertise the support of optional CDMG capabilities. The element is present in Association Request, Association Response, Reassociation Request, Reassociation Response, Probe Request, and Probe Response frames and is optionally present in DMG Beacon, Information Request, and Information Response frames. The CDMG Capabilities element is formatted as defined in Figure 9-589cj.

	Element ID	Length	Element ID Extension	STA Address	AID	CDMG STA Capability Information	CDMG AP or PCP Capability Information
Octets:	1	1	1	6	1	4	1

Figure 9-589cj—CDMG Capabilities element format

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

The STA Address field contains the MAC address of the STA.

The AID field contains the AID assigned to the STA by the AP or CP. The value of the AID field is reserved in Association Request, Reassociation Request, and Probe Request frames and when used in an IBSS.

9.4.2.217.2 CDMG STA Capability Information field

The CDMG STA Capability Information field, shown in Figure 9-589ck, represents the transmitting STA capabilities irrespective of the role of the STA.

	B0 B23	B24	B25	B26	B27	B28 B31
	Supported MCS Set	Dynamic Channel Selection	Opportunistic Transmissions Capable	Selection of Candidate SPs Capable	CDMG Enhanced Beam Tracking Capable	Reserved
Bits:	24	1	1	1	1	4

Figure 9-589ck—CDMG STA Capability Information field format

The Supported MCS Set subfield indicates which MCSs a CDMG STA supports. A MCS is identified by a MCS index, which is represented by an integer in the range 0 to 23. The interpretation of the MCS index (i.e., the mapping from MCS to data rate) is PHY dependent. For the CDMG PHY, see Clause 24. The structure of the Supported MCS Set subfield is defined in Figure 9-589cl.

	B0 B4	B5 B9	B10 B14	B15 B19	B20	B21	B22 B23
	Maximum SC Rx MCS	Reserved	Maximum SC Tx_MCS	Reserved	Low Power SC Mode Supported	Code Rate 13/16	Reserved
Bits:	5	5	5	5	1	1	2

Figure 9-589cl—Supported MCS Set subfield format

The Maximum SC Rx MCS subfield contains the value of the maximum MCS index the CDMG STA supports for reception of single-carrier frames. Values 0-8 of this subfield are reserved. Possible values for this subfield are shown in Table 24-9.

The Maximum SC Tx MCS subfield contains the value of the maximum MCS index the CDMG STA supports for transmission of single-carrier frames. Values 0-8 of this subfield are reserved. Possible values for this subfield are shown in Table 24-9.

The Low-Power SC Mode Supported subfield is set to 1 to indicate that the CDMG STA supports the low-power SC mode (24.6). Otherwise, it is set to 0. If the CDMG STA supports the low-power SC mode, it supports all low-power SC mode MCSs indicated in Table 24-11.

The Code Rate 13/16 subfield specifies whether the CDMG STA supports rate 13/16. It is set to 1 to indicate that the CDMG STA supports rate 13/16 and is set to 0 otherwise. If this subfield is 0, MCSs with 13/16 code rate specified in Table 24-9 is not supported regardless of the value in Maximum SC Tx/Rx MCSMCS subfields.

The Dynamic Channel Selection subfield is set to 1 if the STA supports DCS procedures as defined in 11.49 and is set to 0 otherwise.

The Opportunistic Transmissions Capable subfield is set to 1 if the STA supports opportunistic transmission in alternative channels for CDMG STAs as defined in 10.36.11 and is set to 0 otherwise.

The Selection of Candidate SPs Capable subfield is set to 1 if the STA supports selection of candidate SPs for spatial sharing as described in W.1 and is set to 0 otherwise.

The CDMG Enhanced Beam Tracking Capable subfield is set to 1 if the STA supports CDMG enhanced beam tracking as defined in 10.38.9 and W.3 and is set to 0 otherwise.

9.4.2.217.3 CDMG AP or PCP Capability Information field

The CDMG AP or PCP Capability Information field, illustrated in Figure 9-589cm, represents the capabilities, when the transmitting CDMG STA performs in the role of AP or PCP, that are in addition to the capabilities in the CDMG STA Capability Information field.

	B0	B1	B2	B3	B4 B5
	CDMG Decentralized AP or PCP Clustering	CDMG Centralized AP or PCP Clustering	Opportunistic Transmissions Capable	SPSH in CDMG Cluster	Reserved
Bits:	1	1	1	1	5

Figure 9-589cm—CDMG AP or PCP Capability Information field format

The CDMG Decentralized AP or PCP Clustering subfield is set to 1 if the STA, when operating as an AP or PCP, is capable of performing decentralized AP or PCP clustering as described in 10.37a and is set to 0 otherwise.

The CDMG Centralized AP or PCP Clustering subfield is set to 1 if the STA, when operating as an AP or PCP, is capable of performing centralized AP or PCP clustering and is set to 0 otherwise. An AP or PCP that is incapable of performing centralized AP or PCP clustering is subject to requirements as described in 10.37a.

The SPSH in CDMG Cluster subfield is set to 1 if the STA supports spatial sharing in a CDMG AP or PCP cluster as defined in 10.37a.6 and is set to 0 otherwise. If both the CDMG Decentralized AP or PCP Clustering subfield and the CDMG Centralized AP or PCP Clustering subfield are equal to 0, the SPSH in CDMG Cluster subfield is reserved.

9.4.2.218 Dynamic Bandwidth Control element

The Dynamic Bandwidth Control element defines the information from the CDMG AP or PCP to support the dynamic bandwidth control mechanism described in 10.60 and the CDMG AP or PCP clustering mechanism described in 10.60. The Dynamic Bandwidth Control element is included in a DMG Beacon, Announce, or Notification Period Response frame transmitted to the peer STA and the AP or PCP of a BSS. The format of the Dynamic Bandwidth Control element is shown in Figure 9-589cn.

	Element ID	Length	Element ID Extension	DBC Control	Channel Number	BI Offset	TBTT Offset	NP/BHI Duration	Adjacent NP/BHI Duration
Octets:	1	1	1	7	1	4	4	2	2

Figure 9-589cn—Dynamic Bandwidth Control element format

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

The format of the DBC Control field is shown in Figure 9-589co.

	B0	B1	B2	B3	B4 B5	B6 B53	B54 B55
	Channel Splitting	DBC Option	AP or PCP Role	Adjacent Channel Occupancy	Clustering Status	Synchronizing AP or PCP MAC Address	Reserved
Bits:	1	1	1	1	2	48	2

Figure 9-589co—DBC Control field format

The Channel Splitting subfield is set to 0 to indicate that an AP or PCP operates on a 2.16 GHz channel and the following subfields are reserved. Otherwise, this subfield is set to 1 to indicate that an AP or PCP operates on a 1.08 GHz channel.

The DBC Option subfield indicates the DBC option that an AP or PCP selects to operate on a 1.08 GHz channel. It is set to 0 to indicate that beacon intervals or BHIs are present on the 1.08 GHz channel and otherwise set to 1.

The AP or PCP Role subfield is set to 0 to indicate that the transmitting AP or PCP operating on a 1.08 GHz channel can provide a time reference to the AP or PCP operating on the adjacent 1.08 GHz channel. Otherwise, this subfield is set to 1 to indicate that the transmitting AP or PCP scans for DMG Beacon frames transmitted from the AP or PCP operating on the adjacent 1.08 GHz channel to maintain synchronization among them following the rules defined in 10.60.2.3.

The Adjacent Channel Occupancy subfield is set to 0 to indicate that the adjacent 1.08 GHz channel of the transmitting AP or PCP is occupied by another AP or PCP. Otherwise, this subfield is set to 1.

The Clustering Status subfield indicates the cluster status of the two 1.08 GHz channel within the same 2.16 GHz channel. The first/second bit is set to 0 to indicate that a cluster starts in the current/adjacent 1.08 GHz channel. Otherwise, the first/second bit of this field is set to 1.

The Synchronizing AP or PCP MAC Address subfield indicates the MAC address of the AP or PCP that provides the time reference for the transmitting AP or PCP. If the AP or PCP Role subfield is 0, this subfield is set to the MAC address of itself. Otherwise, this subfield is set to the MAC address of the AP or PCP operating on the adjacent 1.08 GHz channel.

The Channel Number field is set to the number of the channel on which the transmitting STA is operating.

The BI Offset field contains the time offset of the TBTT of the first beacon interval that the transmitting AP or PCP starts on a 1.08 GHz channel relative to the TBTT of the beacon interval that the transmitting AP or PCP starts on the 2.16 GHz channel encompassing this 1.08 GHz channel. This field is reserved if the DBC Option subfield is 1.

The TBTT Offset field contains the time offset of the target starting time of the NP/BHI on a 2.16 GHz channel of the transmitting AP or PCP operating on one of the 1.08 GHz channels relative to that of another AP or PCP operating on the adjacent 1.08 GHz channel.

The NP/BHI Duration field is set to the length of the NP/ BHI duration on a 2.16 GHz channel by the transmitting AP or PCP operating on one of the 1.08 GHz channels.

The Adjacent NP/BHI Duration field is set to the length of the NP/ BHI duration on a 2.16 GHz channel by the AP or PCP operating on the adjacent 1.08 GHz channel of the transmitting AP or PCP.

9.4.2.219 CDMG Extended Schedule element

The CDMG Extended Schedule element is defined in Figure 9-589cp. Like the Extended Schedule element (9.4.2.227), the AP or PCP can split the Allocation fields in the CDMG Extended Schedule element into more than one CDMG Extended Schedule element entry in the same DMG Beacon frame or Announce frame. Despite this splitting, the set of CDMG Extended Schedule element entries conveyed within a DMG Beacon or Announce frame is considered to be a single schedule for the beacon interval and, in this standard, is referred to simply as CDMG Extended Schedule element unless otherwise noted. The Allocation fields are ordered by increasing allocation start time with allocations beginning at the same time arbitrarily ordered.

	Element ID	Length	Element ID Extension	Allocation 1	Allocation 2	...	Allocation *n*
Octets:	1	1	1	19	19		19

Figure 9-589cp—CDMG Extended Schedule element format

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

The Allocation field is formatted as illustrated in Figure 9-589cq.

	Allocation Control	BF Control	Source AID	Destination AID	Allocation Start
Octets:	2	2	1	1	4

	Allocation Block Duration	Number of Blocks	Allocation Block Period	Number of Alternate TX BI	Number of Suspension BI
Octets:	2	1	2	2	2

Figure 9-589cq—Allocation field format

The Allocation Control subfield format is the same as defined in 9.4.2.132, including Allocation ID, AllcationType, Pseudo-static, Truncatable, Extendable, PCP Active, and LP SC Used subfields and reserved bits.

The Allocation ID subfield is the same as defined in 9.4.2.132.

The AllocationType subfield defines the channel access mechanism during the allocation, with the possible values listed in Table 9-262z for CDMG STAs:

Table 9-262z—AllocationType subfield values for CDMG STAs

Bit 4	Bit 5	Bit 6	Meaning
0	0	0	SP allocation in dedicated channel
1	0	0	CBAP allocation in dedicated channel
0	1	0	SP allocation in alternative channel
1	1	0	CBAP allocation in alternative channel
All other combinations			Reserved

The Pseudo-static, Truncatable, Extendable, PCP Active, and LP SC Used subfields are the same as defined in 9.4.2.132.

The BF Control subfield is defined in Figure 9-589cr and Figure 9-589cs.

	Beamforming Training	IsInitiator TXSS	IsResponder TXSS	Total Number of Sectors	Number of RX DMG Antennas	NoPrimary Channel	Reserved
Octets:	1	1	1	7	2	1	3

Figure 9-589cr—BF Control field format when both IsInitiatorTXSS and IsResponderTXSS subfields are equal to 1 and the BF Control field is transmitted in Grant or Grant Ack frames

	Beamforming Training	IsInitiator TXSS	IsResponder TXSS	RXSS Length	RXSSTxRate	NoPrimary Channel	Reserved
Octets:	1	1	1	7	2	1	3

Figure 9-589cs—BF Control field format in all other cases

The BeamformingTraining, IsInitiatorTXSS, IsResponderTXSS, Total Number of Sectors, Number of RX DMG Antennas, RXSS Length, RXSSTxRate subfields are the same as defined in 9.5.5.

The NoPrimaryChannel subfield is set to 1 to indicate the CDMG initiator does not need to perform SLS on the primary channel. It is set to 0 to indicate that the CDMG initiator needs to perform SLS on the primary channel. This subfield is reserved when it is transmitted by an AP or PCP.

The Source AID, Destination AID, Allocation Start, Allocation Block Duration, Number of Blocks, and Allocation Block Period subfields are the same as defined in 9.4.2.132.

The Number of Alternate TX BI subfield indicates the duration of transmission phase in the alternate channel in terms of number of beacon intervals.

The Number of Suspension BI subfield indicates the duration of the suspension phase in the alternate channel in terms of the number of beacon intervals.

9.4.2.220 SSW Report element

The SSW Report element is used by a non-AP and non-PCP STA to report beamforming training information to an AP or PCP (see 11.32.1) or used by a responder STA to deliver the backup sector information to an initiator STA. The format of the SSW Report element is as illustrated in Figure 9-589ct.

	Element ID	Length	Element ID Extension	Report Info 1	Report Info	...	Report Info *n*
Octets:	1	1	1	5 or 2	5 or 2	...	5 or 2

Figure 9-589ct—SSW Report element format

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

The Report Info field is formatted as defined in Figure 9-589cu when its SSW Report Control subfield is 1; otherwise, the Report Info field is formatted as defined in Figure 9-589cv.

	B0	B1 B8	B9 B16	B17 B22	B23 B24	B25 B32	B33	B34 B39
	SSW Report Control	Initiator AID	Responder AID	Sector Select	DMG Antenna Select	SNR Report	Is Initiator TXSS/ Is Responder TXSS	Reserved
Bits:	1	8	8	6	2	8	1	6

Figure 9-589cu—Report Info field format when the SSW Report Control subfield is 1

The SSW Report Control subfield indicates the format of the Report Info field.

The Initiator AID subfield identifies the STA that is the initiator of the beamforming training.

The Responder AID subfield identifies the STA that is the responder of the beamforming training.

The Sector Select subfield is as defined in 9.5.3.

The DMG Antenna Select subfield is as defined in 9.5.3.

The SNR Report subfield is as defined in 9.5.3.

The Is Initiator TXSS/Is Responder TXSS subfield is set to 1 to indicate that an initiator TXSS has been performed between the initiator and the responder. This subfield is set to 0 to indicate that a responder TXSS has been performed between the initiator and the responder.

	B0	B1 B6	B7 B8	B9 B15
	SSW Report Control	Peer Tx_Sector ID	Peer Tx_Antenna ID	Reserved
Bits:	1	6	2	7

Figure 9-589cv—Report Info field format when the SSW Report Control subfield is 0

If the SSW Report Control subfield is 0, the Peer Tx_Sector ID subfield indicates the Sector ID of the alternative Tx sector of the peer STA. The determination of the alternative Tx sector is implementation dependent. Possible values of this subfield range from 0 to 63. Otherwise, the Peer Tx_Sector ID subfield is reserved.

If the SSW Report Control subfield is 0, the Peer Tx_Antenna ID subfield indicates the alternative antenna ID of the alternative Tx antenna of the peer STA. The determination of the alternative Tx antenna is implementation dependent. Otherwise, the Peer Tx_Sector ID subfield is reserved.

9.4.2.221 Cluster Probe element

The Cluster Probe element is used to probe the presence of a CDMG AP or PCP cluster operating on the common 2.16 GHz channel by the CDMG AP or PCP operating on a 1.08 GHz channel. This element can be included in a DMG Beacon, Announce, or Probe Request frame. The Cluster Probe element is shown in Figure 9-589cw.

	Element ID	Length	Element ID Extension	Request Token	SP Offset	SP Space	SP Duration	Repetition Count
Octets:	1	1	1	2	2	4	2	1

Figure 9-589cw—Cluster Probe element format

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

The Request Token field is set to a nonzero value chosen by the requesting AP or PCP.

The SP Offset field is set to the offset of the start of the first SP from the frame that contains this element, expressed in TUs. The reference time is the start of the preamble of the PPDU that contains this element.

The SP interval field is set to the spacing between the start of two consecutive SP intervals, expressed in TUs.

The SP Duration field is set to duration of a single SP, expressed in TUs.

The Repetition Count field is set to the number of requested SPs.

9.4.2.222 Extended Cluster Report element

The Extended Cluster Report element is used to report the cluster synchronization and control information to the cluster probe requesting CDMG AP or PCP by the S-AP or S-PCP of a CDMG AP or PCP cluster. The Extended Cluster Report element is also used by an S-AP to report the cluster information of the S-APs within the same CCSS for an AP or PCP that intends to join the centralized cluster. This element can be included in a DMG Beacon, Announce, or Probe Response frame. The Extended Cluster Report element is shown in Figure 9-589cx.

	Element ID	Length	Element ID Extension	Extended Cluster Report Control	Request Token	Next BTI Offset	Reported Clustering Control	Reported BI Duration	Cluster Channel Number	Available Cluster Offset Bitmap
Octets:	1	1	1	1	0 or 2	4	8	0 or 2	0 or 1	0 or 4

Figure 9-589cx—Extended Cluster Report element format

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

If the Extended Cluster Report Control field is 0, this element is used in decentralized clustering mechanism, and the Reported BI Duration, Cluster Channel Number, and Available Cluster Offset Bitmap fields are not present in this element. Otherwise, this element is used in centralized clustering mechanism, and the Request Token field is not present in this element.

The Request Token field value is copied from the corresponding received Cluster Probe element.

The Next BTI Offset field contains the low-order 4 octets of the TSF for the earliest time at which the next BTI in a subsequent beacon interval starts.

The Reported Clustering Control field is defined in 9.3.4.1 and contains the Clustering Control field in the last transmitted DMG Beacon frame of the S-AP or S-PCP or the reported S-AP.

The Reported BI Duration field is set to the BI value of the reported S-AP, expressed in TUs.

The Cluster Channel Number field is set to the operating channel number of the reported S-AP.

The Available Cluster Time Offset Bitmap field is set to the Available Cluster Time Offset Bitmap field of the reported S-AP's ECAPC Policy element.

9.4.2.223 Cluster Switch Announcement element

A CDMG AP or PCP transmits the Cluster Switch Announcement element to its original cluster before switching from a cluster to another. One of the synchronization pair APs or PCPs also transmits the Cluster Switch Announcement element to its peer CDMG AP or PCP before joining a cluster. The Cluster Switch Announcement element can be included in the DMG Beacon frame or Announce frame received by other member APs or member PCPs. The format of the Cluster Switch Announcement element is shown in Figure 9-589cy.

	Element ID	Length	Element ID Extension	New Channel Number	Reference Timestamp	Reported Clustering Control	Reported BI Duration	Cluster Switch Count
Octets:	1	1	1	2	2	4	2	1

Figure 9-589cy—Cluster Switch Announcement element format

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

The New Channel Number field is set to the operating channel number of the target cluster after cluster switching.

The Reference Timestamp field contains the lower 4 octets of the TSF timer value sampled at the instant that the STA's MAC received the DMG Beacon frame of the S-AP or S-PCP of the target cluster.

The Reported Clustering Control field contains the Clustering Control field included in the received DMG Beacon frame of the S-AP or S-PCP.

The Reported BI Duration field is set to the BI value of the reported S-AP or S-PCP, expressed in TUs.

The Cluster Switch Count field either is set to the number of TBTTs until the AP or PCP sending the Cluster Switch Announcement element switches to the new cluster or is set to 0. This field is set to 1 to indicate that the switch occurs immediately before the next TBTT. It is set to 0 to indicate that the switch occurs at any time after the frame containing the element is transmitted.

9.4.2.224 Enhanced Beam Tracking element

The Enhanced Beam Tracking element is used to configure the alternative link of a CDMG STA, track the alternative link of the enhanced beam tracking initiator and responder, and switch to an alternative link from the current link. The element can be included in a BRP, DMG Beacon, Information Request, or Information Response frame.

The format of the Enhanced Beam Tracking element is shown in Figure 9-589cz.

	Element ID	Length	Element ID Extension	E-BT Control	Peer Tx Antenna Parameter
Octets:	1	1	1	1	1

Figure 9-589cz—Enhanced Beam Tracking element format

The Element ID, Length, and Element ID Extension fields are defined in 9.4.2.226.

The E-BT Control field is defined in Figure 9-589da.

	B0 B1	B2	B3	B4	B5	B6	B7
	Backup AWV Setting	Peer E-BT-R Request	E-BT-R Enabled	Peer E-BT-T Request	E-BT-T Enabled	Switching to Backup AWV Request	Switching to Backup AWV Enabled
Bits:	2	1	1	1	1	1	1

Figure 9-589da—E-BT Control field format

The Backup AWV Setting subfield is used to set the alternative AWV of the peer STA. The default alternative AWV of the peer STA is set to omnidirectional. If the Backup AWV Setting subfield is 0, the peer STA does not update the alternative AWV. If the Backup AWV Setting subfield is 1, the peer STA set the alternative AWV according to the AWV specified by the Peer Tx Antenna Parameter field. If the Backup AWV Setting subfield is 2, the current received AWV of peer is used to update the alternative AWV; if the Backup AWV Setting subfield is 3, the last transmitted AWV of peer is used to update the alternative AWV.

The Peer E-BT-R Request subfield is set to 1 to indicate that the peer STA is requested to enable enhanced beam tracking to receive the e-TRN-R training sequences; otherwise, it is set to 0.

The E-BT-R Enabled subfield is set to 1 to indicate that the requested peer STA acknowledges that it has enabled enhanced receive beam tracking to receive the e-TRN-R training sequences; otherwise, it is set to 0.

The Peer E-BT-T Request subfield is set to 1 to indicate that the peer STA is requested to enable enhanced transmit beam tracking to transmit the e-TRN-T training sequences; otherwise, it is set to 0.

The E-BT-T Enabled subfield is set to 1 to indicate that the requested peer STA acknowledges that it has enabled enhanced transmit beam tracking to transmit the e-TRN-T training sequences; otherwise, it is set to 0.

The Switching to Backup AWV Request subfield is set to 1 to indicate that the peer STA is requested to switch to the alternative AWV; otherwise, it is set to 0.

The Switching to Backup AWV Enabled subfield is set to 1 to indicate that the requested STA acknowledges that its antenna setting is to be switched to the alternative AWV before the next frame and to set the AWV of the current link as the new alternative AWV; otherwise, it is set to 0.

The Peer TX Antenna Parameter field is defined in Figure 9-589db.

	B0 B5	B6 B7
	Peer Tx_Sector ID	Peer Tx_Antenna ID
Bits:	6	2

Figure 9-589db—Peer TX Antenna Parameter field format

If the Backup AWV Setting subfield is 1, the Peer Tx_Sector ID field is set to the Sector ID of the alternative Tx AWV of the peer STA. Otherwise, the Peer Tx_Sector ID field is set to 0.

If the Backup AWV Setting subfield is 1, the Peer Tx_Antenna ID field indicates the Antenna ID of the alternative Tx AWV of the peer STA. Otherwise, the Peer Tx_Sector ID field is set to 0.

9.4.2.225 SPSH Report element

The SPSH Report element is used for an AP or PCP in a cluster to report the possibility of spatial sharing and coexistence between links in other BSSs and links in its own BSS. The SPSH Report element is transmitted in the DMG Beacon frame and is formatted as illustrated in Figure 9-589dc. Because the length parameter supports only 255 octets of payload in an element, the AP or PCP can split the SPSH List fields into more than one SPSH Report element entry in the same DMG Beacon or Announce frame.

	Element ID	Length	Element ID Extension	SPSH List 1	SPSH List 2	...	SPSH List *n*
Octets:	1	1	1	11	11	...	11

Figure 9-589dc—SPSH Report element format

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

The SPSH List field contains information of non-interfering links and is formatted as illustrated in Figure 9-589dd.

	SPSH List ID	BSS ID	SP Source AID	SP Destination AID	Measurement Source AID	Measurement Destination AID
Octets:	1	6	1	1	1	1

Figure 9-589dd—SPSH List field format

The SPSH List ID subfield indicates the identification of the SPSH List field, which is the same as the index of the corresponding field in the SPSH Report Element. It indicates that the channel measurement, between the two STAs indicated by the following Measurement Source AID subfield and the Measurement Destination AID subfield, shows no severe interference while the STA indicated by the SP Source AID subfield communicates with the STA indicated by the SP Destination AID subfield.

The BSS ID subfield indicates the identification of the measured infrastructure BSS or PBSS, which is the MAC address of the AP or PCP in the measured infrastructure BSS or PBSS.

The SP Source AID subfield indicates the AID of the transmitter STA of the link in the measured infrastructure BSS or PBSS.

The SP Destination AID subfield indicates the AID of the receiver STA of the link in the measured infrastructure BSS or PBSS. The SP Source AID and SP Destination AID subfields uniquely identify the link from the source AID STA to the destination AID STA in the BSS identified by the BSSID field.

The Measuring Source AID subfield indicates the AID of the transmitter of the link that is conducting SPSH measurement in the measured infrastructure BSS or PBSS, and the measured link does not interfere with it.

The Measuring Destination AID subfield indicates the AID of the receiver of the link that is conducting SPSH measurement in the measured infrastructure BSS or PBSS, and the measured link does not interfere with it. The Measuring Source AID and Measuring Destination AID subfields uniquely identify the link from the measuring source AID STA to the measuring destination AID STA in the BSS.

9.4.2.226 Clustering Interference Assessment element

The S-AP or S-PCP in a CDMG AP or PCP cluster uses a Clustering Interference Assessment element to enable spatial sharing in the cluster and sets channel quality measurement and control parameters of spatial sharing for their member APs or member PCPs. The Clustering Interference Assessment element can be included in the DMG Beacon frames transmitted by the S-AP or S-PCP, as shown in Figure 9-589de.

	Element ID	Length	Element ID Extension	Clustering SPSH Enabled	Clustering SPSH Control
Octets:	1	1	1	1	1

Figure 9-589de—Clustering Interference Assessment element format

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

The Clustering SPSH Enabled field is set to 0 to indicate that a SPSH measurement phase starts. The Clustering SPSH Enabled field is set to 1 to indicate that the SPSH measurement phase for all member APs or member PCPs terminates and SP spatial sharing among BSSs starts. Other values are reserved. The Clustering SPSH Enabled field is set as the same as the SPSH Measurement Enabled subfield in the Clustering Control field defined in 9.3.4.2.

The Clustering SPSH Control field is illustrated in Figure 9-589df.

	B0 B4	B5 B12	B13 B15
	Channel Quality Measurement Duration	Clustering SPSH Duration	Reserved
Bits:	5	8	3

Figure 9-589df—Clustering SPSH Control field format

The Channel Quality Measurement Duration subfield is set to a value of time duration of directional channel quality measurement for all member APs or member PCPs in a CDMG AP or PCP cluster, in units of BI.

The Clustering SPSH Duration subfield is set to a value of time duration of spatial sharing among BSSs for all member APs or member PCPs in a CDMG AP or PCP cluster, in units of BI.

9.4.2.227 CMMG Capabilities element

9.4.2.227.1 CMMG Capabilities element structure

The CMMG Capabilities element contains a number of fields that are used to advertise the CMMG capabilities of STA. The CMMG Capabilities element is defined in Figure 9-589dg.

	Element ID	Length	Element ID Extension	CMMG Capabilites Info	A-MPDU Parameters	Transmit Beamforming Capabilites	Supported CMMG MCS and NSS Set	CMMG AP or PCP Capability Information
Octets:	1	1	1	7	1	4	8	2

Figure 9-589dg—CMMG Capabilities element format

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

9.4.2.227.2 CMMG Capabilities Info field

The structure of the CMMG Capabilities Info field is defined in Figure 9-589dh.

	B0 B1	B2	B3	B4 B5	B6	B7	B8	B9
	Maximum MPDU Length	Supported Channel Width Set	Tx STBC	Rx STBC	Short GI for 540 MHz	Short GI for 1080 MHz	Supported MIMO	Heart beat
Bits:	2	1	1	2	1	1	1	1

	B10 B11	B12	B13	B14	B15	B16	B17	B18 B23
	TPC	Number of Sounding Dimensions CMMG	TXOP PS	Delayed Block Ack	CMMG Link Adaptation Capable	Rx Antenna Pattern Consistency	Tx Antenna Pattern Consistency	Fast Link Adaptation
Bits:	2	1	1	1	1	1	1	6

	B24	B25 B26	27	B28	B29	B30	B31 B37	B38 B40
	RXSS LengthS	Color	PSH and Interference Mitigation	Number of Rx DMG Antennas	Supports Other_AID	RXSS Tx Rate Supported	CMMG Antenna Reciprocity	Antenna Pattern Reciprocity
Bits:	1	2	1	1	1	1	7	3

	B41 B47	B48 B50	B51 B52	B53	B54 B55
	Total Number of Sectors	Heartbeat Elapsed Indication	MCS Feedback	RD Responder	Reserved
Bits:	7	3	2	1	2

Figure 9-589dh—CMMG Capabilities Info field

The subfields of the CMMG Capabilities Info field are defined in Table 9-262aa.

Table 9-262aa—Subfields of the CMMG Capabilities Info field

Subfield	Definition	Encoding
Maximum MPDU Length	Indicates the maximum MPDU length (see 10.12).	Set to 0 for 3895 octets. Set to 1 for 7991 octets. Set to 2 for 11 454 octets. The value 3 is reserved.
Supported Channel Width Set	Indicates the channel widths supported by the STA. See 11.50.	Set to 0 if the STA does not support 1080 MHz. Set to 1 if the STA supports 1080 MHz.
Tx STBC	Indicates support for the transmission of at least 2x1 STBC.	Set to 0 if not supported. Set to 1 if supported.
Rx STBC	Indicates support for the reception of PPDUs using STBC.	Set to 0 for no support. Set to 1 for support of one spatial stream. Set to 2 for support of one and two spatial streams. The value 3 is reserved.
Short GI for 540 MHz	Indicates short GI support for the reception of packets transmitted with TXVECTOR parameter CH_BANDWIDTH set to CMMG_CBW540.	Set to 0 if not supported. Set to 1 if supported.
Short GI for 1080 MHz	Indicates short GI support for the reception of packets transmitted with TXVECTOR parameter CH_BANDWIDTH set to CMMG_CBW1080.	Set to 0 if not supported. Set to 1 if supported.
Supported MIMO	Indicates whether the STA supports MIMO.	The Supported MIMO field is set to 1 if the STA supports the SC and OFDM MIMO and is set to 0 otherwise.
Heartbeat	Indicate that whether the STA expects to receive a frame from the AP or PCP during the ATI and expects to receive a frame with the CMMG Control modulation from a source CMMG STA at the beginning of an SP or TXOP.	Set to 1 to indicate that the STA expects to receive a frame from the AP or PCP during the ATI and expects to receive a frame with the CMMG Control modulation from a source CMMG STA at the beginning of an SP or TXOP. Otherwise, this field is set to 0.
TPC	Indicates whether the STA supports TPC.	The TPC field is set to 1 if the STA supports the TPC as defined in 11.8 and is set to 0 otherwise.
Number of Sounding Dimensions	Beamformer's capability indicating the maximum value of the TXVECTOR parameter NUM_STS for a CMMG NDP.	If beamformer capable, set to the maximum supported value of the TXVECTOR parameter NUM_STS minus 1. Otherwise, reserved.
TXOP PS	Indicates whether the AP supports CMMG TXOP power save mode or whether the non-AP STA has enabled CMMG TXOP power save mode.	Set to 0 if the AP does not support TXOP power save mode. Set to 1 if the AP supports TXOP power save mode. Set to 0 if the non-AP STA does not enable TXOP power save mode. Set to 1 if the non-AP STA enables TXOP power save mode.

Table 9-262aa—Subfields of the CMMG Capabilities Info field *(continued)*

Subfield	Definition	Encoding
Delayed Block Ack	Indicates support for CMMG delayed Block Ack operation. See 10.24.8.	Set to 0 if not supported. Set to 1 if supported. Support indicates that the STA is able to accept an ADDBA request for Delayed Block Ack.
CMMG Link Adaptation Capable	Indicates whether the STA supports link adaptation using CMMG Control field.	Set to 0 (No Feedback) if the STA does not provide CMMG MFB. Set to 2 (Unsolicited) if the STA provides only unsolicited CMMG MFB. Set to 3 (Both) if the STA can provide CMMG MFB in response to CMMG MRQ and if the STA provides unsolicited CMMG MFB. The value 1 is reserved.
Rx Antenna Pattern Consistency	Indicates the possibility of a receive antenna pattern change.	Set to 0 if the receive antenna pattern might change during the lifetime of the current association. Set to 1 if the receive antenna pattern does not change during the lifetime of the current association. See 11.50.6.
Tx Antenna Pattern Consistency	Indicates the possibility of a transmit antenna pattern change.	Set to 0 if the transmit antenna pattern might change during the lifetime of the current association. Set to 1 if the transmit antenna pattern does not change during the lifetime of the current association. See 11.50.6.
Fast Link Adaptation	Indicates whether the STA supports fast link adaptation.	The Fast Link Adaptation field is set to 1 to indicate that the STA supports the CMMG fast link adaptation procedure described in 10.39a.3. Otherwise, it is set to 0.
RXSS Length	Specifies the total number of receive sectors combined over all receive DMG antennas of the STA.	The value represented by this field is in the range 2 to 128 and is given by (RXSS Length+1)×2. The maximum number of SSW frames transmitted during an RXSS is equal to the value of (RXSS Length+1)×2 times the total number of transmit DMG antennas of the peer device.
Color	Indicates the value that is used for the TXVECTOR parameter COLOR in frames transmitted by members of this BSS, as described in 10.20.	Set to an unsigned integer in the range 0 to 7 if sent by an AP. Otherwise reserved.
SPSH and Interference Mitigation	Indicate whether the STA is capable of performing the function of SPSH and interference mitigation or not.	Set to 1 if the STA is capable of performing the function of SPSH and interference mitigation and if dot11RadioMeasurementActivated is true and is set to 0 otherwise (see 10.32).
Number of RX DMG Antennas	Indicates the total number of receive DMG antennas of the STA.	The value of this field is in the range 1 to 4, with the value being equal to the bit representation plus 1.
Supports Other_AID	Indicate that the STA sets its AWV configuration according to the Other_AID subfield in the BRP Request field.	Set to 1 if the value of the Other_AID subfield is different from zero. Otherwise, this field is set to 0.

Table 9-262aa—Subfields of the CMMG Capabilities Info field *(continued)*

Subfield	Definition	Encoding
RXSSTxRate Supported	Indicate whether the STA can perform an RXSS with the SSW frames transmitted at MCS 1 of the CMMG SC modulation class or not.	Set to 1 to indicate that the STA can perform an RXSS with the SSW frames transmitted at MCS 1 of the CMMG SC modulation class. Otherwise, it is set to 0.
DMG Antenna Reciprocity	Indicate that the best transmit CMMG antenna of the STA is the same as the best receive CMMG antenna of the STA and vice versa.	Set to 1 to indicate that the best transmit DMG antenna of the STA is the same as the best receive DMG antenna of the STA and vice versa. Otherwise, this field is set to 0.
Antenna Pattern Reciprocity	Indicate whether the transmit antenna pattern associated with an AWV is the same as the receive antenna pattern for the same AWV or not.	Set to 1 to indicate that the transmit antenna pattern associated with an AWV is the same as the receive antenna pattern for the same AWV. Otherwise, this field is set to 0.
Total Number of Sectors	Indicates the total number of transmit sectors the STA uses in a transmit sector sweep combined over all DMG antennas.	The value of this field is in the range 1 to 128, with the value being equal to the bit representation plus 1.
Heartbeat Elapsed Indication	Used to calculate the value of the heartbeat elapsed time.	The heartbeat elapsed time is computed according to the following equation: $$T_{HE} = \begin{cases} 0, F_{HE} = 0 \\ \frac{2^{F_{HE}}}{4}, F_{HE} > 0 \end{cases}$$ where T_{HE} is the heartbeat elapsed time (in milliseconds); F_{HE} is the value of the Heartbeat Elapsed Indication subfield.
MCS Feedback	Indicates whether the STA can provide MFB.	Set to 0 (No Feedback) if the STA does not provide MFB. Set to 2 (Unsolicited) if the STA provides only unsolicited MFB. Set to 3 (Both) if the STA can provide MFB in response to MRQ (either Delayed or Immediate, see 10.31) as well as unsolicited MFB The value 1 is reserved.
RD Responder	Indicates support for acting as a reverse direction responder, i.e., the STA might use an offered RDG to transmit data to an RD initiator using the reverse direction protocol described in 10.28.	Set to 0 if not supported. Set to 1 if supported.

NOTE—The value for the Maximum MPDU Length subfield in the CMMG Capabilities Info field imposes a constraint on the allowed value of the Maximum MPDU Length in the CMMG Capabilities Info field of the CMMG Capabilities element carried in the same frame (see 9.11).

9.4.2.227.3 A-MPDU Parameters field

The structure of the A-MPDU Parameters field of the CMMG Capabilities element is shown in Figure 9-589di. The definition for the subfields of the A-MPDU Parameters field is shown in Table 9-262ab.

	B0 B2	B3 B5	B6 B7
	Maximum AMPDU Length Exponent	Minimum MPDU Start Spacing	Reserved
Bits:	3	3	2

Figure 9-589di—A-MPDU Parameters field

Table 9-262ab—Subfields of the A-MPDU Parameters field

Subfield	Definition	Encoding
Maximum AMPDU Length Exponent	Indicates the maximum length of A-MPDU that the STA can receive. EOF padding is not included in this limit.	This field is an integer in the range 0 to 7. The length defined by this field is equal to $2^{(13 + \mathrm{MaximumA-PPDUULenghtExponent}))}$ octets.
Minimum MPDU Start Spacing	Determines the minimum time between the start of adjacent MPDUs within an A-MPDU that the STA can receive, measured at the PHY-SAP. See 9.7d.3.	Set to 0 for no restriction. Set to 1 for 16 ns. Set to 2 for 32 ns. Set to 3 for 64 ns. Set to 4 for 128 ns. Set to 5 for 256 ns. Set to 6 for 512 ns. Set to 7 for 1024 ns.

9.4.2.227.4 Supported CMMG MCS and NSS Set field

The Supported CMMG MCS and NSS Set field is used to convey the combinations of CMMG MCSs and spatial streams that a STA supports for reception and the combinations that it supports for transmission. The structure of the field is shown in Figure 9-589dj.

	B0 B15	B16 B29	B30 B31	B32 B47	B48 B61	B62 B63
	Rx CMMG MCS Map	Rx Highest Supported Long GI Data Rate	Reserved	Tx CMMG MCS Map	Tx Highest Supported Long GI Data Rate	Reserved
Bits:	16	14	2	16	14	2

Figure 9-589dj—Supported CMMG MCS and NSS Set field

The Supported CMMG MCS and NSS Set subfields are defined in Table 9-262ac.

Table 9-262ac—Supported CMMG MCS and NSS Set subfields

Subfield	Definition	Encoding
Rx CMMG MCS Map	Indicates the maximum value of the RXVECTOR parameter MCS of a PPDU that can be received at all channel widths supported by this STA for each number of spatial streams.	The format and encoding of this subfield are defined in Figure 9-589dk and the associated description.
Rx Highest Supported Long GI Data Rate	Indicates the highest CMMG PPDU data rate that the STA is able to receive.	The largest integer value less than or equal to the highest CMMG PPDU data rate in Mb/s the STA is able to receive (see 10.7.14.1). The value 0 indicates that this subfield does not specify the highest CMMG PPDU data rate that the STA is able to receive.
Tx CMMG MCS Map	Indicates the maximum value of the TXVECTOR parameter MCS of a PPDU that can be received at all channel widths supported by this STA for each number of spatial streams.	The format and encoding of this subfield are defined in Figure 9-589dk and the associated description.
Tx Highest Supported Long GI Data Rate	Indicates the highest CMMG PPDU data rate that the STA is able to transmit at.	The largest integer value less than or equal to the highest CMMG PPDU data rate in Mb/s the STA is able to receive/transmit (see 10.7.14.2). The value 0 indicates that this subfield does not specify the highest CMMG PPDU data rate that the STA is able to receive transmit.

The Rx CMMG MCS Map subfield and the Tx CMMG MCS Map subfield have the structure shown in Figure 9-589dk.

	B0 B2	B3 B5	B6 B8	B3 B11	B12 B15
	Max CMMG MCS For 1 SS	Max CMMG MCS For 2 SS	Max CMMG MCS For 3 SS	Max CMMG MCS For 4 SS	Reserved
Bits:	3	3	3	3	4

Figure 9-589dk—Rx CMMG MCS Map and Tx CMMG MCS Map subfields and Basic CMMG MCS and NSS Set field

The Max CMMG MCS For *n* SS subfield (where *n* = 1, 2, 3, 4) is encoded as follows:

- 0 indicates support for SC CMMG-MCSs 1 to 5 or OFDM CMMG-MCSs 9 to 13 for *n* spatial streams
- 1 indicates support for SC CMMG-MCSs 1 to 6 or OFDM CMMG-MCSs 9 to 14 for *n* spatial streams
- 2 indicates support for SC CMMG-MCSs 1 to 7 or OFDM CMMG-MCSs 9 to 15 for *n* spatial streams
- 3 indicates support for SC CMMG-MCSs 1 to 8 or OFDM CMMG-MCSs 9 to 16 for *n* spatial streams
- 4–7 indicate that *n* spatial streams are not supported

9.4.2.227.5 Transmit Beamforming Capabilities field

The structure of the Transmit Beamforming Capabilities field is defined in Figure 9-589dl.

	B0	B1	B2	B3	B4	B5 B7
	Receive Staggered Sounding Capable	Transmit Staggered Sounding Capable	Receive NDP Capable	Transmit NDP Capable	Explicit Compressed Steering Capable	Explicit Compressed Beamforming Feedback Capable
Bits:	1	1	1	1	1	3

	B8 B9	B10 B11	B12 B13	B14 B15	B16 B17	B18 B23
	Minimal Grouping	CSI Number of Beamformer Antennas Supported	Compressed Steering Number of Beamformer Antennas Supported	CSI Max Number of Rows Beamformer Supported	CSI Max Number of Rows Beamformer Supported	Reserved
Bits:	2	2	2	2	2	6

Figure 9-589dl—Transmit Beamforming Capabilities field

The subfields of the Transmit Beamforming Capabilities field are defined in Table 9-262ad.

Table 9-262ad—Subfields of the Transmit Beamforming Capabilities field

Subfield	Definition	Encoding
Receive Staggered Sounding Capable	Indicates whether this STA can receive staggered sounding frames.	Set to 0 if not supported. Set to 1 if supported.
Transmit Staggered Sounding Capable	Indicates whether this STA can transmit staggered sounding frames.	Set to 0 if not supported. Set to 1 if supported.
Receive NDP Capable	Indicates whether this receiver can interpret null data packets as sounding frames.	Set to 0 if not supported. Set to 1 if supported.
Transmit NDP Capable	Indicates whether this STA can transmit null data packets as sounding frames.	Set to 0 if not supported. Set to 1 if supported.
Explicit Compressed Steering Capable	Indicates whether this STA can apply transmit beamforming using compressed beamforming feedback matrix explicit feedback in its transmission.	Set to 0 if not supported. Set to 1 if supported.
Explicit Compressed Beamforming Feedback Capable	Indicates whether this receiver can return compressed beamforming feedback matrix explicit feedback.	Set to 0 if not supported. Set to 1 for delayed feedback. Set to 2 for immediate feedback. Set to 3 for delayed and immediate feedback.

Table 9-262ad—Subfields of the Transmit Beamforming Capabilities field *(continued)*

Subfield	Definition	Encoding
Minimal Grouping	Indicates the minimal grouping used for explicit feedback reports.	Set to 0 if the STA supports groups of 1 (no grouping). Set to 1 indicates groups of 1, 2. Set to 2 indicates groups of 1, 4. Set to 3 indicates groups of 1, 2, 4. Set to 4 indicates groups of 1, 6. Set to 5 indicates groups of 1, 2, 6. Set to 6 indicates groups of 1, 4, 6. Set to 7 indicates groups of 1, 2, 4, 6.
CSI Number of Beamformer Antennas Supported	Indicates the maximum number of beamformer antennas the CMMG beamformee can support when CSI feedback is required.	Set to 0 for single Tx antenna sounding. Set to 1 for 2 Tx antenna sounding. Set to 2 for 3 Tx antenna sounding. Set to 3 for 4 Tx antenna sounding.
Compressed Steering Number of Beamformer Antennas Supported	Indicates the maximum number of beamformer antennas the beamformee can support when compressed beamforming feedback matrix is required.	Set to 0 for single Tx antenna sounding. Set to 1 for 2 Tx antenna sounding. Set to 2 for 3 Tx antenna sounding. Set to 3 for 4 Tx antenna sounding.
CSI Max Number of Rows Beamformer Supported	Indicates the maximum number of rows of CSI explicit feedback from the CMMG beamformee that a CMMG beamformer can support when CSI feedback is required.	Set to 0 for a single row of CSI. Set to 1 for 2 rows of CSI. Set to 2 for 3 rows of CSI. Set to 3 for 4 rows of CSI.
Channel Estimation Capability	Indicates the maximum number of space-time streams (columns of the MIMO channel matrix) for which channel dimensions can be simultaneously estimated when receiving an NDP sounding PPDU or the extension portion of the MCTFs in a staggered sounding PPDU.	Set 0 for 1 space-time stream. Set 1 for 2 space-time streams. Set 2 for 3 space-time streams. Set 3 for 4 space-time streams.
NOTE—The maximum number of space-time streams for which channel coefficients can be simultaneously estimated using the MCTFs corresponding to the data portion of the packet is limited by the Rx MCS Bitmask subfield of the Supported MCS Set field and by the Rx STBC subfield of the CMMG Capability Information field. Both fields are part of the CMMG Capabilities element.		

9.4.2.227.6 CMMG AP or PCP Capability Information field

The CMMG AP or PCP Capability Information field, illustrated in Figure 9-589dm, represents the capabilities, when the transmitting STA performs in the role of AP or PCP, that are in addition to the capabilities in the CMMG STA Capability Information field.

	B0	B1	B2	B3 B10	B11
	TDDTI	Pseudo-static Allocations	PCP Handover	MAX Associated STA Number	Power Source
Bits:	1	1	1	8	1

	B12	B13	B14	B15
	Decentralized AP or PCP Clustering	PCP Forwarding	Centralized AP or PCP Clustering	Reserved
Bits:	1	1	1	1

Figure 9-589dm—CMMG AP or PCP Capability Information field format

The TDDTI (time division data transfer interval) subfield is set to 1 if the STA, while operating as an AP or PCP, is capable of providing channel access as defined in 10.36.6 and 11.4 and is set to 0 otherwise.

The Pseudo-static Allocations subfield is set to 1 if the STA, while operating as an AP or PCP, is capable of providing pseudo-static allocations as defined in 10.36.6.4 and is set to 0 otherwise. The Pseudo-static Allocations subfield is set to 1 only if the TDDTI subfield in the CMMG AP or PCP Capability Information field is equal to 1. The Pseudo-static Allocations subfield is reserved if the TDDTI subfield in the CMMG AP or PCP Capability Information field is equal to 0.

The PCP Handover field is set to 1 if the STA, while operating as a PCP, is capable of performing a PCP handover as defined in 11.29.2 and is set to 0 if the STA does not support PCP handover.

The MAX Associated STA Number field indicates the maximum number of STAs that the STA can perform association with if operating as an AP or PCP. The value of this field includes the STAs, if any, that are collocated with the AP or PCP.

The Power Source field is set to 0 if the STA is battery powered and is set to 1 otherwise.

The Decentralized AP or PCP Clustering field is set to 1 if the STA, when operating as an AP or PCP, is capable of performing decentralized AP or PCP clustering and is set to 0 otherwise.

The PCP Forwarding field is set to 1 if the STA, while operating as a PCP, is capable of forwarding frames it receives from a non-PCP STA and destined to another non-PCP STA in the PBSS. This field is set to 0 otherwise.

The Centralized AP or PCP Clustering field is set to 1 if the STA, when operating as an AP or PCP, is capable of performing centralized AP or PCP clustering and is set to 0 otherwise. An AP or PCP that is incapable of performing centralized AP or PCP clustering is subject to requirements as described in 10.37.2.2.

9.4.2.228 CMMG Operation element

The operation of CMMG STAs in the BSS is controlled by the CMMG Operation element. The format of the CMMG Operation element is defined in Figure 9-589dn.

	Element ID	Length	Element ID Extension	CMMG Operation Information	Basic CMMG MCS and NSS set
Octets:	1	1	1	1	2

Figure 9-589dn—CMMG Operation element format

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

The structure of the CMMG Operation Information field is defined in Figure 9-589do.

	B0 B2	B3	B4	B5	B6
	Primary Channel	Channel Width	PCO Active	PCO Phase	Reserved
Bits:	3	1	1	1	1

Figure 9-589do—CMMG Operation Information field

The subfields of the CMMG Operation Information field are defined in Table 9-262ae.

Table 9-262ae—CMMG Operation Information field format

Subfield	Definition	Encoding
Primary Channel	Indicates the channel number of the primary channel, see 25.10.	Channel number of the primary channel.
Channel Width	This field, defines the BSS operating channel width.	Set to 0 for 540 MHz operating channel width. Set to 1 for 1080 MHz operating channel width.

The Basic CMMG MCS and NSS Set field indicates the CMMG MCSs for each number of spatial streams in CMMG PPDUs that are supported by all CMMG STAs in the BSS (including IBSS and MBSS). The Basic CMMG MCS and NSS Set field is a bitmap of size 2 bits. The Basic CMMG MCS and NSS Set field is defined in Figure 9-589dk.

9.4.2.229 CMMG Operating Mode Notification element

The CMMG Operating Mode Notification element is used to notify STAs that the transmitting STA is changing its operating channel width, the maximum number of spatial streams it can receive, or both. The format of the CMMG Operating Mode Notification element is defined in Figure 9-589dp.

	Element ID	Length	Element ID Extension	CMMG Operating Mode
Octets:	1	1	1	1

Figure 9-589dp—CMMG Operating Mode Notification element

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

The Operating Mode field is defined in 9.4.1.63.

9.4.2.230 CMMG Link Margin element

9.4.2.230.1 General

The format of the CMMG Link Margin element is shown in Figure 9-589dq. The CMMG Link Margin element is included in a Link Measurement Report frame.

	Element	Length	Element ID Extension	Activity	MCS	Link Margin	SNR	Reference Timestamp
Octets:	1	1	1	1	1	1	1	4

Figure 9-589dq—CMMG Link Margin element format

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

The Activity field is set to a preferred action that the STA sending this element recommends that the peer STA indicated in the RA field of the Link Measurement Report frame execute. The method by which the sending STA determines a suitable action for the peer STA is implementation specific. The Activity field is defined in 9.4.2.230.2.

The MCS field is set to an MCS value that the STA sending this element recommends that the peer STA indicated in the RA field of the Link Measurement Report frame use to transmit frames to this STA. The reference PER for selection of the MCS is for an MPDU length of 4096 octets. The method by which the sending STA determines a suitable MCS for the peer STA is implementation specific. The Link Margin field contains the measured link margin of the Data frames received from the peer STA indicated in the RA field of the Link Measurement Report frame and is coded as a 2s complement signed integer in units of decibels. A value of –128 indicates that no link margin is provided. The measurement method of link margin is beyond the scope of this standard.

The SNR field indicates the SNR measured during the reception of a PHY packet. Values are from –13 dB to 50.75 dB in 0.25 dB steps.

The Reference Timestamp field contains the lower 4 octets of the TSF timer value sampled at the instant that the MAC received the PHY-CCA indication (IDLE) signal that corresponds to the end of the reception of the PPDU that was used to generate the feedback information contained in the Link Measurement Report frame.

9.4.2.230.2 Activity field

The Activity field values are defined in Table 9-262af.

Table 9-262af—Activity field values

Preferred Action value	Meaning
0	No change preferred
1	Change(d) MCS
2	Decrease(d) transmit power
3	Increase(d) transmit power
4	Fast session transfer (FST)
5	Power conserve mode
6	Perform SLS
7–255	Reserved

9.4.2.231 CMMG Link Adaptation Acknowledgment element

The format of the CMMG Link Adaptation Acknowledgment element is shown in Figure 9-589dr. The CMMG Link Adaptation Acknowledgment element is carried in the Optional Subelements field of the Link Measurement Report frame.

	Element ID	Length	Activity	Reference Timestamp
Octets:	1	1	1	4

Figure 9-589dr—CMMG Link Adaptation Acknowledgment element format

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

The Activity field is set to the action that the STA sending this element has executed following the reception of the recommended activity in a Link Measurement Report frame. The method by which the sending STA determines the action is described in 10.31, and the Activity field is defined in 9.4.2.230.2.

The Reference Timestamp field contains the lower 4 octets of the TSF timer value sampled at the instant that the MAC received the PHY-CCA indication (IDLE) signal that corresponds to the end of the reception of the PPDU that was used to generate the feedback information contained in the Link Measurement Report frame.

9.5 Fields used in Management and Extension frame bodies and Control frames

9.5.1 Sector Sweep field

Change Figure 9-635 as as follows:

	B0	B1 B9	B10 B15	B16 B17	B18 B23
	Direction	CDOWN	Sector ID	DMG/CMMG Antenna ID	RXSS Length
Bits:	1	9	6	2	6

Figure 9-635—SSW field format

Change the fifth paragraph of 9.5.1 as follows:

The DMG/CMMG Antenna ID subfield indicates the DMG/CMMG antenna the transmitter is currently using for this transmission.

9.6 Action frame format details

9.6.8 Public Action details

9.6.8.1 Public Action frames

Insert the following rows into Table 9-307 in numeric order, and change the Reserved row accordingly:

Table 9-307—Public Action field values

Public Action field value	Description
35	DCS Measurement Request
36	DCS Measurement Report

Table 9-307—Public Action field values *(continued)*

Public Action field value	Description
37	DCS Request
38	DCS Response
39	Extended Notification Period Request
40	Extended Notification Period Response
41	Extended Channel Splitting Request
42	Extended Channel Splitting Response

Insert the following subclauses, 9.6.8.37 to 9.6.8.44 (including Figure 9-687f through Figure 9-687k and Table 9-325h through Table 9-325m), after 9.6.8.36:

9.6.8.37 DCS Measurement Request frame format

The DCS Measurement Request frame is transmitted by a DCS requesting CDMG AP or PCP to a DCS responder CDMG AP or PCP to request all of the STAs in the DCS responder AP's infrastructure BSS or PCP's PBSS to measure a specified channel or all other channels within the supported operating class (as defined in 9.4.2.54). The format of the DCS Measurement Request frame Action field is shown in Figure 9-687f.

	Category	Public Action	Dialog Token	DCS Measurement Request Mode	Operating Class	Optional Subelements
Octets:	1	1	1	1	1	variable

Figure 9-687f—DCS Measurement Request frame Action field format

The Category field is defined in 9.4.1.11.

The Public Action field is defined in 9.6.8.1.

The Dialog Token field is defined in 9.4.1.12 and set by the requesting STA.

The Measurement Request Mode field is set to 1 to indicate that the DCS requesting AP or PCP requests all STAs within the DCS responder AP's or PCP's infrastructure BSS or PBSS to measure all channels within the operating class specified in the following Operating Class field. The Measurement Request Mode field is set to 2 to indicate that the DCS requesting AP or PCP requests all STAs within the DCS responder AP's infrastructure BSS or PCP's PBSS to measure the specified channel(s) indicated within the Optional Subelements field. Other values are reserved.

The Operating Class field is valid when the Measurement Request Mode field is 1. In all other cases, the Operating Class field is reserved. The Operating Class and Channel Number fields together specify the channel frequency and channel bandwidth for which the DCS procedure applies. Valid values of the Operating Class field are shown in Annex E.

The Optional Subelements field is present when the Measurement Request Mode field is 2. The Optional Subelements field contains zero or more subelements, each consisting of a 1-octet Subelement ID field, a 1-octet Length field, and a variable-length Data field, as defined in 9.4.3. The optional subelements are ordered by nondecreasing subelement ID.

The Subelement ID field values for the defined optional subelements are shown in Table 9-325h. A Yes in the Extensible column of a subelement listed in Table 9-325h indicates that the Length of the subelement might be extended in future revisions or amendments of this standard. When the Extensible column of an element is Subelements, then the subelement might be extended in future revisions or amendments of this standard by defining additional subelements within the subelement. See 10.27.9.

Table 9-325h—Optional subelement IDs for DCS Measurement Request frame

Subelement ID	Name	Extensible
0	Reserved	
1	Channel Measurement Request	Yes
2–220	Reserved	
221	Vendor Specific	
222–255	Reserved	

The Channel Measurement Request subelement is used to specify the channel(s) to be measured. The format of the DCS Channel Measurement Request subelement is shown in Figure 9-687g.

	Subelement ID	Length	Measurement Token	Operating Class	Channel Number
Octets:	1	1	1	1	1

Figure 9-687g—DCS Channel Measurement Request subelement format

The Subelement ID field is defined in Figure 9-325h.

The Length field is defined in 9.4.3.

The Measurement Token field is set to a nonzero value that is unique among the Channel Measurement Request subelements in a particular DCS Measurement Request frame.

The Operating Class and Channel Number fields together specify the channel frequency and channel bandwidth for which the DCS procedure applies. Valid values of the Operating Class field are shown in Annex E (Country elements and operating classes).

The Channel Number field is set to the channel number for which the Channel Measurement Request applies (as defined in 17.3.8.4.3).

9.6.8.38 DCS Measurement Response frame format

The DCS Measurement Response frame is transmitted by a DCS responder AP or PCP to a DCS requesting AP or PCP to report the results of measuring one or more channels. The format of the DCS Measurement Response frame Action field is shown in Figure 9-687h.

	Category	Public Action	Dialog Token	DCS Measurement Report Mode	Operating Class	Optional Subelements
Octets:	1	1	1	1	1	variable

Figure 9-687h— DCS Measurement Response frame Action field format

The Category field is defined in 9.4.1.11.

The Public Action field is defined in 9.6.8.1.

The Dialog Token field is copied from the corresponding DCS Measurement Request frame.

The Measurement Report Mode field is set to 0 to indicate no clear channel to which the DCS responder AP's or PCP's BSS can move within the operating class specified in the following Operating Class field, or the DCS request has been declined by the DCS responder AP or PCP. The Measurement Report Mode field is set to 1 to indicate that all other channels within the operating class specified in the following Operating Class field are available for the DCS responder AP's or PCP's BSS. The Measurement Report Mode field is set to 2 to indicate that the clear channel for the DCS responder AP's or PCP's BSS is indicated by the Optional Subelement field in the DCS Measurement Response frame. Other values are reserved.

The Operating Class field is valid when the Measurement Report Mode field is 1. In all other cases, the Operating Class field is reserved. The Operating Class and Channel Number fields together specify the channel frequency and channel bandwidth for which the DCS procedure applies. Valid values of the Operating Class field are shown in Annex E.

The Optional Subelements field is present when the Measurement Report Mode field is 2. The Optional Subelements field contains zero or more subelements, each consisting of a 1-octet Subelement ID field, a 1-octet Length field, and a variable-length Data field, as defined in 9.4.3. The optional subelements are ordered by nondecreasing subelement ID.

The Subelement ID field values for the defined optional subelements are shown in Table 9-325i. A Yes in the Extensible column of a subelement listed in Table 9-325i indicates that the Length of the subelement might be extended in future revisions or amendments of this standard. When the Extensible column of an element is Subelements, then the subelement might be extended in future revisions or amendments of this standard by defining additional subelements within the subelement. See 10.27.9.

Table 9-325i—Optional subelement IDs for DCS Measurement Response frame

Subelement ID	Name	Extensible
0	Reserved	
1	Channel Measurement Report	Yes
2–220	Reserved	
221	Vendor Specific	
222–255	Reserved	

The Channel Measurement Report subelement is used to report the number of available channel to which the DCS responder AP's or PCP's BSS can move. The DCS Channel Measurement Report subelement format is as shown in Figure 9-687i.

	Subelement ID	Length	Measurement Token	Operating Class	Channel Number
Octets:	1	1	1	1	1

Figure 9-687i—DCS Channel Measurement Report subelement format

The Subelement ID field is defined in Table 9-325i.

The Length field is defined in 9.4.3.

The Measurement Token field is copied from the corresponding Channel Measurement Request subelement in the received DCS Measurement Request frame.

The Operating Class and Channel Number fields together specify the channel frequency and channel bandwidth for which the DCS procedure applies. Valid values of the Operating Class field are shown in Annex E.

The Channel Number field is set to the channel number to which the DCS responder AP's or PCP's BSS can move (as defined in 17.3.8.4.3).

9.6.8.39 DCS Request frame format

The DCS Request frame is transmitted by a DCS requesting AP or PCP to a DCS responder AP or PCP to request the DCS responder AP's or PCP's BSS to move to an available channel indicated in the DCS Measurement Response frame. The format of the DCS Request frame Action field is shown in Figure 9-687j.

	Category	Public Action	Dialog Token	Request Type	Operating Class	New Channel Number
Octets:	1	1	1	1	1	1

Figure 9-687j— DCS Request frame Action field format

The Category field is defined in 9.4.1.11.

The Public Action field is defined in 9.6.8.1.

The Dialog Token field value is copied from the corresponding DCS Measurement Response frame.

The Request Type field value is set to 0 to indicate that the requesting AP or PCP requests the responder AP or PCP to tear down the DCS procedure or the DCS request is refused by the responder AP or PCP; then the following Operation Class field and New Channel Number field are reserved. The Request Type field value is set to 1 to indicate that the DCS requesting AP or PCP to request the DCS responder AP's or PCP's BSS to move to an available channel indicated by the following Operating Class field and New Channel Number field. Other values are reserved.

The Operating Class and Channel Number fields together specify the channel frequency and channel bandwidth for which the DCS procedure applies. Valid values of the Operating Class field are shown in Annex E. This field is valid when the Request Type field sets to 1; otherwise, it is reserved.

The New Channel Number field is set to the channel number to which the DCS requesting AP or PCP request the DCS responder AP's or PCP's BSS to move (as defined in 17.3.8.4.3). This field is valid when the Request Type field sets to 1; otherwise, it is reserved.

9.6.8.40 DCS Response frame format

The DCS Response frame is transmitted by a DCS responder AP or PCP to a DCS requesting AP or PCP to confirm that the DCS responder AP's or PCP's BSS is moving to the channel specified in the DCS request frame. The format of the DCS Response frame Action field is shown in Figure 9-687k.

	Category	Public Action	Dialog Token	Responder Type	Operating Class	New Channel Number	Channel Switch Count
Octets:	1	1	1	1		1	1

Figure 9-687k— DCS Response frame Action field format

The Category field is defined in 9.4.1.11.

The Public Action field is defined in 9.6.8.1.

The Dialog Token field is copied from the corresponding DCS Request frame.

The Operating Class and Channel Number fields together specify the channel frequency and channel bandwidth for which the DCS procedure applies. Valid values of the Operating Class field are shown in Annex E.

The New Channel Number field is set to the channel number copied from the corresponding received DCS Request frame.

The Channel Switch Count field either is set to the number of TBTTs until the DCS responder AP or PCP sending the Channel Switch Announcement frame or element within its BSS switches to the new channel or is set to 0. It is set to 1 to indicate that the switch occurs immediately before the next TBTT. It is set to 0 to indicate that the switch occurs at any time after the frame containing the element is transmitted.

9.6.8.41 Extended Notification Period Request frame format

The format of the Extended Notification Period Request frame Action field is shown in Table 9-325j.

Table 9-325j—Extended Notification Period Request frame Action field format

Order	Information
0	Category
1	Public Action
2	Dialog Token
3	NP/BHI Duration

The Category field is defined in 9.4.1.11.

The Public Action field is defined in 9.6.29.4.

The Dialog Token field is defined in 9.4.1.12 and set by the requesting STA.

The NP/BHI Duration field is set to the length of the NP/BHI duration requested by the STA intending to establish its BSS on a free 1.08 GHz channel to the peer STA operating on the adjacent 1.08 GHz channel. The length of this field is 2 octets.

9.6.8.42 Extended Notification Period Response frame format

The format of the Extended Notification Period Response frame Action field is shown in Table 9-325k.

Table 9-325k—Extended Notification Period Response frame Action field format

Order	Information
0	Category
1	Public Action
2	Dialog Token
3	Status Code
4	Dynamic Bandwidth Control element

The Category field is defined in 9.4.1.11.

The Public Action field is defined in 9.6.8.1.

The Dialog Token field is copied from the corresponding Extended Notification Period Response frame.

The NP/BHI Duration field is set to the length of the NP/BHI duration requested by the STA intending to establish its BSS on a free 1.08 GHz channel to the peer STA operating on the adjacent 1.08 GHz channel. The length of this field is 2 octets.

9.6.8.43 Extended Channel Splitting Request frame format

The format of the Extended Channel Splitting Request frame Action field is shown in Table 9-325l.

Table 9-325l—Extended Channel Splitting Request frame Action field format

Order	Information
0	Category
1	Public Action
2	Dialog Token
3	NP/BHI Duration

The Category field is defined in 9.4.1.11.

The Public Action field is defined in 9.6.29.4.

The Dialog Token field is defined in 9.4.1.12 and set by the requesting STA.

The NP/BHI Duration field is set to the length of the NP/BHI duration requested by the STA intending to establish its BSS on a free 1.08 GHz channel to the peer STA operating on the adjacent 1.08 GHz channel. The length of this field is 2 octets.

9.6.8.44 Extended Channel Splitting Response frame format

The format of the Extended Channel Splitting Response frame Action field is shown in Table 9-325m.

Table 9-325m—Extended Channel Splitting Response frame Action field format

Order	Information
0	Category
1	Public Action
2	Dialog Token
3	Status Code
4	Channel Switch Announcement
5	Beacon Interval
6	Dynamic Bandwidth Control

The Category field is defined in 9.4.1.11.

The Public Action field is defined in 9.6.8.1.

The Dialog Token field is copied from the corresponding Extended Channel Splitting Response frame.

The Status Code field indicates the result of the notification period allocation request and is defined in 9.4.1.9.

The Channel Switch Announcement element is defined in 9.4.2.19. This element is present if the Status Code field indicates successful; otherwise, it is not present.

The Beacon Interval field specifies the beacon interval length on a 2.16 GHz channel set by the STA operating on one of the 1.08 GHz channel after channel splitting and is defined in 9.4.1.3. This field is present if the Status Code field indicates successful; otherwise, it is not present.

The Dynamic Bandwidth Control element specifies the information of the STA operating on a 1.08 GHz channel after channel splitting and is defined in 9.4.2.218. This element is present if the Status Code field indicates successful; otherwise, it is not present.

9.6.22 Unprotected DMG Action frame details

9.6.22.2 Announce frame format

Insert the following rows into Table 9-416 in numeric order:

Table 9-416—Announce frame Action field format

Order	Information
23	Cluster Probe
24	Extended Cluster Report
25	Cluster Switch Announcement

9.6.22.3 BRP frame format

Insert the following rows into Table 9-417 in numeric order:

Table 9-417—BRP frame Action field format

Order	Information
7	Enhanced Beam Tracking element
8	SSW Report element

Insert the following two paragraphs at the end of 9.6.22.3:

The Enhanced Beam Tracking element is defined in 9.4.2.224.

The SSW Report element is defined in 9.4.2.220.

Insert the following subclauses, 9.6.29 and 9.6.30 (including Table 9-421z through Table 9-421af and Figure 9-740e through Figure 9-740g), after 9.6.28.3:

9.6.29 CDMG Action frame details

9.6.29.1 CDMG Action field

Several Action frame formats are defined to support CDMG features. A CDMG Action field, in the octet immediately after the Category field, differentiates the CDMG Action frame formats. The CDMG Action field values associated with each frame format within the CDMG category are defined in Table 9-421z.

Table 9-421z—CDMG Action field values

CDMG Action field value	Meaning
0	Notification Period Request frame
1	Notification Period Response frame
2	Channel Splitting Request frame
3	Channel Splitting Response frame
4	CDMG Allocation Request frame
5	CDMG Allocation Response frame

9.6.29.2 Notification Period Request frame format

The format of the Notification Period Request frame Action field is shown in Figure 9-740e.

	Category	CDMG Action	Dialog Token	NP/BHI Duration
Octets:	1	1	1	2

Figure 9-740e—Notification Period Request frame Action field format

The Category field is defined in 9.4.1.11.

The CDMG Action field is defined in 9.6.29.1.

The Dialog Token field is defined in 9.4.1.12 and set by the requesting STA.

The NP/BHI Duration field is set to the length of the NP/BHI duration requested by the STA intending to establish its BSS on a free 1.08 GHz channel to the peer STA operating on the adjacent 1.08 GHz channel.

9.6.29.3 Notification Period Response frame format

The format of the Notification Period Response frame Action field is shown in Table 9-421aa.

Table 9-421aa—Notification Period Response frame Action field format

Order	Information
0	Category
1	CDMG Action
2	Dialog Token
3	Status Code
4	Dynamic Bandwidth Control element

The Category field is defined in 9.4.1.11.

The CDMG Action field is defined in 9.6.29.1.

The Dialog Token field is copied from the corresponding Notification Period Request frame.

The Status Code field indicates the result of the notification period allocation request and is defined in 9.4.1.9.

The Dynamic Bandwidth Control element is defined in 9.4.2.218. This element is present if the Status Code field indicates successful; otherwise, it is not present.

9.6.29.4 Channel Splitting Request frame format

The format of the Channel Splitting Request frame Action field is shown in Figure 9-740f.

	Category	CDMG Action	Dialog Token	NP/BHI Duration
Octets:	1	1	1	2

Figure 9-740f—Channel Splitting Request frame Action field format

The Category field is defined in 9.4.1.11.

The CDMG Action field is defined in 9.6.29.1.

The Dialog Token field is defined in 9.4.1.12 and set by the requesting STA.

The NP/BHI Duration field is set to the length of the NP/BHI duration requested by the STA intending to establish its BSS on a free 1.08 GHz channel to the peer STA operating on the adjacent 1.08 GHz channel.

9.6.29.5 Channel Splitting Response frame format

The format of the Channel Splitting Response frame Action field is shown in Table 9-421ab.

Table 9-421ab—Channel Splitting Response frame Action field format

Order	Information
0	Category
1	CDMG Action
2	Dialog Token
3	Status Code
4	Channel Switch Announcement
5	Beacon Interval
6	Dynamic Bandwidth Control

The Category field is defined in 9.4.1.11.

The CDMG Action field is defined in 9.6.29.1.

The Dialog Token field is copied from the corresponding Channel Splitting Request frame.

The Status Code field indicates the result of the channel splitting request and is defined in 9.4.1.9.

The Channel Switch Announcement element is defined in 9.4.2.18. This element is present if the Status Code field indicates successful; otherwise, it is not present.

The Beacon Interval field specifies the beacon interval length on a 2.16 GHz channel set by the STA operating on one of the 1.08 GHz channel after channel splitting and is defined in 9.4.1.3. This element is present if the Status Code field indicates successful; otherwise, it is not present.

The Dynamic Bandwidth Control element specifies the information of the STA operating on a 1.08 GHz channel after channel splitting and is defined in 9.4.2.218. This element is present if the Status Code field indicates successful; otherwise, it is not present.

9.6.29.6 CDMG Allocation Request frame format

The format of the CDMG Allocation Request frame Action field is shown in Figure 9-740g.

	Category	CDMG Action	Dialog Token
Octets:	1	1	1

Figure 9-740g—CDMG Allocation Request frame Action field format

The Category field is defined in 9.4.1.11.

The CDMG Action field is defined in 9.6.29.1.

The Dialog Token field is defined in 9.4.1.12 and set by the requesting STA.

9.6.29.7 CDMG Allocation Response frame format

The format of the CDMG Allocation Response frame Action field is shown in Table 9-421ac.

Table 9-421ac—CDMG Allocation Response frame Action field format

Order	Information
0	Category
1	CDMG Action
2	Dialog Token
3	Status Code
4	Extended Schedule

The Category field is defined in 9.4.1.11.

The CDMG Action field is defined in 9.6.29.1.

The Dialog Token field is copied from the corresponding CDMG Allocation Request frame.

The Status Code field indicates the result of the Allocation request and is defined in 9.4.1.9.

The Extended Schedule element indicates all the available time that can be allocated to the DMG STAs on a 2.16 GHz channel by the STA operating on the adjacent 1.08 GHz channel of the STA sending this response and is defined in 9.4.2.132. This element is present if the Status Code field indicates successful; otherwise, it is not present.

9.6.30 CMMG Action frame details

9.6.30.1 CMMG Action field

Several Action frame formats are defined to support CMMG functionality. A CMMG Action field, in the octet immediately after the Category field, differentiates the CMMG Action frame formats. The CMMG Action field values associated with each frame format within the CMMG category are defined in Table 9-421ad.

Table 9-421ad—CMMG Action field values

Value	Meaning	Time priority
0	CMMG CSI	Yes
1	CMMG Compressed Beamforming	Yes
2	Operating Mode Notification frame format	Yes
3–255	Reserved	

9.6.30.2 CMMG Compressed Beamforming frame format

The CMMG Compressed Beamforming frame is an Action or an Action No Ack frame of category CMMG. The format of its Action field is defined in Table 9-421ae.

Table 9-421ae—CMMG Compressed Beamforming frame Action field format

Order	Information
1	Category
2	CMMG Action
3	CMMG MIMO Control (see 9.4.1.61)
4	CMMG Compressed Beamforming Report (see 9.4.1.62)

The Category field is defined in 9.4.1.11.

The CMMG Action field is defined in 9.6.30.1.

The CMMG MIMO Control field (see 9.4.1.61) are used as described in Table 9-76c.

The CMMG Compressed Beamforming Report field is defined in 9.4.1.62.

9.6.30.3 Operating Mode Notification frame format

The Operating Mode Notification frame is an Action frame of category CMMG. It is used to notify STAs that the transmitting STA is changing its operating channel width, the maximum number of spatial streams it can receive, or both.

The Action field of the Operating Mode Notification frame contains the information shown in Table 9-421af.

Table 9-421af— Operating Mode Notification frame Action field format

Order	Information
1	Category
2	CMMG Action
3	CMMG Operating Mode (see 9.4.1.63)

The Category field is defined in 9.4.1.11.

The CMMG Action field is defined in 9.6.30.1.

The CMMG Operating Mode field is defined in 9.4.1.63.

10. MAC sublayer functional description

10.2 MAC architecture

10.2.1 General

Change the first paragraph as follows:

The MAC architecture is shown in Figure 10-1, Figure 10-1a, ~~and~~ Figure 10-2, and Figure 10-2a.

Change the title of Figure 10-1 as follows:

Figure 10-1—Non-DMG non-CMMG non-S1G STA MAC architecture

Insert the following figure, Figure 10-2a, after Figure 10-2:

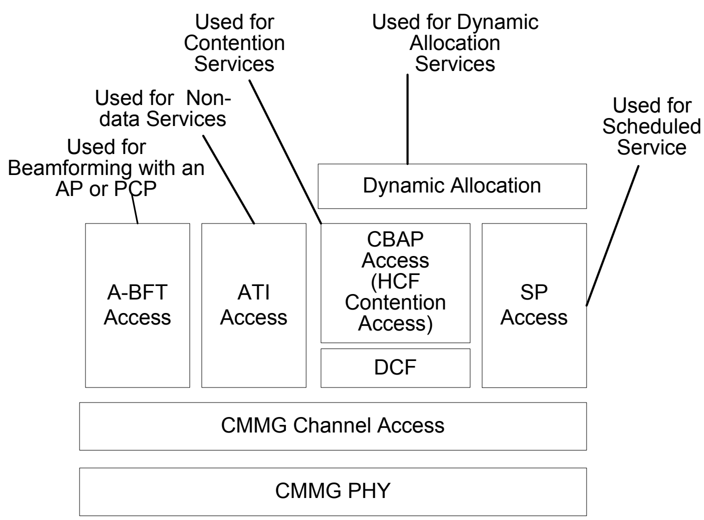


Figure 10-2a—CMMG STA MAC architecture

Change the second paragraph of 10.2.1 as follows (the dashed list remains unchanged:

In a non-DMG non-CMMG ~~and~~ non-S1G STA:

Insert the following paragraph at the end of 10.2.1:

In a CMMG STA:

- — The MAC provides services using the CMMG channel access mechanisms.
- — Specific rules apply for access during scheduled periods, which include the association beamforming training (A-BFT) period, announcement transmission interval (ATI), contention based access period (CBAP), and service period (SP).
- — The DCF is used during contention based access periods.
- — Dynamic allocation (10.36.7) is built on service period and contention based access period.

10.3 DCF

10.3.2 Procedures common to the DCF and EDCAF

Insert the following subclause, 10.3.2.6a, after 10.3.2.6:

10.3.2.6a CMMG RTS procedure

A CMMG STA shall transmit an RTS frame carried in CMMG or CMMG duplicate format (see 25.3.10). If the STA sending the RTS frame is capable of dynamic bandwidth operation (see 10.3.2.7), the CMMG STA shall set the TXVECTOR parameter DYN_BANDWIDTH to Dynamic. Otherwise, the STA shall set the TXVECTOR parameter DYN_BANDWIDTH to Static.

10.3.2.7 CTS and DMG CTS procedure

Insert the following paragraphs at the end of 10.3.2.7:

A CMMG STA that has received an RTS frame in a CMMG or CMMG duplicate PPDU that has the RXVECTOR parameter DYN_BANDWIDTH equal to Static behaves as follows:

- If the NAV indicates idle and CCA has been idle for the secondary channel (secondary 540 MHz channel) in the channel width indicated by the RTS frame's RXVECTOR parameter CH_BANDWIDTH for a PIFS period prior to the start of the RTS frame, then the STA shall respond with a CTS frame carried in a CMMG or CMMG duplicate PPDU after a SIFS. The CTS frame's TXVECTOR parameters CH_BANDWIDTH shall be set to the same value as the RTS frame's RXVECTOR parameter CH_BANDWIDTH.
- Otherwise, the STA shall not respond with a CTS frame.

A CMMG STA that is addressed by an RTS frame in a CMMG or CMMG duplicate PPDU that has the RXVECTOR parameter DYN_BANDWIDTH equal to Dynamic behaves as follows:

- If the NAV indicates idle, then the STA shall respond with a CTS frame in a CMMG or CMMG duplicate PPDU after a SIFS. The CTS frame's TXVECTOR parameters CH_BANDWIDTH may be set to any channel width for which CCA has been idle for a PIFS prior to the start of the RTS frame and that is equal to or less than the channel width indicated in the RTS frame's RXVECTOR parameter indicated in the RTS frame's RXVECTOR parameter CH_BANDWIDTH.
- Otherwise, the STA shall not respond with a CTS frame.

10.3.4 DCF access procedure

10.3.4.4 Recovery procedures and retransmit limits

Insert the following paragraph at the end of 10.3.4.4:

A CMMG AP that fails to receive an acknowledgment after the AP transmits a frame with the More Data field set to 0 to a non-AP CMMG STA in CMMG TXOP power save mode, may retransmit the frame within the current TXOP under certain conditions as described in 11.2.3.21.

10.7 Multirate support

10.7.1 Overview

Change the fourth paragraph in 10.7.1 as follows:

Otherwise, a non-DMG and non-CMMG STA shall transmit the frame using a rate that is in accordance with rules defined in 10.7.5 and 10.7.6. A DMG STA shall transmit the frame using a rate that is in accordance with rules defined in 10.7.7. A CMMG STA shall transmit the frame using a rate that is in accordance with rules defined in 10.7.7a.

Insert the following items at the end of the dashed list of the fifth paragraph of 10.7.1:

- Clause 24 for CDMG
- Clause 25 for CMMG

Insert the following items at the end of the dashed list of the sixth paragraph of 10.7.1:

- 25.14.3 for CMMG PLME TXTIME calculation

Insert the following subclause, 10.7.7a, after 10.7.7.5:

10.7.7a Multirate support for CMMG STAs

10.7.7a.1 Usage of CMMG Control modulation class

The CMMG Control modulation class has only one MCS, which is CMMG MCS 0 defined in 25.6.8.14. The DMG Beacon, SSW-Feedback, SSW-Ack, RTS, CTS, and first BRP packet in beam refinement shall be transmitted using the CMMG Control modulation class. In the case of an RXSS that was specified through the Beamforming Control field in which the RXSSTxRate subfield is 1 and the RXSSTxRate Supported field in the CMMG Capabilities element of the STA performing the RXSS is 1, the first SSW frame of the RXSS shall be transmitted using the CMMG Control modulation class, and the remaining frames of the RXSS shall be transmitted using MCS 0 of the CMMG SC modulation class. In all other cases, the SSW frames shall be transmitted using the CMMG Control modulation class. Other CMMG beamforming training frames may be transmitted using the CMMG Control modulation class or the CMMG SC modulation class.

10.7.7a.2 Rate selection rules for Control frames transmitted by CMMG STAs

This subclause describes the rate selection rules for Control frames transmitted by CMMG STAs. The rate selection rules apply only for MCSs defined in Clause 25.

A Control frame that does not have an MCS defined in 10.7.7a.1 and that is not a control response frame shall be transmitted using an MCS from the mandatory MCS set of the CMMG SC modulation class or CMMG Control modulation class.

A STA transmitting a Grant Ack frame shall use the CMMG Control modulation class or any MCS from the mandatory MCS set of the CMMG SC modulation class.

A STA transmitting an Ack or a BlockAck frame that is a response to a frame sent using the CMMG Control modulation class shall use the CMMG Control modulation class.

A STA transmitting an Ack frame or a BlockAck frame in response to a frame sent using the CMMG SC modulation class or CMMG OFDM modulation class shall use an MCS from the mandatory MCS set of the CMMG SC modulation class as long as (a) the selected MCS has a data rate that does not exceed the data rate of the frame that elicited the response, (b) no other MCS satisfying condition (a) results in a shorter frame transmission time.

NOTE—A control response frame is a Control frame that is transmitted within an MPDU as a response to a reception SIFS after the PPDU containing the frame that elicits the response, e.g., a CTS frame in response to an RTS frame reception, an Ack frame in response to a Data frame reception, a BlockAck frame in response to a BlockAckReq frame reception. In some situations, the transmission of some of these Control frames is not a control response transmission, such as when a DMG CTS frame is used to initiate a TXOP.

Except in an A-MPDU consisting of one of the combinations listed below, the rules in this subclause do not apply to Control frames that are contained in A-MPDUs that also include at least one MPDU with the Type subfield equal to Data or Management. In the following cases, the rate selection rules are the same as those for a standalone Ack or BlockAck frame:

— An Ack frame and a QoS Null frame
— A BlockAck frame and a QoS Null frame
— A BlockAckReq frame and a QoS Null frame
— A BlockAck frame, a BlockAckReq frame, and a QoS Null frame

10.7.7a.3 Rate selection for group addressed Data and Management frames transmitted by CMMG STAs

This subclause describes the rate selection rules for group addressed Data and Management frames transmitted by CMMG STAs. The rate selection rules apply only for MCSs defined in Clause 25.

If the transmit antenna pattern of a single transmission of a group addressed frame covers more than one receiver and the supported set of each of the receivers is known to the sender, then the MCS used for the transmission shall be an MCS common to the supported MCS sets of all of the receivers. If such an MCS is not known, the frame shall be transmitted using an MCS from the mandatory MCS set of the CMMG control or SC mode.

If the transmit antenna pattern of a single transmission of a group addressed frame covers only one receiver, the frame shall be transmitted following the rate selection rules of individually addressed frames as described in 10.7.7a.4.

For SC and OFDM MIMO transmission, if the BSSBasicRateSet parameter is empty, the BSSBasicMCSSet parameter is empty, and the BSS basic CMMG MCS and NSS set is not empty, then the frame shall be transmitted in a CMMG PPDU using one of the <CMMG MCS, NSS> tuples included in the BSS basic CMMG MCS and NSS set.

10.7.7a.4 Rate selection for individually addressed Data and Management frames transmitted by CMMG STAs

This subclause describes the rate selection rules for individually addressed Data and Management frames as transmitted by CMMG STAs. The rate selection rules apply only for MCSs defined in Clause 25.

An individually addressed Data or Management frame shall be sent using an MCS supported by the receiver STA, as reported in the maximum receive MCS subfields in the Supported MCS Set field in Management frames transmitted by the receiver STA.

When the supported MCS set of the receiving STA is not known, the transmitting STA shall transmit using an MCS from the mandatory MCS set of the CMMG control or SC mode.

The rules in this subclause also apply to A-MPDUs that contain at least one MPDU with Type subfield equal to Control and at least one MPDU with Type subfield equal to Data or Management.

A Data frame or Management frame for SC and OFDM MIMO transmission shall be sent using any data rate, MCS, or <CMMG MCS, NSS> tuple subject to the following constraints:

- A STA shall not transmit a frame using a rate or MCS that is not supported by the receiver STA or STAs, as reported in any Supported Rates element, Extended Supported Rates element, or Supported MCS Set field in the Management frames transmitted by the receiver STA.
- A STA shall not transmit a frame using a <CMMG MCS, NSS> tuple that is not supported by the receiver STA, as reported in any Supported CMMG MCS and NSS Set field in the Management frames transmitted by the receiver STA.
- If at least one Operating Mode field with the Rx NSS Type subfield equal to 0 was received from the receiver STA:
  - A STA shall not transmit a frame with the number of spatial streams greater than that indicated in the Rx NSS subfield in the most recently received Operating Mode field with the Rx NSS Type subfield equal to 0 from the receiver STA.
- A STA shall not transmit a frame using a value for the CH_BANDWIDTH parameter of the TXVECTOR that is not supported by the receiver STA, as reported in any CMMG Capabilities element or CMMG Capabilities element received from the intended receiver.
- A STA that is a member of a BSS and that is not a CMMG STA shall not transmit a frame using a value for the CH_BANDWIDTH parameter of the TXVECTOR that is not permitted for use in the BSS, as reported in the most recently received CMMG Operation element with the exception transmissions on a TDLS off-channel link, which follow the rules described in 11.22.
- A CMMG STA that is a member of a BSS shall not transmit a frame using a value for the CH_BANDWIDTH parameter of the TXVECTOR that is not permitted for use in the BSS, as reported in the most recently received CMMG Operation element with the following exceptions:
  - Transmissions on a TDLS off-channel link follow the rules described in 11.22.
  - Transmissions by a CMMG STA on a TDLS link follow the rules described in 11.22.
- If at least one Operating Mode field with the Rx NSS Type subfield equal to 0 was received from the receiver STA:
  - A STA shall not transmit a frame using a value for the TXVECTOR parameter CH_BANDWIDTH that is not supported by the receiver STA as reported in the most recently received Operating Mode field with the Rx NSS Type subfield equal to 0 from the receiver STA.
- A STA shall not initiate transmission of a frame at a data rate higher than the greatest rate in the OperationalRateSet, or using an MCS that is not in the CMMG OperationalMCSset, or using a <CMMG MCS, NSS> tuple that is not in the OperationalCMMGMCS_NSSSet, which are parameters of the MLME-JOIN.request primitive.

When the supported rate set of the receiving STA or STAs is not known, the transmitting STA shall transmit using a rate in the BSSBasicRateSet parameter, or an MCS in the BSSBasicMCSSet parameter, or a <CMMG MCS, NSS> tuple in the BSS basic CMMG MCS and NSS set, or a rate from the mandatory rate set of the attached PHY if the BSSBasicRateSet, the BSSBasicMCSSet, and the BSS basic CMMG MCS and NSS set are empty.

The rules in this subclause also apply to A-MPDUs that aggregate MPDUs of type Data or Management with any other types of MPDU.

10.7.7a.5 Rate selection for BRP packets for CMMG STAs

The first BRP packet transmitted from the initiator to the responder after the SLS phase shall use MCS 0.

The first BRP packet transmitted from the responder to the initiator after the SLS phase shall use MCS 0.

BRP packets transmitted during beam refinement should use MCS 0 and shall not use any MCS greater than MCS 8. BRP packets transmitted during beam refinement should use MCS 0 if the BRP packet is sent at start of an SP as defined in 10.36.6.2.

BRP packets transmitted during the BRP setup subphase, the MID subphase, and the BC subphase shall use MCS 0.

BRP packets transmitted during a BC subphase, as part of a BC subphase only training, may use MCS 0 to MCS 8. BRP packets transmitted during beam tracking may use any MCS.

10.7.9 Modulation classes

Change the second column heading of Table 10-6 as shown, and insert the following rows at the end of the table:

Table 10-6—Modulation classes

Description of modulation	Condition that selects this modulation class		
	Clause 15 to Clause 18 PHYs, or Clause 20, <u>or Clause 24, or Clause 25 PHY</u>	Clause 19 PHY	Clause 21 PHY
CDMG Control	Clause 24 transmission and MCS is 0	N/A	N/A
CDMG SC	Clause 24 transmission and $1 \le \text{MCS} \le 16$	N/A	N/A
CDMG Low-power SC	Clause 24 transmission and $17 \le \text{MCS} \le 23$	N/A	N/A
CMMG Control	Clause 25 transmission and MCS is 0	N/A	N/A
CMMG SC	Clause 25 transmission and $1 \le \text{MCS} \le 8$	N/A	N/A
CMMG OFDM	Clause 25 transmission and $9 \le \text{MCS} \le 16$	N/A	N/A

Insert the following subclause, 10.7.14, after 10.7.13.3:

10.7.14 Rate selection constraints for CMMG STAs

10.7.14.1 Rx supported CMMG MCS and NSS set

The Rx supported CMMG MCS and NSS set of a CMMG STA is determined for each <CMMG MCS, NSS> tuple NSS = 1,…, 4 and bandwidth (540 MHz and 1080 MHz) from its Supported CMMG MCS and NSS Set field as follows:

— If support for the CMMG MCS for NSS spatial streams at that bandwidth is mandatory (see 25.15), then the <CMMG MCS, NSS> tuple at that bandwidth is supported by the STA on receive.

— Otherwise, the <CMMG MCS, NSS> tuple at that bandwidth is not supported by the STA on receive.

A CMMG STA shall not, unless explicitly stated otherwise, transmit a CMMG PPDU unless the <CMMG MCS, NSS> tuple and bandwidth used are in the Rx Supported CMMG MCS and NSS Set of the receiving STA(s).

10.7.14.2Tx supported CMMG MCS and NSS set

The Tx supported CMMG MCS and NSS set of a CMMG STA is determined for each <CMMG MCS, NSS> tuple NSS = 1,…, 4 and bandwidth (540 MHz and 1080 MHz) from its Supported CMMG MCS and NSS Set field as follows:

— If support for the <CMMG MCS, NSS> tuple at that bandwidth is mandatory (see 25.15), then the <CMMG MCS, NSS> tuple at that bandwidth is supported by the STA on transmit.

— Otherwise, the <CMMG MCS, NSS> tuple at that bandwidth is not supported by the STA on transmit.

Insert the following subclause, 10.9a, after 10.9:

10.9a CMMG Control field operation

If the CMMG Control field is present in an MPDU aggregated in an A-MPDU, then all MPDUs of the same frame type (i.e., having the same value for the Type subfield of the Frame Control field) aggregated in the same A-MPDU shall contain a CMMG Control field. The CMMG Control field of all MPDUs containing the CMMG Control field aggregated in the same A-MPDU shall be set to the same value.

10.12 A-MSDU operation

Change the now 16th paragraph of 10.12 as follows:

A STA shall support the reception of an A-MSDU, where the A-MSDU is carried in a QoS Data frame with Ack Policy equal to Normal Ack in the following cases:

— For an HT STA if the A-MSDU is not aggregated within an A-MPDU

— For a VHT STA if the A-MSDU is sent as a VHT single MPDU

— For a CMMG STA if the A-MSDU is not aggregated within an A-MPDU

Change the now 21st and 22nd paragraphs of 10.12 as follows:

A VHT STA shall not transmit an A-MSDU that includes a number of MSDUs greater than the value indicated by the Max Number Of MSDUs In A-MSDU field in any Extended Capabilities element sent by the recipient STA. An HT STA should not transmit an A-MSDU that includes a number of MSDUs greater than the value indicated by the Max Number Of MSDUs In A-MSDU field in any Extended Capabilities element sent by the recipient STA. A STA shall not transmit an A-MSDU in a CMMG PPDU to a STA if the A-MSDU length exceeds the value indicated by the Maximum A-MSDU Length field of the CMMG Capabilities element received from the recipient STA.

A DMG STA shall not transmit an A-MSDU that includes a number of Basic A-MSDU subframes greater than the value indicated by the Maximum Number Of Basic A-MSDU Subframes In A-MSDU subfield in any DMG Capabilities element sent by the recipient STA. A DMG STA shall not transmit an A-MSDU that includes a number of Short A-MSDU subframes greater than the value indicated by the Maximum Number Of Short A-MSDU Subframes In A-MSDU subfield in any DMG Capabilities element sent by the recipient

STA. A DMG STA that sets the A-MSDU Subframe subfield to 1 in a DMG Attributes field of TSPEC element (9.4.2.30), which indicates Short A-MSDU subframe support, shall be capable of receiving at least 32 Short A-MSDU subframes in A-MSDU. A CMMG STA that sets the Maximum MPDU Length subfield in the CMMG Capabilities element to indicate 3895 octets shall set the maximum A-MSDU length in the CMMG Capabilities element to indicate 3839 octets. A CMMG STA that sets the Maximum MPDU Length subfield in the CMMG Capabilities element to indicate 7991 octets or 11 454 octets shall set the maximum A-MSDU length in the CMMG Capabilities element to indicate 7935 octets.

Insert the following two paragraphs at the end of 10.12:

The length of an A-MSDU transmitted in a CMMG PPDU is limited by the maximum MPDU size supported by the recipient STA (see 10.13.5).

A CMMG STA shall not transmit to a recipient CMMG STA an A-MSDU that includes a number of MSDUs greater than the value indicated by the Max Number of MSDUs in A-MSDU field in the Extended Capabilities element received from the recipient STA.

10.14 PPDU duration constraint

Insert the following paragraph after the second paragraph ("A STA shall not transmit a DMG PPDU ....") of 10.14:

A CMMG STA shall not transmit a PPDU that has a duration (as determined by the PHY-TXTIME.confirm primitive defined in 6.5.8) that is greater than aPPDUMaxTime.

10.17 STBC operation

Insert the following paragraphs at the end of 10.17:

A STA that has not set the Tx STBC subfield to 1 in the CMMG Capabilities element shall not transmit CMMG PPDUs with a TXVECTOR parameter STBC set to a nonzero value.

A STA shall not send a CMMG PPDU with the TXVECTOR parameter STBC set to a nonzero value to a recipient STA unless the recipient STA has indicated in the Rx STBC field of its CMMG Capabilities element that it supports the reception of PPDUs using STBC with a number of spatial streams equal to or greater than the number of spatial streams in the CMMG PPDU.

Change the title of 10.20 as follows:

10.20 Group ID and partial AID in VHT and CMMG PPDUs

Change the first paragraph of 10.20 as follows:

The partial AID is a nonunique STA identifier defined in Table 10-9 and in Table 10-9a. The partial AID is carried in the TXVECTOR parameter PARTIAL_AID of a VHT SU PPDU or a CMMG PPDU and is limited to 9 bits.

Insert the following paragraph after the second paragraph of 10.20:

A STA transmitting a CMMG PPDU carrying one or more group addressed MPDUs shall set the TXVECTOR parameters PARTIAL_AID to 0.

Change the title of Table 10-9 as follows:

Table 10-9—Settings for the TXVECTOR parameters GROUP_ID and PARTIAL_AID for VHT STAs

Insert the following paragraph and Table 10-9a after Table 10-9:

A STA transmitting a CMMG PPDU carrying one or more individually addressed MPDUs shall set the TXVECTOR parameter PARTIAL_AID as shown in Table 10-9a.

Table 10-9a—Settings for the TXVECTOR parameter PARTIAL_AID for CMMG STAs

Condition	PARTIAL_AID
A frame that is not a Control frame that is addressed to an AP.	$(dec(\text{BSSID}[39:47])\bmod(2^9-1))+1$
A frame that is not a Control frame that is addressed to an AP.	$(dec(\text{RA}[39:47])\bmod(2^9-1))+1$
A frame that is not a Control frame that is sent by an AP and addressed to a STA associated with that AP or sent by a DLS or TDLS STA in a direct path to a DLS or TDLS peer STA.	$(dec(AID[0:8]) + dec(\text{BSSID}[44:47] \oplus \text{BSSID}[40:43]) \times 2^5)\bmod 2^6$ (10-12a) where *dec*(A[b:c]) is the cast to decimal operator where *b* is scaled by 2^0 and *c* by 2^{c-b}
Otherwise (see NOTE)	0
NOTE—The last row covers the following cases: — A PPDU sent to an IBSS STA — A PPDU sent by an AP to a non associated STA — Any other condition not explicitly listed elsewhere in the table	

Change the now sixth paragraph of 10.20 as follows:

In Table 10-9 and Table 10-9a, BSSID[*b*:*c*] and RA[*b*:*c*] represent bits *b* to *c* inclusive of the BSSID and RA, respectively, with bit 0 being the Individual/Group bit and bit 47 being the last transmitted bit, in which bit position *b* is then scaled by 2^0 and *c* by 2^{c-b}.

Change the now eighth paragraph of 10.20 as follows:

A STA that transmits a VHT or CMMG PPDU to a DLS or TDLS peer STA obtains the AID for the peer STA from the DLS Setup Request, DLS Setup Response, TDLS Setup Request, or TDLS Setup Response frame.

Change the now ninth paragraph of 10.20 as follows:

A VHT AP should not assign an AID to a VHT STA that results in a 0 value PARTIAL_AID (as computed using Equation (10-12)). A CMMG AP should not assign to a CMMG STA an AID that results in the PARTIAL_AID value, as computed using Equation (10-12a), being equal to either

0 or $(dec(\text{BSSID}[39:47])\bmod(2^9-1))+1$ or $(dec(\text{OBSSID}[39:47])\bmod(2^9-1))+1$

where OBSSID is the BSSID of a BSS that is not the BSS of which the AP is a member and for which the AP might be heard by the STA being assigned the AID.

Insert the following paragraphs at the end of 10.20:

As an example of the PARTIAL_AID setting, consider the case of a BSS with BSSID 00-21-6A-AC-53-52 that has as a member a non-AP CMMG STA assigned AID 5. In CMMG PPDUs sent to an AP, the PARTIAL_AID is set to 165. In CMMG PPDUs sent by the AP to the non-AP STA associated with that AP, the PARTIAL_AID is set to 37.

NOTE 1—In the example above, BSSID[47:40] = 0x52, that is, BSSID[47] = 0, BSSID[46] = 1, BSSID[45] = 0, BSSID[44] = 1, etc.

NOTE 2—As described in IEEE Std 802-2001, the use of hyphens for the BSSID indicates hexadecimal representation rather than bit-reversed representation such that the leftmost octet in the representation is the first transmitted octet for 802.11. Using the BSSID vector numbering described above, the BSSID in IEEE Std 802-2001 hexadecimal representation is BSSID[7:0]-BSSID[15:8]- BSSID[23:16]-BSSID[31:24]- BSSID[39:32]-BSSID[47:40].

A STA transmitting a CMMG PPDU that is addressed to an AP shall set the TXVECTOR parameter UPLINK_INDICATION to 1. The UPLINK_INDICATION parameter shall be set to 0 for all other cases.

The TXVECTOR parameter COLOR is used to assist a receiving STA in identifying the BSS from which a reception originates so that the receiving STA might increase spatial reuse and reduce power consumption by terminating the reception process in the case when the reception is not from the BSS with which the STA is associated. A STA transmitting a CMMG PPDU that is addressed to an AP need not include the TXVECTOR parameter COLOR in the TXVECTOR. A STA transmitting a CMMG PPDU that is not an NDP frame and that is sent by a DLS or TDLS STA in a direct path to a DLS or TDLS peer STA shall set the TXVECTOR parameter COLOR to the value of the COLOR parameter, if present, from the RXVECTOR of the most recently received frame from its associated AP or from the DO of the IBSS of which it is a member that contained a COLOR parameter. An AP transmitting a CMMG PPDU shall set the TXVECTOR parameter COLOR to a value of its choosing within the range 0 to 7 and shall maintain that value for the duration of the existence of the BSS. The AP which is a member of a Multiple BSSID Set shall set the TXVECTOR parameter COLOR for each different BSSID(i) to a same value.

An AP shall include the value within the range 0 to 7 that it is using for the TXVECTOR parameter COLOR in the COLOR field of the CMMG Capabilities Info field of the CMMG Capabilities element in all frames that contain that element. The COLOR field of the CMMG Capabilities Info field of the CMMG Capabilities element in all frames transmitted from a non-AP STA is reserved.

10.22 HCF

10.22.2 HCF contention based channel access (EDCA)

10.22.2.4 Obtaining an EDCA TXOP

Change the last paragraph of 10.22.2.4 as follows:

A STA shall save the TXOP holder address for the BSS in which it is associated, which is the MAC address from the Address 2 field of the frame that initiated a frame exchange sequence except when this is a CTS frame, in which case the TXOP holder address is the Address 1 field. If the TXOP holder address is obtained from a Control frame, a VHT STA shall save the nonbandwidth signaling TA value obtained from the Address 2 field. If a non-VHT STA receives an RTS frame with the RA address matching the MAC address of the STA and the MAC address in the TA field in the RTS frame matches the saved TXOP holder address, then the STA shall send the CTS frame after SIFS, without regard for, and without resetting, its NAV. If a VHT STA receives an RTS frame with the RA address matching the MAC address of the STA and the nonbandwidth signaling TA value obtained from the Address 2 field in the RTS frame matches the saved TXOP holder address, then the STA shall send the CTS frame after SIFS, without regard for, and without resetting, its NAV. If a CMMG STA receives an RTS frame with the RA address matching the MAC address of the STA and the TA value obtained from the Address 2 field in the RTS frame matches the saved TXOP holder address, then the STA shall send the CTS frame after SIFS, without regarding for, and without resetting its NAV. When a STA receives a frame addressed to it that requires an immediate response, except for RTS frames, it shall transmit the response independent of its NAV. The saved TXOP holder address shall be cleared when the NAV is reset or when the NAV counts down to 0.

10.22.2.7 Multiple frame transmission in an EDCA TXOP

Change the second paragraph of 10.22.2.7 as follows:

Multiple frames may be transmitted in an EDCA TXOP that was acquired following the rules in 10.22.2.4 if there is more than one frame pending in the primary AC for which the channel has been acquired. However, those frames that are pending in other ACs shall not be transmitted in this EDCA TXOP except when sent in a VHT or S1G MU PPDU with TXVECTOR parameter NUM_USERS > 1 and if allowed by the rules in 10.22.2.6. If a TXOP holder has in its transmit queue an additional frame of the primary AC as the duration of transmission of that frame plus any expected acknowledgment for that frame is less than the remaining TXNAV timer value, then the STA TXOP holder may commence transmission of that frame a SIFS (or a RIFS, if the conditions defined in 10.3.2.3.2 are met) after the completion of the immediately preceding frame exchange sequence, subject to the TXOP limit restriction as described in 10.22.2.8. A STA shall not commence the transmission of an RTS frame with a bandwidth signaling TA until at least PIFS time after the immediately preceding frame exchange sequence. A CMMG STA shall not commence the transmission of an RTS frame until at least PIFS time after the immediately preceding frame exchange sequence. An HT STA that is a TXOP holder may transmit multiple MPDUs of the same AC within an A-MPDU as long as the duration of transmission of the A-MPDU plus any expected BlockAck response is less than the remaining TXNAV timer value. An S1G STA that is a TXOP holder may transmit multiple MPDUs of the same AC within an A-MPDU as long as the duration of transmission of the A-MPDU plus any expected (NDP) BlockAck frame response is less than the remaining TXNAV timer value.

NOTE 1—PIFS is used by a VHT STA to perform CCA in the secondary 20 MHz, 40 MHz, and 80 MHz channels before receiving RTS (see 10.3.2).

NOTE 2—An RD responder can transmit multiple MPDUs as described in 10.28.4.

NOTE 3—Within a BDT, STAs can transmit multiple MPDUs as described in 10.46.

NOTE 4—A PIFS interval is required to be present preceding an RTS transmission by a CMMG STA in order to allow a recipient of the RTS to perform CCA in the secondary 540 MHz channels to determine the appropriate response to the RTS.

Insert the following subclause, 10.22.2.12 (including Table 10-12a), after 10.22.2.11.2:

10.22.2.12 EDCA channel access in a CMMG BSS

If the MAC receives a PHY-CCA.indication primitive with the channel-list parameter present, the channels considered idle are defined in Table 10-12a.

Table 10-12a—Channels indicated idle by the channel-list parameter

PHY-CCA.indication channel-list element	Idle channel
Primary	None
Secondary	Primary 540 MHz

In the following description, the CCA is sampled according to the timing relationships defined in 10.3.7. Slot boundaries are determined solely by activity on the primary channel. "Channel idle for an interval of PIFS" means that whenever CCA is sampled during the period of PIFS that ends at the start of transmission, the CCA for that channel was determined to be idle.

If a STA is permitted to begin a TXOP (as defined in 10.22.2.3) and the STA has at least one MSDU pending for transmission for the AC of the permitted TXOP, the STA shall perform exactly one of the following steps:

a) Transmit a 1080 MHz mask PPDU if the secondary 540 MHz channel is idle during an interval of PIFS immediately preceding the start of the TXOP.
b) Transmit a 540 MHz mask PPDU on the primary 540 MHz channel.
c) Restart the channel access attempt by invoking the backoff procedure as specified in 10.22.2 as though the medium is busy on the primary channel as indicated by either physical or virtual CS and the backoff timer has a value of 0.

NOTE 1—In the case of rule c), the STA selects a new random number using the current value of CW[AC], and the retry counters are not updated (as described in 10.22.2.5; backoff procedure invoked for event a)).

NOTE 2—For CMMG STAs, an EDCA TXOP is obtained based on activity on the primary channel (see 10.22.2.3). The width of transmission is determined by the CCA status of the non-primary channels during the PIFS interval before transmission (see 10.22.2.4).

10.30 Sounding PPDUs

Change the first paragraph of 10.30 as follows:

The behavior described in this subclause is specific to the use of the HT variant HT Control field and CMMG Control field.

Change the third paragraph through the fifth paragraph of 10.30 as follows:

A STA transmits sounding PPDUs when it operates in the following roles:

— MFB requester (see 10.31.2 and 10.31.4)
— HT beamformee responding to a training request, calibration initiator, or responder involved in implicit transmit beamforming (see 10.32.2.2, 10.32.2.3, and 10.32.2.4)
— HT beamformer involved in explicit transmit beamforming (see 10.32.3)
— ASEL transmitter and ASEL sounding-capable transmitter involved in ASEL (see 10.33.2)
— CMMG beamformer involved in explicit transmit beamforming (see 10.32.5)

A STA receives sounding PPDUs when it operates in the following roles:

— MFB responder (see 10.31.2 and 10.31.4)
— HT beamformer sending a training request, calibration initiator, or responder involved in implicit transmit beamforming (see 10.32.2.2, 10.32.2.3, and 10.32.2.4)
— HT beamformee involved in explicit transmit beamforming (see 10.32.3)
— Transmit ASEL responder and ASEL receiver involved in ASEL (see 10.33.2)
— CMMG beamformee involved in explicit transmit beamforming (see 10.32.5)

When transmitting a sounding PPDU, the transmitting STA follows the rules stated below to determine the maximum number of space-time streams for which channel coefficients can be simultaneously estimated:

— When transmitting a sounding PPDU that
  — Contains a +HTC frame with the MRQ subfield equal to 1, or

- Is sent as a response to a +HTC frame with the TRQ field equal to 1, or
- Is sent during a calibration sounding exchange, or
- Is sent by an HT beamformer involved in explicit transmit beamforming, or
- Is sent in transmit or receive ASEL exchanges,
- Is sent by a CMMG beamformer involved in explicit transmit beamforming

— Then:

- ...

10.31 Link adaptation

Insert the following subclause, 10.31.4, after 10.31.3:

10.31.4 Link adaptation using the CMMG Control field

The behavior described in this subclause is specific to the CMMG Control field.

A STA that supports link adaptation using the CMMG Control field shall set the CMMG Link Adaptation Capable subfield in the CMMG Capabilities Info field of the CMMG Capabilities element to Unsolicited or Both, depending on its specific link adaptation feedback capability. A STA shall not send an MRQ to STAs that have not set the CMMG Link Adaptation Capable subfield to Both in the CMMG Capabilities Info field of the CMMG Capabilities element. A STA whose most recently transmitted MCS Feedback field of the CMMG Extended capabilities field of the CMMG Capabilities element is equal to Unsolicited or Both may transmit unsolicited MFB in any frame that contains a CMMG Control field.

The MFB requester may set the MRQ field to 1 in the CMMG Control field of a frame to request a STA to provide link adaptation feedback. In each request the MFB requester shall set the MSI/STBC field to a value in the ranges 0 to 6, 0 to 2, or 0 to 3, depending on the settings in the Unsolicited MFB and STBC fields (see 9.2.4.6a). The choice of MSI value is implementation dependent.

NOTE—The MFB requester might use the MSI subfield as an MRQ sequence number, or it might implement any other encoding of the field.

The appearance of more than one instance of a CMMG Control field with the MRQ field equal to 1 within a single PPDU shall be interpreted by the receiver as a single request for link adaptation feedback.

In OFDM transmission the number of MCTFs sent in the sounding PPDU or in the NDP is determined by the total number of spatial dimensions to be sounded, including any extra spatial dimensions beyond those used by the data portion of the frame.

On receipt of a CMMG Control field with the MRQ subfield equal to 1, an MFB responder computes the CMMG-MCS, NUM_STS, and SNR estimates based on the PPDU carrying the MRQ or, in the case of a CMMG with the NDP Announcement subfield set to 1 carrying the MRQ, based on the subsequent CMMG NDP. The MFB responder labels the result of this computation with the MSI value from the CMMG Control field in the received frame carrying the MRQ. The MFB responder may include the received MSI value in the MFSI field of the corresponding response frame. In the case of a delayed response, this allows the MFB requester to associate the MFB with the soliciting MRQ.

An MFB responder that sends a solicited MFB shall set the Unsolicited MFB subfield in CMMG Control field to 0.

The MFB responder may send a solicited response frame with any of the following combinations of CMMG MCS, NUM_STS, and MFSI:

— CMMG-MCS = 31, NUM_STS = 3 in the MFB subfield, MFSI = 7: no information is provided for the immediately preceding request or for any other pending request. This combination is used when the responder is required to include a CMMG Control field due to other protocols that use this field (e.g., the reverse direction protocol) and when no MFB is available. It has no effect on the status of any pending MRQ.
— CMMG-MCS = 31, NUM_STS = 3 in the MFB subfield, MFSI in the range 0 to 6: the responder is not now providing, and will never provide, feedback for the request that had the MSI value that matches the MFSI value.
— CMMG-MCS = valid value, NUM_STS = valid value in the MFB subfield, MFSI in the range 0 to 6: the responder is providing feedback for the request that had the MSI value that matches the MFSI value.

An MFB responder that discards or abandons the MFB estimates computed in response to an MRQ may indicate that it has done so by setting the CMMG-MCS to 31 and NUM_STS to 3 in the MFB subfield in the next frame addressed to the MFB requester that includes the CMMG Control field. The value of the MFSI is set to the value of the MSI/STBC subfield of the frame that contains an MRQ for which the computation was abandoned, regardless of whether the MSI/STBC subfield contains an MSI or a Compressed MSI and STBC Indication subfields.

The STA receiving MFB may use the received MFB to compute the appropriate CMMG-MCS, SNR, BW, and NUM_STS.

When computing the MCS estimate for an MFB requester whose Tx MCS Set Defined field is equal to 1, the number of spatial streams corresponding to the recommended MCS shall not exceed the limit indicated by the Tx Maximum Number Spatial Streams Supported field.

Hardware and buffer capability may limit the number of MCS estimate computations that a MFB responder is capable of computing simultaneously. When a new MRQ is received either from a different MFB requester or from the same MFB requester with a different MSI value and when the MFB responder is not able to complete the computation for MRQ, then the MFB responder may either discard the new request or abandon an existing request in order to initiate computation for the new MRQ.

A STA sending unsolicited MFB feedback using the CMMG Control field shall set the Unsolicited MFB subfield to 1.

Unsolicited CMMG-MCS, NUM_STS, BW, and SNR estimates reported in the MFB subfield of a CMMG Control field sent by a STA are computed based on the most recent PPDU received by the STA that matches the description indicated by the STBC Indication and FB Tx Type fields in the same CMMG Control field.

In an unsolicited MFB response the STBC Indication, FB Tx Type, and BW fields are set according to the RXVECTOR parameters of the received PPDU from which the CMMG-MCS, SNR, BW, and NUM_STS are estimated, as follows:
— The STBC Indication field is set to 1 if the parameter STBC is equal to 1 and set to 0 if the parameter STBC is equal to 0.
— The FB TX Type field is set to 1 if the parameter BEAMFORMED is equal to 1 and set to 0 if the parameter BEAMFORMED is equal to 0.
— The BW field shall indicate a bandwidth equal to or less than the bandwidth indicated by the parameter CH_BANDWIDTH.

In an MFB response solicited by an MRQ that was not carried in a CMMG NDP Announcement frame, the MFB is computed based on RXVECTOR parameters CH_BANDWIDTH, NUM_STS, BEAMFORMED, and STBC of the received PPDU that carried the MRQ and might additionally be based on other factors that are not part of the RXVECTOR. The NUM_STS subfield of the MFB subfield of the CMMG Control field shall be set to an equal or smaller value than the RXVECTOR parameter NUM_STS of the received PPDU that triggered the MRQ.

If the MFB is in the same PPDU as a CMMG Compressed Beamforming frame, the MFB responder should estimate the recommended MFB under the assumption that the MFB requester uses the steering matrices contained therein.

If the MFB is in the same MPDU as a CMMG Compressed Beamforming frame, the MFB responder shall estimate the recommended MFB under the assumption that the beamformer uses the steering matrices contained therein. In this case the value of the NUM_STS field in the MFB subfield of the CMMG Control field shall be the same as the value of the Nc Index field in the CMMG MIMO Control field of the CMMG Compressed Beamforming frame; and, if the MFB is unsolicited, the FB Tx Type shall be set to 0. Additionally, MFB estimate shall be based on the bandwidth indicated by the Channel Width subfield of the CMMG MIMO Control field of the CMMG Compressed Beamforming frame. In this case the SNR and BW subfields are reserved and set to 0.

If an unsolicited MFB is not in the same MPDU as a CMMG Compressed Beamforming frame, the NUM_STS subfield of the MFB subfield of the CMMG Control field shall be set to an equal or smaller value than the RXVECTOR parameter NUM_STS of the received PPDU from which the MFB parameters are estimated.

After the MFB estimate computation is completed, the MFB responder should include the MFB in the MFB field in the next transmission of a frame addressed to the MFB requester that includes a CMMG Control field. When the MFB requester sets the MRQ subfield to 1 and sets the MSI subfield to a value that matches the MSI subfield value of a previous request for which the responder has not yet provided feedback, the responder shall discard or abandon the computation for the MRQ that corresponds to the previous use of that MSI subfield value.

A STA may respond immediately to a current request for MFB with a frame containing an MFSI field value and MFB field value that correspond to a request that precedes the current request.

NOTE 1—If a CMMG STA includes the CMMG Control field in the initial frame of an immediate response exchange and the responding CMMG STA includes the CMMG Control field in the immediate response frame, the immediate response exchange effectively permits the exchange of the CMMG Control field elements.

NOTE 2—If an MRQ is included in the last PPDU in a TXOP and there is not enough time for a response, the recipient might transmit the response MFB in a subsequent TXOP.

NOTE 3—Bidirectional request/responses are supported. In this case, a STA acts as the MFB requester for one direction of a duplex link and a MFB responder for the other direction and transmits both MRQ and MFB in the same CMMG data frame.

Insert the following subclause, 10.31a, after 10.31.4:

10.31a CMMG beamforming

A CMMG STA may use beamforming transmission to achieve diversity gain with directional beamforming or the spatial multiplex gain with transmit beamforming.

— Directional beamforming (BF) that does not use an omnidirectional antenna pattern or quasi-omni antenna pattern is a mechanism that is used by a pair of STAs to achieve the necessary link budget for subsequent communication. Directional BF training is a bidirectional sequence of BF frame transmissions that uses sector sweep and provides the necessary signaling to allow each STA to determine appropriate antenna system settings for both transmission and reception. CMMG STAs shall follow the same beamforming training rules defined in 10.38. BF frame transmitted by a CMMG STA is contained in CMMG PPDU.

— Transmit beamforming (see 10.32) that use an omnidirectional antenna pattern or quasi-omni antenna pattern.

10.32 Transmit beamforming

10.32.1 HT steering matrix calculations

Insert the following paragraphs at the end of 10.32.1:

In order for a CMMG beamformer to calculate an appropriate steering matrix for transmit spatial processing when transmitting to a specific CMMG beamformee, the CMMG beamformer needs to have an accurate estimate of the channel over which it is transmitting. The method of calculation for CMMG beamformer based on explicit feedback is defined as follows:

— When using explicit feedback, the CMMG beamformee makes a direct estimate of the channel from training symbols sent to the CMMG beamformee by the CMMG beamformer. The CMMG beamformee may prepare CSI or steering feedback based on an observation of these training symbols. The CMMG beamformee quantizes the feedback and sends it to the CMMG beamformer. The CMMG beamformer can use the feedback as the basis for determining transmit steering vectors. See 10.32.5.

A CMMG STA shall not transmit a PPDU with the TXVECTOR EXPANSION_MAT parameter present if dot11BeamFormingOptionActivated is false.

Insert the following subclause, 10.32.5 (including Table 10-18a and Table 10-18b), after 10.32.4:

10.32.5 Explicit feedback beamforming for CMMG STAs

The procedures in this subclause apply to CMMG PPDUs for which the CMMG Control field, if present, is the CMMG Control field.

In this subclause, the terms *CMMG beamformer* and *CMMG beamformee* refer to STAs that are involved in explicit feedback beamforming.

A CMMG beamformer uses the feedback response that it receives from the CMMG beamformee to calculate a beamforming feedback matrix for transmit beamforming. This feedback response has the following format:

— *Compressed beamforming*: The CMMG beamformee sends compressed beamforming feedback matrices to the CMMG beamformer.

The supported formats shall be advertised in the beamformee's CMMG Capabilities element.

NOTE—An HT and CMMG beamformer might discard the feedback response if the TSF time when the PHY-CCA.indication(IDLE) primitive corresponding to the feedback response frame's arrival minus the value from the Sounding Timestamp field in the feedback response frame is greater than the coherence time interval of the propagation channel.

A CMMG beamformee's responding capabilities shall be advertised in CMMG Capabilities elements contained in DMG Beacon, Probe Request, Probe Response, Association Request, Association Response, Action, and Action No Ack frames that are transmitted by the CMMG beamformee. Devices that are capable of acting as a CMMG beamformee shall advertise one of the following response capabilities in the Explicit Compressed Beamforming Feedback Capable subfield of the Transmit Beamforming Capability field:

— *Immediate:* The CMMG beamformee is capable of sending a feedback response an SIFS after receiving a sounding PPDU and/or is capable of sending a feedback response aggregated in a PPDU that contains a MAC response within the CMMG beamformer's TXOP.

— *Delayed:* The CMMG beamformee is not capable of sending the feedback response within the CMMG beamformer's TXOP, but it is capable of sending the feedback response in a TXOP that it obtains.
— *Immediate and Delayed:* The CMMG beamformee is capable of sending a feedback response an SIFS after receiving a sounding PPDU, sending a feedback response aggregated in a PPDU that contains a MAC response within the CMMG beamformer's TXOP, or sending the feedback response in a TXOP that it obtains.

The sounding frame types supported by the CMMG beamformee, staggered and/or NDP, are advertised in the CMMG Capabilities element in frames that are transmitted by the CMMG beamformee.

A STA that sets Explicit Compressed Beamforming Feedback Capable fields to 1 shall transmit explicit feedback based on the receipt of a sounding PPDU in which the CSI/Steering subfield has a nonzero value. This requirement is independent of the values of the Receive Staggered Sounding Capable and the Receive NDP Capable fields.

A CMMG beamformer shall set the SOUNDING parameter of the TXVECTOR to SOUNDING in the PHY-TXSTART.request primitive corresponding to each packet that is used for sounding.

A CMMG beamformer shall set the response type format indicated in the CSI/Steering subfield of the CMMG Control field of any sounding frame excluding the NDP and of any PPDU with the NDP Sounding Announcement field equal to 1 to the value of the type Compressed Beamforming.

The receipt of a PHY-RXSTART.indication primitive with the RXVECTOR SOUNDING parameter value equal to SOUNDING indicates a sounding packet. A non-NDP request for feedback is a sounding PPDU that contains a nonzero value of the CSI/Steering subfield and that has the NDP Announcement subfield equal to 0.

An NDP request for feedback is the combination of a CMMG MPDU that contains a nonzero value of the CSI/Steering subfield and that has the NDP Announcement subfield equal to 1 and the NDP that follows.

A CMMG beamformee that transmits a feedback frame in response to a sounding PPDU sent by a beamformer shall transmit a Compressed Beamforming frame.

The CMMG beamformee decides on any tone grouping to be used in the explicit beamforming feedback. The value selected shall be a value supported by the CMMG beamformer as indicated in the Minimal Grouping subfield of the CMMG beamformer's CMMG Capabilities element.

A CMMG beamformee that sets the Explicit Compressed Feedback Capable field of its CMMG Capabilities element to either 2 or 3 shall transmit explicit compressed beamforming feedback after SIFS or later in the beamformer's TXOP as a response to a non-NDP request for feedback in a frame that is appropriate for the current frame exchange sequence following Table 10-18a.

Table 10-18a—Rules for CMMG beamformee immediate feedback transmission responding to non-NDP sounding

Type of response	Rule
CTS response	If the transmission of a CTS is required in response to the non-NDP request for feedback, the transmission of the feedback response frame shall be delayed until the CMMG beamformee's next transmission within the TXOP. This feedback response frame may be aggregated in an A-MPDU with an Ack or BlockAck frame.

Table 10-18a—Rules for CMMG beamformee immediate feedback transmission responding to non-NDP sounding *(continued)*

Type of response	Rule
Acknowledgment response	If the transmission of an Ack or BlockAck frame is required in response to the non-NDP request for feedback, both the feedback response frame and the control response frame may be aggregated in an A-MPDU.
No control response	If the transmission of a control response frame is not required in response to the non-NDP request for feedback, the feedback response frame shall be sent an SIFS after the reception of the sounding PPDU containing the request for feedback.
Later aggregation of feedback and acknowledgment	If the immediate-feedback-capable CMMG beamformee cannot transmit an aggregated or immediate CSI/Steering response in an SIFS after the end of the received sounding packet and the CMMG beamformee is subsequently required to transmit an Ack or BlockAck frame in the same TXOP, it may transmit the feedback response in an A-MPDU with the Ack or BlockAck frame.

A CMMG beamformee that sets the Explicit Compressed Beamforming Feedback Capable field of its CMMG Capabilities element to either 2 or 3 shall transmit the explicit compressed beamforming feedback after SIFS or later in the CMMG beamformer's TXOP as a response to an NDP request for feedback in a frame that is appropriate for the current frame exchange sequence following Table 10-18b.

Table 10-18b—Rules for CMMG beamformee immediate feedback transmission responding to NDP sounding

Type of response	Rule
Control response	If the transmission of a control response frame is required in response to the NDP request for feedback, the control response frame is transmitted an SIFS after reception of the PPDU that elicited the control response, and the feedback response frame may be transmitted an SIFS after the reception of the NDP. — If the feedback response frame is not transmitted an SIFS after the reception of the NDP and the CMMG beamformee is subsequently required to transmit anAck or BlockAck frame in the same TXOP, then the feedback response may be aggregated with the Ack or BlockAck frame. — If the feedback response frame is not transmitted an SIFS after the reception of the NDP and is not transmitted with an aggregated Ack or BlockAck frame in the same TXOP, then the feedback response frame is delayed until the CMMG beamformee's next transmission within the TXOP.
No control response	If the transmission of a control response frame is not required in response to the NDP request for feedback, the feedback response frame may be sent an SIFS after the reception of the NDP. — If the feedback response frame is not transmitted an SIFS after the reception of the NDP and the CMMG beamformee is subsequently required to transmit an Ack or BlockAck frame in the same TXOP, then the feedback response may be aggregated with the Ack or BlockAck frame. — If the feedback response frame is not transmitted an SIFS after the reception of the NDP and is not transmitted with an aggregated Ack or BlockAck frame in the same TXOP, then the feedback response frame is delayed until the CMMG beamformee's next transmission within the TXOP.

When the CMMG beamformee sets the Explicit Compressed Beamforming Feedback Capable field of its CMMG Capabilities element to either 2 or 3 and the CMMG beamformer has transmitted an NDP or an non-NDP explicit compressed beamforming feedback request in a frame that does not require immediate control response, the CMMG beamformer shall not transmit the next packet to the beamformee until PIFS after transmitting the sounding request.

A CMMG beamformee shall not transmit Compressed Beamforming frame except in response to a request for feedback.

NOTE—Error recovery in a TXOP is not affected by sounding. A beamformer that is a TXOP holder and that fails to receive an expected response to a sounding PPDU can continue transmission as specified in 10.22.2.4.

A CMMG beamformee transmitting a feedback response after SIFS or later in the beamformer's TXOP shall use an Action No Ack frame defined in 9.3.3.15.

A CMMG beamformee transmitting delayed feedback response shall use an Action frame to send this information within a separate TXOP.

If necessary, the Compressed Beamforming Report field may be split into up to 8 frames. The length of each segment shall be equal number of octets for all segments except the last, which may be smaller.

NOTE—A STA that has been granted an RDG can act as a CMMG beamformer during the RDG time period, provided that the RD rules are obeyed.

A CMMG beamformee that advertises itself as delayed-feedback-capable shall not transmit an immediate feedback response unless it also advertises itself as immediate-feedback-capable.

An explicit feedback request may be combined with an MRQ. If the response contains a beamforming feedback matrix, the returned MCS shall be derived from the same information that was used to generate this particular beamforming feedback matrix. If the response contains channel coefficients, the returned MCS shall be derived from an analysis of the sounding frame that was used to generate the channel coefficients. The MFB field set to 127 (meaning no feedback) may be used when the CMMG beamformee is unable to generate the MCS in time for inclusion in the response transmission frame. A CSI-capable STA may be incapable of generating MFB.

Explicit feedback shall be calculated only from a sounding PPDU.

A CMMG beamformee that transmits a feedback frame of type Compressed Beamforming in response to a sounding PPDU sent by a CMMG beamformer shall set the value of N_r in the MIMO Control field of the feedback frame to be the same value as the number of streams in the sounding PPDU.

Insert the following subclause, 10.34a, after 10.34.7:

10.34a Null data packet (NDP) sounding for CMMG STAs

10.34a.1 NDP rules

Sounding may be accomplished using CMMG NDP, as described in 25.6.8.14. The MAC rules associated with sounding using CMMG NDP are described in 10.34a.1 and 10.34a.2.

A CMMG STA that has set the Receive NDP Capable field of its CMMG Capabilities element to 1 during association processes a CMMG NDP as a sounding packet if the destination of the sounding packet is determined to match itself and if the source of the sounding packet can be ascertained.

An RXVECTOR LENGTH parameter equal to 0 indicates that the PPDU is a CMMG NDP.

A STA that is a TXOP holder or an RD responder shall not set both the CMMG NDP Announcement and RDG/More PPDU subfields to 1 simultaneously.

An NDP sequence contains at least one CMMG NDP and at least one PPDU that is not an NDP. Only one PPDU in the NDP sequence may contain a CMMG NDP announcement. An NDP sequence begins with a CMMG NDP announcement. The NDP sequence ends at the end of the transmission of the last CMMG NDP that is announced by the CMMG NDP announcement. A STA that transmits the first PPDU of an NDP sequence is the NDP sequence owner. In the NDP sequence, only PPDUs carrying CMMG NDP and PPDUs carrying single MPDU Control frames may follow the NDP sequence's starting PPDU.

A STA shall transmit only one CMMG NDP per NDP announcement. Each PPDU in an NDP sequence shall start a SIFS after end of the previous PPDU.

NOTE—A CTS frame cannot be used for CMMG NDP announcement: if the CTS frame is a response to an RTS frame, the optional NAV reset timeout that starts at the end of the RTS frame does not include the additional CMMG NDP and SIFS. Also, if the CTS frame were the first frame of an NDP sequence, it would not be possible to determine the destination address of the CMMG NDP.

A STA shall transmit a CMMG NDP as follows:

a) A SIFS after sending a PPDU that is a CMMG NDP announcement and that does not contain an MPDU that requires an immediate response.
b) A SIFS after successfully receiving a correctly formed and addressed immediate response to a PPDU that is a CMMG NDP announcement and that contains an MPDU that requires an immediate response.

This rule enables the NDP receiver to know that it receives a CMMG NDP and can determine the source and destination of the CMMG NDP. It enables the receiver and transmitter to know when the immediate response and CMMG NDP are transmitted relative to the frame containing the CMMG NDP announcement indication.

A STA that has transmitted a CMMG NDP announcement in a frame that requires an immediate response and that does not receive the expected response shall terminate the NDP sequence at that point (i.e., the STA does not transmit a CMMG NDP in the current NDP sequence).

Feedback information generated from the reception of a CMMG NDP is transmitted using any of the feedback rules and signaling as appropriate, e.g., immediate or delayed.

10.34a.2 Transmission of a CMMG NDP

A STA that transmits a CMMG NDP shall set the LENGTH, SOUNDING, NSS, and STBC parameters of the TXVECTOR as specified in this subclause.

— LENGTH shall be set to 0.
— SOUNDING shall be set to SOUNDING.
— STBC shall be set to 0.
— NSS indicates two or more spatial streams.

The number of spatial streams sounded is indicated by the NSS parameter of the TXVECTOR and shall not exceed the limit indicated by the Channel Estimation Capability field in the Transmit Beamforming Capabilities field transmitted by the STA that is the intended receiver of the CMMG NDP.

10.34a.3 Determination of CMMG NDP destination

The destination of a CMMG NDP is determined at the NDP receiver by examining the CMMG NDP announcement as follows:

— The destination of the first CMMG NDP in the NDP sequence is equal to the RA of any MPDU within the CMMG NDP announcement.

— If Calibration Position subfield is equal to 1 in the CMMG NDP announcement at the NDP receiver, the destination of the second CMMG NDP is equal to the TA of that frame. Otherwise, the destination of the second and any subsequent CMMG NDPs is equal to the destination of the previous CMMG NDP.

10.34a.4 Determination of CMMG NDP source

The source of a CMMG NDP is determined at the NDP receiver by examining the NDP sequences's starting PPDU as follows:

— If any MPDU within the CMMG NDP announcement contains two or more addresses, the source of the first CMMG NDP is equal to the TA of that frame.
— Otherwise (i.e., the CMMG NDP announcement contains one address), the source of the first CMMG NDP is equal to the RA of the MPDU to which the CMMG NDP announcement is a response.

If the Calibration Position subfield is equal to 1 in an MPDU in the CMMG NDP announcement, the source of the second CMMG NDP is equal to the RA of that MPDU. Otherwise, the source of the second and any subsequent CMMG NDPs is equal to the source of the previous NDP.

Change the title of 10.36 as follows:

10.36 DMG <u>and CMMG </u>channel access

10.36.1 General

Change the text of 10.36.1 as follows:

Channel access by a DMG STA is related to beacon interval timing and is coordinated using a schedule. A DMG STA operating as an AP or PCP generates the schedule and communicates it to STAs using DMG Beacon and Announce frames. A non-PCP STA that is a non-AP STA and that receives scheduling information accesses the medium during the scheduled periods using the access rules specific to that period. Medium access rules to establish a BSS are defined in 10.37 and 11.1.4. <u>CMMG STAs follow the same rules of DMG channel access except the specific modification for CMMG STAs as described in 10.36.</u>

10.36.2 Access periods within a beacon interval

Change the first paragraph of 10.36.2 as follows:

Medium time within a DMG <u>or CMMG</u> BSS is divided into beacon intervals. Subdivisions within the beacon interval are called *access periods*. Different access periods within a beacon interval have different access rules. The access periods are described in a schedule that is communicated by the AP or PCP to the non-PCP and non-AP STAs within the BSS. The schedule communicated by the AP or PCP can include the following access periods:

— *BTI:* <u>For DMG STAs, it is </u>an access period during which one or more DMG Beacon frames is transmitted. Not all DMG Beacon frames are detectable by all non-PCP and non-AP STAs (see 10.38.4). <u>For CMMG STAs, it is an access period during which one or more DMG Beacon frames are transmitted at least in the primary 540 MHz channel. Not all DMG Beacon frames are detectable by all non-PCP and non-AP STAs. </u>Not all beacon intervals contain a BTI. A non-PCP STA that is a non-AP STA shall not transmit during the BTI of the BSS of which it is a member.
— ...

Insert the following paragraphs and Figure 10-54a after Figure 10-54:

For a 1080 MHz CMMG BSS, the DTI can comprise contention-based access periods (CBAPs) and scheduled service periods (SPs), and the bandwidth of the allocation in the DTI can be 540 MHz and 1080 MHz.

Figure 10-54a illustrates an example of access periods within a beacon interval for a 1080 MHz CMMG BSS, comprising a BHI, that may contain BTI, A-BFT, and ATI, and two 540 MHz CBAPs and SPs within the DTI and one 1080 MHz CBAPs and SPs within the DTI. Any combination in the number and order of SPs and CBAPs can be present in the DTI. For a CMMG BSS, the BHI shall be sent on the primary 540 MHz channel and can be sent on the 1080 MHz channel with duplicate format.

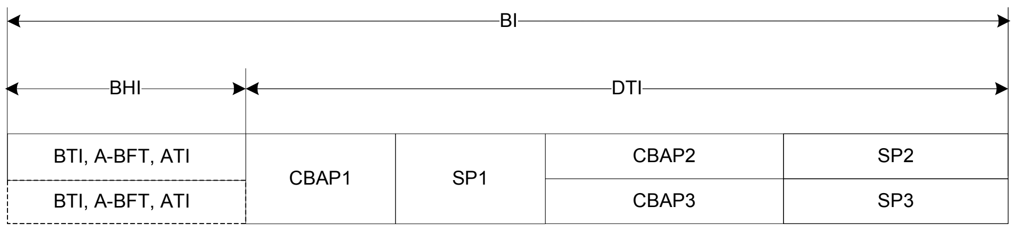


Figure 10-54a—Example of access periods within a BI for CMMG STAs

10.36.3 ATI transmission rules

Change the fourth paragraph of 10.36.3 as follows:

For DMG STAs, ~~D~~during each ATI the AP or PCP shall schedule transmissions to a non-AP and non-PCP STA if the non-AP and non-PCP STA Heartbeat field in the STA's DMG Capabilities element within the Association Request frame of the last successful association attempt is 1. If the non-AP and non-PCP STA does not respond to the frame transmitted by the AP or PCP, the AP or PCP shall use the DMG Control modulation class (10.7.7.1) at its next transmission attempt to the non-AP and non-PCP STA. The AP or PCP shall use the DMG Control modulation class for all subsequent transmissions to the non-AP and non-PCP STA until it receives a valid frame from the non-AP and non-PCP STA STA.

Insert the following paragraph after the fourth paragraph of 10.36.3:

For CMMG STAs, during each ATI the AP or PCP shall schedule transmissions to a non-AP and non-PCP STA if the non-AP and non-PCP STA Heartbeat field in the STA's CMMG Capabilities element within the Association Request frame of the last successful association attempt is 1 and the non-AP and non-PCP STA is in the Awake state. If the non-AP and non-PCP STA does not respond to the frame transmitted by the AP or PCP, the AP or PCP shall use the CMMG Control modulation class (10.7.7a.1) at its next transmission attempt to the non-AP and non-PCP STA. The AP or PCP shall use the CMMG Control modulation class for all subsequent transmissions to the non-AP and non-PCP STA until it receives a valid frame from the non-AP and non-PCP STA.

Insert the following paragraph at the end of 10.36.3:

For CMMG STAs, the bandwidth of a response frame transmitted during the ATI shall be set to the same as previously received request frame.

10.36.4 DTI transmission rules

Change the first three paragraphs of 10.36.4 as follows:

During the DTI, a STA may initiate a frame exchange (following the DMG channel access rules for DMG STAs and following the CMMG channel access rules for CMMG STAs) if any of the following conditions are met:

a) During a CBAP for which the STA is identified or included as source or destination (10.36.6.3, 10.36.7, and 10.36.8)
b) During an SP for which the STA is identified as source or destination (10.36.6.2 and 10.36.7)

and shall not initiate a frame exchange if none of these conditions are met. A STA initiating data transfer shall check that the transaction, including acknowledgments, completes before the end of the CBAP or SP in which it was initiated. Also, a CMMG STA initiating data transfer shall use a bandwidth no larger than the allocated channel bandwidth of the CBAP or SP in which it was initiated.

When the entire DTI is allocated to CBAP (that is, the CBAP Only field is 1 in the DMG Parameters field for DMG STAs, or the CBAP Only field is 1 in the CMMG Parameters field for CMMG STAs), for DMG STAs the ATI Present field within the DMG Beacon frame containing the DMG Parameters field shall be set to 0, and for CMMG STAs the ATI Present field within the DMG Beacon frame containing the CMMG Parameters field shall be set to 0.

A DMG or CMMG STA shall be capable of processing Grant frames. A non-AP and non-PCP DMG or CMMG STA shall be capable of processing Poll frames and the Extended Schedule element. An AP or PCP shall be capable of processing the SPR frames transmitted by a non-AP and non-PCP STA and responding to an SPR frame with a Grant frame.

10.36.5 Contention based access period (CBAP) transmission rules

Change the seventh paragraph of 10.36.5 as follows:

At the beginning of a TXOP with a TXOP responder that has the Heartbeat field in the TXOP responder's DMG Capabilities element equal to 1 for DMG STAs or has the Heartbeat field in the TXOP responder's CMMG Capabilities element equal to 1 for CMMG STAs, the following rules apply:

— For DMG STAs, ~~T~~the TXOP holder shall transmit a frame to the TXOP responder using the DMG Control modulation class before it uses any other modulation class for transmission if the time elapsed since the last frame received from the TXOP responder is larger than or equal to the Heartbeat Elapsed Time value computed using the Heartbeat Elapsed Indication field within the TXOP responder's DMG Capabilities element.
— For DMG STAs, ~~T~~the TXOP holder may transmit a frame using a modulation class other than the DMG Control modulation class at the start of the TXOP if the time elapsed since the last frame received from the TXOP responder is shorter than the heartbeat elapsed time value computed using the Heartbeat Elapsed Indication field within the TXOP responder's DMG Capabilities element.
— For CMMG STAs, the TXOP holder shall transmit a frame to the TXOP responder using the CMMG Control modulation class before it uses any other modulation class for transmission if the time elapsed since the last frame received from the TXOP responder is larger than or equal to the Heartbeat Elapsed Time value computed using the Heartbeat Elapsed Indication field within the TXOP responder's CMMG Capabilities element.
— For CMMG STAs, the TXOP holder may transmit a frame using a modulation class other than the CMMG Control modulation class at the start of the TXOP if the time elapsed since the last frame received from the TXOP responder is shorter than the Heartbeat Elapsed Time value computed

using the Heartbeat Elapsed Indication field within the TXOP responder's CMMG Capabilities element.

10.36.6 Channel access in scheduled DTI

10.36.6.1 General

Insert the following paragraph after the seventh paragraph ("The end of the* ith *individual ....") of 10.36.6.1:

For CMMG STAs, an SP or CBAP allocation within an Extended Schedule element may be a 540 MHz allocation or a 1080 MHz allocation; the channel and bandwidth of the SP or CBAP allocation are indicated in the Extended Schedule element.

10.36.6.2 Service period (SP) allocation

Insert the following paragraph after the second paragraph ("An SP is assigned ....") of 10.36.6.2:

An SP is assigned to the source CMMG STA identified in the Source AID subfield in an Allocation field that is not an obsolete allocation within the Extended Schedule element. The source CMMG STA shall initiate the frame exchange sequence that takes place during the SP at the start of the SP, except when the source CMMG STA intends to establish a CMMG protected period in which case the rules described in 10.36.6.6 shall be followed before the source CMMG STA initiates the frame exchange in the SP. The SP allocation identifies the TC or TS for which the allocation is made; however, the type of traffic transmitted is not restricted to the specified TC or TS (11.4.1).

Insert the following paragraph after the now sixth paragraph ("At the beginning of an SP (except ....") of 10.36.6.2:

At the beginning of an SP in a CMMG band, except when the source CMMG STA intends to establish a CMMG protected period (see 10.36.6.6) before the source CMMG STA initiates the frame exchange in the SP, a source CMMG STA shall transmit a frame to the destination CMMG STA using the CMMG Control modulation class before it uses any other modulation class for transmission if the Heartbeat field in the destination CMMG STA's CMMG Capabilities element is 1. The frame sent by the source STA may be an RTS frame or a DMG CTS-to-self frame. The frame sent by the source STA may be an SSW frame or a BRP packet if the source STA is performing beamforming (10.7.7a.5).

Insert the following paragraph after the now eighth paragraph ("At the beginning of an SP, an ....") of 10.36.6.2:

At the beginning of an SP, a destination CMMG STA shall transmit a frame to the source CMMG STA using the CMMG Control modulation class before it uses any other modulation for transmission if the Heartbeat field in the source CMMG STA's CMMG Capabilities element is 1 and the frame sent by the destination CMMG STA is the unsolicited DMG DTS as first frame in the SP of the STA performing CMMG protected period.

Change the title of 10.36.6.6 as follows:

10.36.6.6 DMG and CMMG protected period

10.36.6.6.1 Introduction

Insert the following paragraph after the first paragraph ("Communicating ....") of 10.36.6.6.1:

In the CMMG protected period that has 540 MHz or 1080 MHz bandwidth, the STA can use dynamic bandwidth operation to negotiate a bandwidth that can be used in this SP.

Insert the following paragraph after the now fourth paragraph ("Both the source ....") of 10.36.6.6.1:

A CMMG protected period can use the dynamic bandwidth operation during an SP if the bandwidth of the SP that indicated in the Extended Schedule element is 1080 MHz.

Insert the following paragraph after the now sixth paragraph ("A DMG STA ....") of 10.36.6.6.1:

A CMMG STA that creates a CMMG protected period during an SP in which it is a source CMMG STA or a destination CMMG STA moves to and stays in listening mode during time interval that starts before the start of the SP and remains in the listening mode until it is allowed to use the SP. The actual duration of the time the STA stays in the listening mode is limited by the aCMMGPPMinListeningTime parameter. The intent of the listening mode is that the CMMG STA listens to other CMMG STAs that may have an SP that overlaps with the SP where the CMMG STA is a source CMMG STA or a destination CMMG STA. The NAV mechanism is used to indicate the time and frequency occupancy, and the CMMG STA in the listening mode updates NAV timers. If the NAV timers are not equal to 0 for the corresponding channel bandwidth, the CMMG STA does not use the time and the band of the SP in which it is a source CMMG TA or a destination CMMG STA. If none of the NAV timers has a nonzero value at the start of the SP, the DMG STA is allowed to leave the listening mode and use the SP. If at least one of the NAV timers has a nonzero value at the start of the SP, the DMG STA is allowed to leave the listening mode and to use the time remaining in the SP after all NAV timers become or already have value zero.

Change the last paragraph of 10.36.6.6.1 as follows:

A DMG protected period is established through an RTS/DMG CTS handshake. The DMG CTS can be sent in a CMMG PHY format and can be sent in 540 MHz or 540 MHz duplicated mode. To create a DMG protected period, the source DMG STA of an SP sends an RTS, and the recipient STA responds with a DMG CTS. If the recipient STA responds with a DMG CTS, then a DMG protected period is established; otherwise, no DMG protected period has been established. In all cases of DMG protected period establishment, the same antenna configurations that are used by the STAs that establish the DMG protected period are used for the exchange of frames during the DMG protected period.

Change the title of 10.36.6.6.2 as follows:

10.36.6.6.2 DMG and CMMG protected period establishment and maintenance

Insert the following paragraph after the first paragraph ("A DMG STA that attempts ....") of 10.36.6.6.2:

A CMMG STA that attempts to create a CMMG protected period shall transition to listening mode on a channel that the bandwidth is indicated in the Extended Schedule element for this SP.

Change the now third paragraph of 10.36.6.6.2 as follows:

A DMG STA shall not issue an RTS frame to establish a DMG protected period if any of its NAV timers is not equal to 0.

Insert the following paragraph after the now third paragraph of 10.36.6.6.2:

A CMMG STA shall not issue an RTS frame to establish a CMMG protected period on a channel if any of its NAV timers corresponding to this channel are not equal to 0. A CMMG STA may issue an RTS frame to establish a CMMG protected period on a channel if the bandwidth of the channel is less than the SP allocated channel bandwidth and all of its NAV timers that correspond to this channel are 0.

Insert the following paragraph after the now fifth paragraph ("A DMG STA that transmits ....") of 10.36.6.6.2:

A CMMG STA that transmits an RTS frame to establish a CMMG protected period during an SP in which it is a source CMMG STA shall not transmit the RTS frame outside of the SP, and the value of the Duration field of the RTS frame shall not exceed the duration of the portion of the SP that remains following the RTS transmission. And a CMMG STA that transmits an RTS frame to establish a CMMG protected period during an SP in which it is a source CMMG STA shall not transmit an RTS frame that has a bandwidth that is larger than the allocated bandwidth.

Insert the following paragraph after the now tenth paragraph ("During an SP ... shall not respond ....") of 10.36.6.6.2:

During an SP in which it is the destination CMMG STA, a CMMG STA that receives a valid RTS frame addressed to itself and the TA corresponding to the source CMMG STA of the SP shall not respond with a DMG CTS frame on the channel if at the start of the reception of the RTS frame the recipient CMMG STA has a nonzero value in at least one of its NAV timers corresponding to this channel.

Insert the following subclauses, 10.36.6.6.2a and 10.36.6.6.2b (including Figure 10-56a), after 10.36.6.6.2:

10.36.6.6.2a CDMG protected period establishment and maintenance

In addition to establishing a DMG protected period on its current operating channel, a CDMG STA might create another DMG protected period on an overlapping channel to avoid the potential interference from the overlapping channel. This subclause describes rules for establishing and maintaining a CDMG protected period for a pair of CDMG STAs.

A CDMG AP or PCP shall set the Protected Period subfield within the Extended Schedule element sent to the source and destination STAs to indicate whether the protected period is to be created and on which channels the protected period should be created for an SP allocation. The CDMG AP or PCP should determine the time and frequency overlapping status of an SP scheduled by itself with other SPs or CBAPs scheduled by other APs or PCPs according to the schedule information of the neighboring APs or PCPs and itself. The CDMG AP or PCP can obtain the schedule information of the neighboring APs or PCPs by receiving DMG Beacon frames directly if it is within an AP or PCP cluster, or by receiving interference reports included in the Cluster Report elements or DMG TSPEC elements transmitted by STAs within the BSS.

If a CDMG AP or PCP determines that there exists at least one SP or CBAP scheduled by a neighboring AP or PCP that is overlapping in both time and frequency with an SP allocated by the CDMG AP or PCP and cannot determine that the neighboring SP or CBAP does not interfere with its allocated SP based on the received interference report (10.36.6.6.4) from STAs, the CDMG AP or PCP shall set the Protected Period subfield to a nonzero value for the allocated SP to indicate that the source and destination CDMG STAs are required to establish a protected period for the SP. Otherwise, the CDMG AP or PCP shall set the Protected Period subfield to 0 to indicate that the source and destination CDMG STAs do not have to establish a protected period for the SP.

If a potentially interfering SP or CBAP is allocated on the current operating channel, the AP or PCP shall set the Protected Period subfield within the Allocation Control field to 1. The source and destination CDMG STAs shall follow the rules defined in 10.36.6.6.1 to establish a DMG protected period on its current operating channel.

If the source CDMG STA and destination CDMG STA are operating on a 1.08 GHz channel and a potentially interfering SP or CBAP is allocated on the overlapping 2.16 GHz channel, the CDMG AP or

PCP shall set the Protected Period subfield to 2. The source CDMG STA and destination CDMG STA shall create a CDMG protected period on both the current operating 1.08 GHz channel and the overlapping 2.16 GHz channel.

If the source CDMG STA and destination CDMG STA are operating on a 2.16 GHz channel and a potentially interfering SP or CBAP is allocated on the overlapped low-frequency 1.08 GHz channel, the CDMG AP or PCP shall set the Protected Period subfield to 2 to indicate that the source CDMG STA and destination CDMG STA create a DMG protected period on both the current operating 2.16 GHz channel and the low-frequency 1.08 GHz channel.

If the source CDMG STA and destination CDMG STA are operating on a 2.16 GHz channel and a potentially interfering SP or CBAP is allocated on the overlapped high-frequency 1.08 GHz channel, the CDMG AP or PCP shall set the Protected Period subfield to 3 to indicate that the source CDMG STA and destination CDMG STA create a DMG protected period on both the current operating 2.16 GHz channel and the high-frequency 1.08 GHz channel.

If creating a CDMG protected period on two channels is required, the source and destination STAs shall listen to the current channel first and transition to and stay in listening mode following the rules specified in 10.36.6.6.1. If both the results of the PHY layer carrier sensing (CS) and the virtual carrier sensing show that the current channel is idle, the source STA and destination STA shall perform a RTS/DMG CTS handshake on the current channel. Once the first RTS/DMG CTS handshake is completed, the source STA and destination STA shall perform another RTS/DMG CTS handshake on the second channel after a SIFS. After the second RTS/DMG CTS handshake is done, the source STA and destination STA shall switch back to their operating channel and transmit data following a SIFS. An example of creating a CDMG protected period through two RTS/DMG CTS handshakes for CDMG STAs operating on a 1.08 GHz channel is shown in Figure 10-56a.

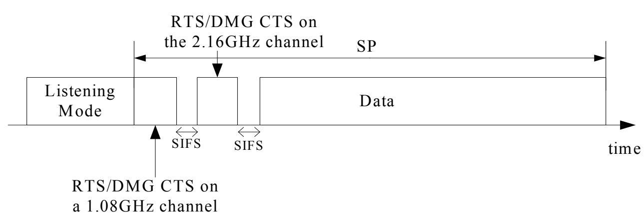


Figure 10-56a—An example of creating a CDMG protected period on two channels for CDMG STAs

If an RTS/DMG CTS frame exchange on the 1.08 GHz channel failed, the CDMG STA shall not transmit the subsequent RTS frame on the 2.16 GHz channel after SIFS from the end of the expected CTS frame on the 1.08 GHz channel as shown in Figure 10-56a.

In order to maintain protection from STAs that are not aware of the establishment of the CDMG protected period because they have begun listening to the medium after the establishment of a CDMG protected period, a CDMG STA that established a CDMG protected period should transmit additional RTS frames on the channels that are the same as the channels used when establishing the CDMG protected period. The source STA should initiate an additional two RTS/DMG CTS handshakes on the two channels at the end of every (aDMGPPMinListeningTime – aRTSTimeoutTime) interval during the CDMG protected period if the duration of the two RTS/DMG CTS handshakes exchange is less than the time remaining in the SP.

A CDMG AP or PCP can merge the time interval of listening mode when creating a CDMG protected period and the channel measurement time during SPSH (see 11.32) by using the Protected Period subfield and the

Directional Channel Quality Request element. If the AP or PCP determines two SPs allocated for two pairs of CDMG STAs within the BSS should both be created with protected period, the AP or PCP may transmit a Directional Channel Quality Request element to the two pairs of STAs based on allocation positions of the SPs for the two pairs of STAs. The directional channel measurement time interval indicated by the Directional Channel Quality Request element of one pair of STAs should cover the listening mode that begins at the start of the SP of this pair of STAs. Thus, the two pairs of STAs can direct their received antennae to their peer STAs involved in the same SP to perform channel monitoring required for establishing the protected period and perform the directional channel quality measurement required by the SPSH mechanism simultaneously. The AP or PCP may use the received Directional Channel Quality Report elements after the listening mode for subsequent SPSH with time overlapping SPs for the two pairs of STAs after the beginning of the next BI.

10.36.6.6.2b Dynamic and static bandwidth operation during CMMG protected period

If the CMMG STA that sending the RTS frame to establish a CMMG protected period during an SP in which it is a source CMMG STA is capable of dynamic bandwidth operation (see 10.3.2.7), the STA shall set the TXVECTOR parameter DYN_BANDWIDTH to Dynamic. Otherwise, the STA shall set the TXVECTOR parameter DYN_BANDWIDTH to Static.

During an SP, a CMMG STA that is the destination CMMG STA in the SP and that is addressed by an RTS frame in a CMMG PPDU that has the RXVECTOR parameter DYN_BANDWIDTH equal to Static behaves as follows:

- If the NAV indicates idle and CCA has been idle for all the channel width indicated by the RTS frame’s RXVECTOR parameter CH_BANDWIDTH, then the STA shall respond with a DMG CTS frame carried in a CMMG PPDU after a SIFS. The DMG CTS frame’s TXVECTOR parameter CH_BANDWIDTH shall be set to the same value as the RTS frame’s RXVECTOR parameter CH_BANDWIDTH.
- Otherwise, the STA shall not respond with a CTS frame.

During an SP, a CMMG STA that is the destination CMMG STA of the SP and that is addressed by an RTS frame in a CMMG PPDU that has the RXVECTOR parameter DYN_BANDWIDTH equal to Dynamic behaves as follows:

- If the NAV indicates idle in the primary 540 MHz channel, then the STA shall respond with a DMG CTS frame carried in a CMMG PPDU after a SIFS. The DMG CTS frame’s TXVECTOR parameter CH_BANDWIDTH shall be set to 540 MHz if the CCA on the secondary 540 MHz channel is detected as busy and shall be set to 1080 MHz if the CCA on the secondary 540 MHz channel is detected as idle and the channel width indicated in the RTS frame’s RXVECTOR parameter CH_BANDWIDTH is 1080 MHz.
- Otherwise, the STA shall not respond with a CTS frame.

Change the title of 10.36.6.6.3 as follows:

10.36.6.6.3 NAV update in DMG <u>and CMMG</u> protected period

10.36.6.6.4 Interference report

Insert the following paragraph after the seventh paragraph (“The Interferer ....”) of 10.36.6.6.4:

CMMG STAs shall also include the Interferer Channel Bandwidth subfield in the report, and the Interferer Channel Bandwidth subfield shall be set to the CH_BANDWIDTH of the NAV timer.

10.36.7 Dynamic allocation of service period

10.36.7.3 Grant period (GP)

Change the fourth paragraph of 10.36.7.3 as follows:

To commence the GP, the AP or PCP shall transmit Grant frames to notify the source DMG STA and destination DMG STA about a dynamically allocated service period, or the AP or PCP shall transmit Grant frames to notify the source CMMG STA and destination CMMG STA about a dynamically allocated service period. The AP or PCP should transmit the last Grant frame within a GP to the source of the dynamically allocated SP if the source of the dynamically allocated SP is not the AP or PCP. In each transmitted Grant frame, the AP or PCP shall set the Duration field within the Grant frame to a time that covers the duration of all remaining Grant frame and Grant Ack frame transmissions, if any, plus all appropriate IFSs (10.3.2.3). In addition, the Source AID and Destination AID fields shall be set to the source and destination, respectively, of the dynamically allocated SP, the AllocationType subfield set to indicate the channel access mechanism during the allocation, and the Allocation Duration field set to a value that, if added to the value of the Duration field, does not overlap in time with another SP that has either the source AID or destination AID different from the broadcast AID. An allocation that is indicated in this manner begins at the time that is equal to the PHY-TXEND.indication primitive of the Grant frame plus the value from the Duration field of the Grant frame.

Insert the following paragraph after the sixth paragraph ("During the SP ....") of 10.36.7.3:

During an SP between a source CMMG STA and a destination CMMG STA, the source CMMG STA may transmit a Grant frame to the destination CMMG STA to relinquish the remainder of the SP to the destination CMMG STA. In the Allocation Info field of the transmitted Grant frame, the source CMMG STA shall set the Source AID field to the AID of the destination CMMG STA, the Destination AID field to the AID of the source CMMG STA, the AllocationType subfield to indicate SP, the Allocation Duration field to the time remaining in the SP minus the time taken to transmit the Grant frame, and the Allocation Channel Band field to the same channel and bandwidth as the original SP. The Duration field in the Grant frame shall be set to the value of the Allocation Duration field. Upon transmission of the Grant frame, for the remainder of the SP, the roles of source CMMG STA and destination CMMG STA are swapped between the STAs.

Change the now eighth paragraph of 10.36.7.3 as follows:

During a TXOP between a TXOP holder and a TXOP responder, the TXOP holder may transmit a Grant frame to the TXOP responder to relinquish the remainder of the TXOP to the TXOP responder. In the transmitted Grant frame, the TXOP holder shall set the Source AID field to the AID of the TXOP responder, the Destination AID field to the AID of the TXOP holder, the AllocationType subfield to indicate CBAP, and the Allocation Duration field to a value of 32768 as defined in 9.5.2. For CMMG STAs, the Channel Band field shall be set to the same channel and bandwidth as the original TXOP. The Duration field in the Grant frame shall be set to the time remaining in the TXOP minus TXTIME (Grant frame) minus aSIFSTime. Upon transmission of the Grant frame with the Beamforming Training subfield equal to 0, for the remainder the TXOP, the roles of TXOP holder and TXOP responder are swapped between the STAs.

10.36.8 Dynamic truncation of service period

Insert the following subclause heading immediately after the 10.36.8 subclause heading (and incorporate all of the former 10.36.8 text into the new subclause):

10.36.8.1 DMG dynamic truncation of service period

Insert the following paragraph after the third paragraph ("Only the source DMG STA ....") of 10.36.8.1:

Only the source CMMG STA of an SP may truncate the SP, except that the destination CMMG STA may truncate the SP if it does not receive an expected transmission from the source CMMG STA at the start of the SP as defined in 10.36.6.7.

Insert the following subclause, 10.36.8.2, after 10.36.8.1:

10.36.8.2 CDMG dynamic truncation of service period

A CDMG STA truncates an SP to release the remaining time in the SP. The dynamic truncation of SP includes two types of truncation. The first type of truncation is that the STA can return to the AP or PCP the time left in the SP, thus allowing the AP or PCP to grant any portion of the released time as part of an SP to any other STA or to allocate any portion of it as a CBAP. The second type of truncation is that the STA can use the Grant frame to release any part of the time left in the SP as a CBAP.

A CDMG STA supports the DMG dynamic truncation of SP as described in 10.36.8.1. Unlike the DMG dynamic truncation of SP, the SP truncation type shall be determined by the CDMG AP or PCP when allocating an SP.

A CDMG AP or PCP shall determine whether an SP is truncatable and which truncation type is adopted by setting the Truncatable subfield and the Truncation Type subfield within the Allocation Control field when allocating an SP for the source CDMG STA and destination CDMG STA. If the Truncatable subfield of the Extended Schedule element is equal to 1, the CDMG STA may truncate the SP to release any part of the time left in the SP in accordance with the truncation type indicated by the received Truncation Type subfield.

A CDMG AP or PCP should determine the Truncatable subfield and the Truncation Type subfield according to the allocation type requirements of the STAs in its BSS, in order to satisfy the channel access requirements of the STAs using the potential released time of SPs. If the remaining time in the SP released as a CBAP might cause interference to other STAs during SPSH, the CDMG AP or PCP shall set the Truncatable subfield to 1 and the Truncation Type subfield to 0 for the SPs that are under SPSH state to indicate that the CDMG STA returns the time left in the SP to the AP or PCP; otherwise, the CDMG AP or PCP may set the Truncatable subfield to 1 and the Truncation Type subfield to 1. The CDMG AP or PCP may also set the Truncation Type subfield to 0 for an SP in order to mitigate interference to other STAs of a adjacent BSS based on the schedule information of the adjacent BSS.

A CDMG PCP may sleep in a truncatable SP that the time left in this SP is released as a CBAP by the CDMG STA by setting the Truncation Type subfield to 1 and the PCP Active field to 0. If both the Truncatable subfield and the Extendable subfield are set to 0, or if the Truncatable subfield is equal to 1 and the Truncation Type subfield is equal to 1, the CDMG PCP can set the PCP Active subfield to 0.

10.36.10 Updating multiple NAVs

Change the first paragraph of 10.36.10 as follows:

If a DMG STA supports multiple NAVs, the number of available NAVs within the STA shall be not less than aMinNAVTimersNumber. Each NAV is identified by a pair of MAC addresses, NAVSRC and NAVDST, and has associated variables NAV_RTSCANCELABLE, ~~and~~ NAV_DTSCANCELABLE, and NAV_CHANNEL the last of which is used only by CMMG STAs. The variable NAV_CHANNEL indicates the channel on which the Duration field is received, and it is a channel index that contains channel bandwidth information. Each STA also maintains a variable UPDATE_OPTIONAL. When a STA is enabled for operation, all NAVs shall have NULL values for their NAVSRC and NAVDST identifiers, the value of NAV_RTSCANCELABLE shall be false, the value of NAV_DTSCANCELABLE shall be false, the value of NAV_CHANNEL shall be NULL only for CMMG STAs, and each NAV shall have the value 0. NAV address pairs correspond to the NAV-SA and NAV-DA fields in DMG DTS frames and correspond to the RA and TA fields of all other received frames that are used to update the NAVs. Receipt of any frame can cause an update to the NAV whose identifying address pair corresponds to the specified address fields of the received frame according to the rules in this subclause.

Change the second paragraph of 10.36.10 as follows (the pseudocode passage of the second paragraph remains unchanged):

DMG STAs receiving any valid frame shall perform the following NAV update operation expressed using the following pseudocode:

Insert the following paragraph and pseudocode passage after the pseudocode passage of the second paragraph of 10.36.10:

CMMG STAs receiving any valid frame shall perform the following NAV update operation expressed using the following pseudocode:

```
NAV_TIMER_UPDATE(received_frame):

        UPDATE_OPTIONAL ← false

        If (received_frame = DMG DTS) {
                UPDATE_OPTIONAL ← true

        }
        If (received_frame(RA) ≠ This STA MAC address || UPDATE_OPTIONAL = true) {
                If (received_frame = DMG DTS) {
                        R_DST ← received_frame(NAV-DA)
                        R_SRC ← received_frame(NAV-SA)
                        R_CHANNEL ← received_frame(CHANNEL BANDWIDTH)
                } else if (received_frame = Ack) {
                        R_DST ← received_frame(RA)
                        R_SRC ← 0
                        NAV_CHANNEL ← received_frame(CHANNEL BANDWIDTH)
        } else {
                R_DST ← received_frame(RA)
                R_SRC ← received_frame(TA)
        }
                R_DUR ← received_frame(DUR)
                N_TIMER ← –1
        // Searching for a matching NAV timer
        For (x = 0; x < aMinNAVTimersNumber; x++) {
                If (received_frame = Ack || NAVSRC(x)=R_DST) {
                        If(NAVDST(x) = R_DST) {
                                N_TIMER ← x
                                Break
                        }
                        } else if (NAVSRC(x) = R_SRC && (NAVDST(x) = R_DST|| NAVDST(x) = 0)
                        ||(NAVSRC(x)=0 && NAVDST(x) = R_DST) ||
                        (NAVDST(x)=R_SRC && NAVSRC(x)=R_DST)) {
```

```
                N_TIMER ← x
                Break
            }
        }
        // No NAV timer has been found that matches the addresses
        If (N_TIMER < 0) {
            For (x = 0; x < aMinNAVTimersNumber; x++) {
                If (NAVSRC(x) = NULL && NAVDST(x) = NULL
                || NAV(x) = 0) {
                    NAVSRC(x) ← R_SRC
                    NAVDST(x) ← R_DST
                    NAV_CHNNAL(x) ← R_CHANNEL
                    N_TIMER ← x
                    Break
                }
            }
        }
        // Existing NAV timer found
        If (N_TIMER >= 0) {
            If (UPDATE_OPTIONAL = false) {
                NAV(N_TIMER) ← R_DUR
                NAV_CHNNAL(N_TIMER) ← R_CHANNEL
                If (received_frame = RTS) {
                    NAV_RTSCANCELABLE(N_TIMER) ← true
                } else {
                    NAV_RTSCANCELABLE(N_TIMER) ← false
                }
            } else if (UPDATE_OPTIONAL = true) {
                If ((implementation decision to update = true) ||
                (received_frame(RA) = This STA MAC address &&
                This STA MAC address = source DMG STA MAC address for current
                SP))) {
                    NAV_DTSCANCELABLE(N_TIMER) ← true
                    NAV(N_TIMER) ← R_DUR
                    NAV_CHNNAL(N_TIMER) ← R_CHANNEL
                    }
                }
            }
        } else {
            No change to NAV timers
        }
END OF NAVEND OF NAV_TIMER_UPDATE
```

Insert the following subclause, 10.36.11 (including Figure 10-57a), after 10.36.10:

10.36.11 Opportunistic transmission in alternative channel for CDMG STAs

When dot11OpportunisticTransmissionsActivated is true, an AP or PCP is capable of supporting the scheduling of opportunistic data transmission between two or more non-AP and non-PCP CDMG STAs that support such opportunistic transmission in a channel that is not the BSS's operating channel. The channel for such opportunistic transmission is termed the alternative channel while the BSS's operating channel is termed the dedicated channel as a contrast in this subclause. The spectrum access in the alternative channel is divided into three phases: monitor phase, transmission phase, and suspension phase. Scheduled transmission in the alternative channel shall start with the monitor phase, and then the three phases rotate cyclically until all the scheduled transmissions in the alternative channel are completed as illustrated in Figure 10-57a.

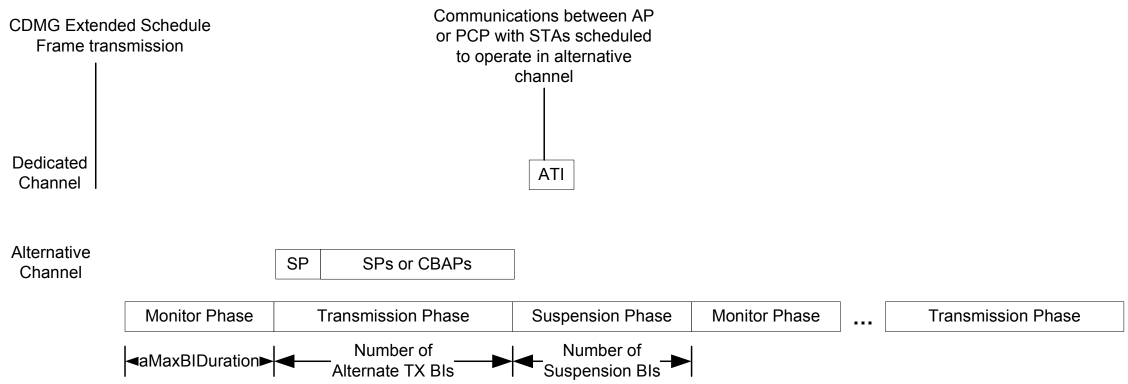


Figure 10-57a—Opportunistic transmission in alternative channels for CDMG STAs

The monitor phase shall last for at least aMaxBIDuration. During the monitor phase, a CDMG STA that is scheduled to operate in the alternative channel shall listen for the transmission of DMG Beacon frames in the alternative channel. If a CDMG STA receives one or more valid DMG Beacon frames with a BSSID different from its own, it shall abandon transmission during the transmission phase.

During the transmission phase, a CDMG STA may transmit frames according to the DTI transmission rules (10.36.4). A CDMG STA may continue to listen for the transmission of DMG Beacon frames in the alternative channel during the transmission phase when the CDMG STA is not transmitting. If a CDMG STA is not the source or destination STA in an access period, it may switch to the dedicated channel to receive the DMG Beacon frame or Announce frame send out by the AP or PCP to maintain synchronization with the AP or PCP.

During the suspension phase, a CDMG STA that is scheduled to operate in the alternative channel shall switch to the dedicated channel and be ready to receive transmission from the AP or PCP in the dedicated channel. The CDMG STA may receive the DMG Beacon frame or Announce frame transmitted by the AP or PCP to maintain synchronization with the AP or PCP during the suspension phase. If a CDMG STA receives a DELTS frame from the AP or PCP during the suspension phase, the CDMG STA should cease opportunistic transmission in the alternative channel.

The schedule of the transmission in the alternative channel is communicated through the CDMG Extended Schedule element (9.4.2.219). The AP or PCP shall transmit the CDMG Extended Schedule element in the Announce frame and/or DMG Beacon frame. The CDMG Extended Schedule element shall contain the scheduling information of all allocations in the alternative channel. The Number of Alternate TX BI field in the CDMG Extended Schedule element indicates the number of BIs that makes up the transmission phase. The Number of Suspension BI field in the CDMG Extended Schedule element indicates the number of BIs that makes up the suspension phase.

The access periods in the alternative channel may be scheduled to be either CBAPs or SPs but the first access period shall be an SP. The CBAPs in the alternative channel may be used by the AP or PCP to send more CDMG STAs to operate in the alternative channel after the initial setup. The source CDMG STA of the first SP in the alternative channel shall transmit a DMG Beacon frame at the start of the first transmission phase in the alternative channel and after every aMaxBIDuration within the transmission phase if the duration of the transmission phase exceeds aMaxBIDuration.

The AP or PCP should send a DMG CTS-to-self frame in the ATIs (10.36.3) during the suspension phase to each of the CDMG STAs scheduled to operate in the alternative channel. If a CDMG STA receives one or more DMG Beacon frames with a BSSID different from its own during the monitor phase, the CDMG STA shall respond with a DELTS frame to the AP or PCP with the Reason Code field (9.4.1.7) set to the value defined in 9.4.1.7 that indicates the alternative channel is occupied upon the reception of a DMG CTS-to-self frame from the AP or PCP during the ATI. If a transmission link in the alternative channel cannot be established during the transmission phase, the CDMG STA shall respond with a DELTS frame to the AP or PCP with the Reason Code field set to 67 to indicate that the transmission link establishment in alternative channel is failed. If the AP or PCP received a DELTS frame with the Reason Code field (9.4.1.7) set to 68 in an ATI, the AP or PCP shall transmit a DELTS frame to each of the CDMG STAs scheduled to operate in the alternative channel in the same ATI.

A CDMG AP or PCP may allocate a pair of STAs to perform SLS on an alternative channel. A CDMG STA may reuse the transmit sector indicated by the Sector Select field obtained from the operating channel, which is the primary channel on an alternative channel with the same channel width, and vice-versa. If an SPR frame with the Beamforming Training subfield equal to 1 is received from a CDMG initiator STA, the CDMG AP or PCP may configure a channel for the initiator and the responder designated by the initiator to perform BF training according to the AllocationType subfield in the SPR frame. The SPR frame contains channel allocation request in the AllocationType subfield and BF Control field for the initiator and responder that form a BF pair. If the NoPrimaryChannel subfield in the BF Control field is equal to 1 and the Beamforming Training subfield is equal to 1 in the SPR frame, the CDMG AP or PCP can allocate SPs on an alternative channel using the CDMG Extended Schedule element included in a DMG Beacon frame or an Announce frame for the initiator and the responder; otherwise, the CDMG AP or PCP should allocate SPs on the current operating channel. If the CDMG AP or PCP receives SPR frames from multiple pairs of initiators and responders, the CDMG AP or PCP may allocate time overlapping SPs on designated channels with different channel numbers for different pairs of STAs to perform an SLS.

Change the title of 10.37 as follows:

10.37 DMG <u>and CMMG</u> AP or PCP clustering

10.37.1 General

Change the first paragraph of 10.37.1 as follows (the dashed list remains unchanged):

An AP or PCP may use the AP or PCP clustering mechanism to improve spatial sharing and interference mitigation with other co-channel DMG BSSs. <u>An AP or PCP may use the AP or PCP clustering mechanism to improve spatial sharing and interference mitigation with other co-channel CMMG BSSs.</u> There are two types of clustering:

Change the third paragraph of 10.37.1 as follows:

A STA is decentralized AP or PCP clustering capable if it sets the Decentralized AP or PCP Clustering field to 1 within the DMG AP Or PCP Capability Information field in the DMG Capabilities element. <u>A STA is decentralized AP or PCP clustering capable if it sets the Decentralized AP or PCP Clustering field to 1 within the CMMG AP or PCP Capability Information field in the CMMG Capabilities element</u>. A STA is centralized AP or PCP clustering capable if it sets the Centralized AP or PCP Clustering field to 1 within the DMG AP Or PCP Capability Information field in the DMG Capabilities element. <u>A STA is centralized AP or PCP clustering capable if it sets the Centralized AP or PCP Clustering field to 1 within the CMMG AP or</u>

PCP Capability Information field in the CMMG Capabilities element. The AP or PCP employs the Clustering Control field and ECAPC Policy Enforced field defined in 9.3.4.2 to configure the use of AP or PCP Clustering. A decentralized AP or PCP clustering capable or centralized AP or PCP clustering capable AP or PCP that transmits the Clustering Control field is decentralized clustering enabled or centralized clustering enabled, respectively.

10.37.3 Cluster maintenance

10.37.3.4 Centralized AP or PCP cluster MAC requirements

Change the third paragraph of 10.37.3.4 as follows:

If the most recent ECAPC Policy element, received by a non-AP and non-PCP STA in a BSS from the member AP, S-AP, or member PCP of the BSS, has the TXSS CBAP Enforced field set to 1, then the non-AP and non-PCP STA shall perform each of its TXSSs in the DTI within one or more TXSS CBAPs. If the non-AP and non-PCP STA is the source DMG STA of an SP and if the non-AP and non-PCP STA determines that it needs to perform a TXSS before continuing to transmit to the destination DMGSTA of the SP, then the non-AP and non-PCP STA should truncate the SP (see 10.36.8). If the non-AP and non-PCP STA is the source CMMG STA of an SP and if the non-AP and non-PCP STA determines that it needs to perform a TXSS before continuing to transmit to the destination CMMG STA of the SP, then the non-AP and non-PCP STA should truncate the SP.

Change the fourth paragraph of 10.37.3.4 as follows:

A TXSS CBAP shall last from T_{Start} to T_{End}, as defined below, excluding any time that overlaps a BHI or an SP that has source and destination DMG AIDs set to 255 (such as for a Beacon SP). A TXSS CBAP shall last from T_{Start} to T_{End}, as defined below, excluding any time that overlaps a BHI or an SP that has source and destination CMMG AIDs set to 255 (such as for a Beacon SP).

10.37.5 Decentralized AP or PCP cluster request

Change the third paragraph of 10.37.5 as follows:

If the non-AP and non-PCP STA does not receive a DMG Beacon frame from its AP or PCP with decentralized AP or PCP clustering enabled after dot11ClusterEnableTime following the transmission to its AP or PCP of a Cluster Report element with the Cluster Request subfield set to 1, the non-AP and non-PCP STA may transmit an Announce frame including the last Extended Schedule element transmitted by the AP or PCP. If the Announce frame is transmitted, it shall use MCS 0, and the TA field shall be set to the broadcast address. If a DMG STA receives an Announce frame with the TA field set to the broadcast address and with the BSSID field different from the BSSID of its BSS, the STA may send a Cluster Report element containing the Extended Schedule element within the received Announce frame to its AP or PCP, which might be used by the AP or PCP to reschedule SPs in portions of the beacon interval that are nonoverlapping in time with the SPs contained in the Extended Schedule element reported by the STA. If a CMMG STA receives an Announce frame with the TA field set to the broadcast address and with the BSSID field different from the BSSID of its BSS, the STA may send a Cluster Report element containing the Extended Schedule element within the received Announce frame to its AP or PCP, which might be used by the AP or PCP to reschedule SPs in portions of the beacon interval that are nonoverlapping in time with the SPs contained in the Extended Schedule element reported by the STA.

Insert the following subclause, 10.37a (including Figure 10-58a through Figure 10-58d), after 10.37.5:

10.37a CDMG AP or PCP clustering

10.37a.1 General

A CDMG AP or PCP may use the CDMG AP or PCP clustering mechanism to improve spatial sharing and interference mitigation with other co-channel DMG or CDMG BSSs.

A clustering enabled AP or PCP that is operating on a 2.16 GHz or 1.08 GHz channel and transmitting DMG Beacon frames with the DBC Option subfield of the Dynamic Bandwidth Control element set to 1 (10.60.2.2) is able to start a decentralized AP or PCP cluster or a centralized AP or PCP cluster on a 2.16 GHz channel following the rules as described in 10.37.

A clustering enabled AP or PCP that is operating on a 1.08 GHz channel and transmitting DMG Beacon frames with the DBC Option subfield of the Dynamic Bandwidth Control element set to 0 (10.60.2.2) is able to start an AP or PCP cluster on a 1.08 GHz channel. Starting an AP or PCP cluster on a 1.08 GHz channel shall follow the rules defined in 10.37 and in this subclause.

If an AP or PCP cluster starts on a 1.08 GHz channel, the S-AP or S-PCP shall not only transmit its DMG Beacon frame during the first Beacon SP (10.37.1) on this 1.08 GHz channel but also transmit the DMG Beacon frame during the notification period (NP) of each allocated quiet period (QP) on the corresponding 2.16 GHz common channel as described in 10.60. Moreover, according to the rules in 10.60, the S-AP or S-PCP shall set its beacon interval on the 2.16 GHz common channel as an integer multiple of the beacon interval on the 1.08 GHz channel in terms of TUs, and the maximum length of beacon interval on the 1.08 GHz channel can be given as the same length of the beacon interval on the 2.16 GHz channel.

The member AP or member PCP of a cluster starting on a 1.08 GHz channel shall not allocate QP on the 2.16 GHz common channel to transmit its DMG Beacon frame if there is no legacy non-AP and non-PCP DMG STA within its BSS or it does not involve in a synchronization pair with another AP or PCP operating in the adjacent 1.08 GHz channel. Otherwise, the member AP or member PCP shall transmit its DMG Beacon frame during its NP of the allocated QP on the 2.16 GHz common channel, similar to the S-AP or S-PCP.

10.37a.2 Cluster formation

10.37a.2.1 Decentralized CDMG AP or PCP cluster formation

A decentralized clustering enabled AP or PCP starts a decentralized AP or PCP cluster on a 1.08 GHz channel by becoming an S-AP or S-PCP, subject to the absence of existing clusters on this 1.08 GHz channel as described below and in 10.37.2.1.

The S-AP or S-PCP of an AP or PCP cluster starting on a 1.08 GHz channel shall set the DMG Parameters field and the Clustering Control field following the rules defined in 10.37.2.1 and also set the first bit of the Clustering Status subfield contained in the Dynamic Bandwidth Control element to 1.

A decentralized clustering enabled AP or PCP that receives a DMG Beacon frame from an S-AP or S-PCP on either a 2.16 GHz channel or a 1.08 GHz channel shall know the exact channel on which this S-AP or S-PCP selects to start a cluster through the Channel Splitting subfield, Clustering Status subfield, and the Channel Number field contained in the Dynamic Bandwidth Control element.

If an existing AP or PCP cluster is operating on a 2.16 GHz channel, the decentralized clustering enabled AP or PCP shall monitor the corresponding 2.16 GHz channel and then follow the procedures defined in 10.37.2.1 to become a member AP or member PCP of this cluster.

If the decentralized clustering enabled AP or PCP receives a DMG Beacon frame containing the Clustering Control field from an S-AP or S-PCP on a 1.08 GHz channel, the AP or PCP shall monitor the corresponding 1.08 GHz channel during each Beacon SP according to the received cluster synchronization and control information to listen whether the Beacon SPs are occupied by other member APs or member PCPs. If an empty Beacon SP is discovered, the AP or PCP shall follow the same procedures defined in 10.37.2.1 to become a member AP or member PCP of this cluster.

A decentralized clustering enabled AP or PCP shall not become a member of a cluster starting on a 1.08 GHz channel if no Beacon SP is determined to be empty during aMinChannelTime, in which case, subject to the requirements described in 10.37.2.1, then the AP or PCP may become the S-AP or S-PCP of a new cluster, or may cease its activity on this 1.08 GHz channel, or may request to operate on the unoccupied adjacent 1.08 GHz channel within the 2.16 GHz common channel (10.60.2.3), and, if desired, attempt operation on a different 2.16 GHz or 1.08 GHz channel.

The AP or PCP of a decentralized AP or PCP cluster shall not transmit or schedule transmissions during a Beacon SP that is not its own Beacon SP and a QP duration that is not its own QP.

Figure 10-58a illustrates an example of a decentralized AP or PCP cluster starting on the 1.08 GHz channel 35 while the adjacent 1.08 GHz channel 36 is unoccupied. The S-AP or S-PCP and member AP 3 or member PCP 3 with a BSS in which there is at least one DMG STA transmit DMG Beacon frames during the NPs of the allocated QPs on the 2.16 GHz channel 2 and their own Beacon SPs on channel 35, respectively. Other member APs or member PCPs transmit DMG Beacon frames only during their own Beacon SPs on channel 35.

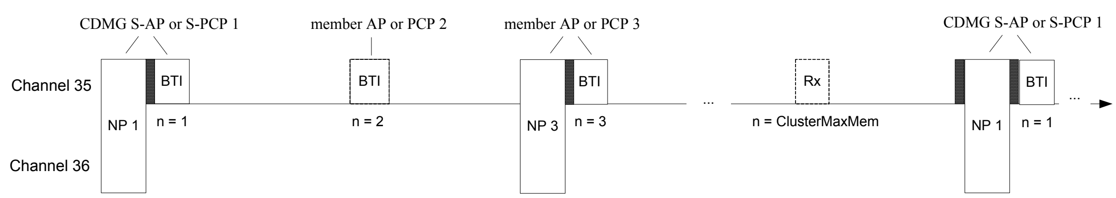


Figure 10-58a—Example of a decentralized AP or PCP cluster on a 1.08 GHz channel

Figure 10-58b illustrates an example of two decentralized AP or PCP clusters starting on the two adjacent 1.08 GHz channel 35 and channel 36, respectively. Two S-APs or S-PCPs form a synchronization pair under the first mode of DBC mechanism (10.39a) and transmit DMG Beacon frames during their own NPs of the allocated QPs on the 2.16 GHz channel 2 and the Beacon SPs on the 1.08 GHz channel 35 and channel 36. Other member APs or member PCPs APs transmit DMG Beacon frames only during their own Beacon SPs on the corresponding 1.08 GHz channels.

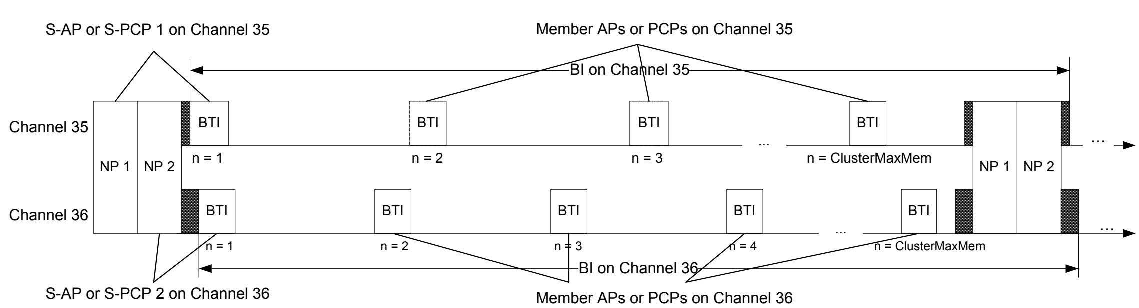


Figure 10-58b—Example of decentralized clusters for two APs or PCPs of a synchronization pair

The member AP or member PCP operating on a 1.08 GHz channel shall select a beacon interval length on the 1.08 GHz channel that is equal to the beacon interval length of its S-AP or S-PCP on the same channel.

The AP or PCP operating on the 1.08 GHz channel should determine its beacon interval on the 2.16 GHz channel to be equal to the beacon interval of the S-AP or S-PCP on the 2.16 GHz channel according to the cluster synchronization and control information of the S-AP or S-PCP. The AP or PCP operating on the 1.08 GHz channel should continue transmitting the DMG Beacon frames on the 2.16 GHz channel during the beacon SP according to the beacon interval on the 2.16 GHz channel. The AP or PCP operating on the 1.08 GHz channel shall switch back to the 1.08 GHz channel to transmit DMG Beacon frames during the BTI on the 1.08 GHz channel according to the beacon interval on the 2.16 GHz channel.

If a member AP or member PCP does not involve in a synchronization pair with another AP or PCP (10.60.2.3), it shall set the beacon interval length on the 2.16 GHz channel as an integer multiple of its beacon interval length on the 1.08 GHz channel. Otherwise, if the member AP or member PCP is involved in a synchronization pair with another AP or PCP operating in the adjacent 1.08 GHz channel, it shall adjust its beacon interval length on the 2.16 GHz channel as an integer multiple of its beacon interval length on the 1.08 GHz channels and also notify the neighboring AP or PCP that is involved in the synchronization pair to adjust the beacon interval on the 2.16 GHz channel to the same value through a DMG BSS Parameter Change element within the DMG Beacon frame transmitted in its NP of the allocated QP on the 2.16 GHz common channel following the rules in 11.31.3. In this case, subject to the requirement described in 10.60, the neighboring AP or PCP may further adjust its beacon interval on the 1.08 GHz channel as an integer factor of the new beacon interval length on the 2.16 GHz channel in units of TUs. The procedures of the adjusting BI and CDMG SBBI for AP or PCP 1 and AP or PCP 2 that is involved in a synchronization pair should be as follows:

a) If the AP or PCP 1 detected an empty Beacon SP on the 1.08 GHz channel, AP or PCP 1 shall change the current beacon interval length BI 1 to BI 2 on the 2.16 GHz channel to align the beginning of the first BTI on the 1.08 GHz channel after BI 2 duration with the beginning of the empty Beacon SP.
b) Determine whether the ratio of BI 2 divided by CDMG SBBI of the S-AP or S-PCP is an integer. If the ratio of BI 2 divided by CDMG SBBI of the S-AP or S-PCP is an integer, the AP or PCP 1 shall adjust CDMG SBBI 1 to equal the CDMG SBBI of the S-AP or S-PCP. Otherwise, the AP or PCP 1 shall change its beacon interval length BI 2 to BI 3 on 2.16 GHz channel during its next NP 1 and set its CDMG SBBI 1 to the CDMG SBBI of S-AP or S-PCP during the BTI to make the ratio of BI 3 divided by CDMG SBBI of the S-AP or S-PCP an integer. For both cases, the AP or PCP 1 shall notify the AP or PCP 2 of the new BI 2 or BI 3 during the first QP at the end of BI 2 or BI 3, where the QP comprises the NP and a guard interval (GI) used for channel switching, and the AP or PCP 2 should also adjust its SBBI 2 to make the ratio of BI 2 or BI 3 divided by CDMG SBBI 2 an integer.
c) The AP or PCP 1 transmits the DMG Beacon frame including the Clustering Control field during the empty Beacon SP on the 1.08 GHz channel to join the intended 1.08 GHz cluster as a member AP or member PCP.

An example of adjusting BI and CDMG SBBI for step a) and b) is illustrated in Figure 10-58c. For step a) and step b), changing BI on the 2.16 GHz channel or changing SBBI on the 1.08 GHz channel is completed by AP or PCP 1 by negotiation with AP or PCP 2 in a notification period (NP) that comprises NP1 and NP2. AP or PCP 1 transmits the DMG Beacon frame to AP or PCP 2 in NP1, and AP or PCP 2 transmits the DMG Beacon frame to AP or PCP 1 in NP2.

A synchronized AP or PCP is a CDMG AP or PCP that is operating on a 1.08 GHz channel but still transmitting its DMG Beacon frames on the relevant 2.16 GHz channel with the AP or PCP Role subfield of the Dynamic Bandwidth Control element (9.4.2.218) set to 1 and synchronizing with the synchronizing AP or PCP on the relevant 2.16 GHz channel.

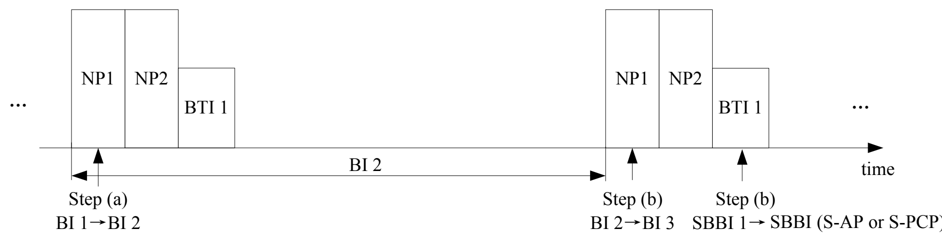


Figure 10-58c—Example of joining the CDMG AP or PCP cluster for a CDMG AP or PCP involved in a synchronization pair with another AP or PCP

A synchronizing AP or PCP is a CDMG AP or PCP that is operating on a 1.08 GHz channel but still transmitting its DMG Beacon frames on the relevant 2.16 GHz channel with the AP or PCP Role subfield of the Dynamic Bandwidth Control element (9.4.2.218) set to 0 and providing synchronization service to a synchronized AP or PCP on the relevant 2.16 GHz channel.

If an AP or PCP involved in a synchronization pair is a synchronized AP or PCP and intends to join to a co-channel AP or PCP cluster, it shall set the AP or PCP Role subfield within the Dynamic Bandwidth Control element to 0 to exchange the role with the synchronizing AP or PCP before joining the co-channel cluster. When the AP or PCP Role subfield is changed, the synchronized AP or PCP shall include the Cluster Switch Announcement element in the DMG Beacon frame to indicate the time that the AP or PCP role exchange occurs.

If an AP or PCP that is involved in a synchronization pair intends to join a discovered cluster or intends to start a cluster on the 2.16 GHz common channel, it should send a Cluster Switch Announcement element included in the DMG Beacon frame during its NP to notify the peer AP or PCP involved in the synchronization pair to monitor the common 2.16 GHz channel and join the cluster on 2.16 GHz channel if an empty Beacon SP can be found. After the Cluster Switch Announcement element is transmitted, the AP or PCP should cease transmission during its NP.

When a decentralized clustering enabled AP or PCP operating on 1.08 GHz channel receives a DMG Beacon frame that contains the Clustering Control field in the Cluster Switch Announcement element from its neighboring AP or PCP of a synchronization pair to indicate the presence of a cluster on the 2.16 GHz common channel, it may monitor this 2.16 GHz channel to become a member AP or member PCP following the procedures described in 10.37.2.1.

When a decentralized clustering enabled AP or PCP operating on a 1.08 GHz channel still experiences poor channel conditions after performing all the actions in an attempt to mitigate any interference, it may broadcast one or more Cluster Probe elements using the DMG Beacon frame or Probe Request frame to detect the presence of a cluster actively on the 2.16 GHz common channel during its NPs, SPs, or CBAPs. In addition to transmitting Cluster Probe elements included in DMG Beacon frames on the 2.16 GHz common channel during NPs, the AP or PCP operating on a 1.08 GHz channel may reserve multiple SPs during DTI and switch to the 2.16 GHz channel during each of the SPs to transmit Cluster Probe elements included in Probe Request frames on the 2.16 GHz common channel.

For an AP or PCP that is operating on a 1.08 GHz channel and is involved in a synchronization pair, the AP or PCP may transmit Cluster Probe elements on the common 2.16 GHz channel, using Probe Request frames during its reserved SPs or using DMG Beacon frames during its NPs. The SPs for receiving a Probe Response frame from S-PCP or S-AP can be scheduled in the NP of the next BI on the 2.16 GHz channel or in a DTI. The peer AP or PCP that is involved in the synchronization pair shall also reserve the same SPs with destination AIDs set to 255 to listen for a Probe Response frame and to avoid interferences to the SPs used for cluster probe.

The S-AP or S-PCP that is operating on the 2.16 GHz common channel and receives a Cluster Probe element shall respond with one or more Probe Response frames including an Extended Cluster Report element in each SP scheduled according to the Cluster Probe element to indicate its presence by including the cluster synchronization and control information of the S-AP or S-PCP in the Extended Cluster Report element. The Cluster Probe element contains timing information for the CDMG S-AP or S-PCP operating on the 2.16 GHz channel to transmit the Probe Response frame for the Cluster Probe element. This element defines a sequence of SPs that are scheduled in a DTI or the next NP by both the cluster probe requesting AP or PCP and responder AP or PCP for receiving and transmitting the response frames. The multiple SPs are reserved corresponding to the SPs during which the Cluster Probe elements are transmitted.

After receiving a Probe Response frame from an S-AP or S-PCP operating on the 2.16 GHz common channel, during at least one of the reserved SPs in a DTI, the decentralized clustering enabled AP or PCP operating on 1.08 GHz channel may switch to the 2.16 GHz common channel, by using the cluster synchronization and control information in the Extended Cluster Report element in the Probe Response frame of the S-AP or S-PCP operating on the 2.16 GHz channel, and attempt to discover an empty Beacon SP. If an empty Beacon SP exists, then the AP or PCP may transmit DMG Beacon frames during the empty Beacon SP to become a member AP or member PCP of this cluster following the procedures described in 10.37.2.1.

If two APs or PCPs involved in a synchronization pair both receive an Extended Cluster Report element and discover an empty Beacon SP during their reserved SPs at the same time, the AP or PCP that first transmits a Cluster Switch Announcement element during NP should join the empty Beacon SP with priority, and the peer AP or PCP should monitor the 2.16 GHz channel for another aMinChannelTime to find another empty Beacon SP.

If the decentralized clustering enabled AP or PCP on the 1.08 GHz channel does not receive any Probe Response frame from an S-AP or S-PCP during the reserved SPs on the 2.16 GHz channel in the whole DTI, it may reschedule multiple SPs whose positions are adjusted stochastically in the following DTI.

10.37a.2.2 Centralized CDMG AP or PCP cluster formation

In order to become an S-AP, a centralized clustering enabled CDMG STA that is operating on a 2.16 GHz channel or a 1.08 GHz channel and is stationary with respect to its local environment shall successfully perform both the configuration step and verification step in order and take the actions following the rules as described in 10.37.2.2.

If at least one DMG Beacon frame that has the ECAPC Policy Enforced field set to 1 and is sent by an S-AP or member AP or member PCP from another ECAPC is received during the monitoring period, the centralized clustering enabled CDMG STA shall follow the rules as described in 10.37.2.2.

The remaining available channels for a centralized CDMG AP or PCP cluster are channels 3, 37, and 38. Channels 2, 35, and 36 are the channels upon which the S-AP is excluded from operating. The channels 3, 37, and 38 that interfere with each other form a channel set. The channel set available for a centralized CDMG AP or PCP cluster is channel {3, 37, 38}.

The functions of a CDMG CCSR shall cover the channel set. The CDMG CCSR shall provide coordination services for all the S-APs operating on the channels of the channel set {3, 37, 38} within the CCSS to mitigate interference. The CDMG CCSR should provide an S-AP with the cluster information of other S-APs. Thus, each S-AP operating on a channel within the channel set can obtain the same cluster information from the CDMG CCSR.

After receiving a DMG Beacon frame including cluster information transmitted by an S-AP, a centralized clustering enabled AP or PCP that intends to become a member AP or member PCP shall successfully perform the following steps in order:

a) The AP or PCP shall monitor the channel for DMG Beacon frames during each Beacon SP over an interval of length at least aMinChannelTime to find an empty Beacon SP and measure the status of each Beacon SP and the signal quality (RCPI and RSNI) of the received DMG Beacon frames based on the received cluster information of the S-AP. The AP or PCP can determine the timing start point of each Beacon SP over a BI of the S-AP based on the Next BTI Offset field, the Reported BI Duration field, and the Reported Clustering Control field. Thus, the AP or PCP can measure each Beacon SP over a BI of the S-AP based on the timing start point of each Beacon SP over a BI and obtain the status of each Beacon SP and signal quality over a BI.
b) If an empty Beacon SP is discovered, the second non-AP and non-PCP STA shall attempt to associate with the S-AP and thereby receive an Announce frame from the S-AP. The contents of the Announce frame are passed to the AP or PCP. All the centralized cluster information of the S-AP(s) operating on the channels in the same channel set except the current S-AP shall be included in the Announce frame. The cluster information of the other S-AP(s) can be conveyed in the Extended Cluster Report elements.
c) The CDMG AP or PCP should determine whether to join the current S-AP's cluster or other S-AP(s)'s cluster based on the signal quality, the states of Beacon SPs during a BI indicated by the Available Cluster Offset Bitmap field in the ECAPC Policy element of the S-AP or the member APs or member PCPs of the current S-AP's cluster, and other S-AP(s)'s cluster information. If the AP or PCP elects to join the current cluster, it proceeds to step d); otherwise, the AP or PCP monitors the channels for DMG Beacon frames during each Beacon SP of all the centralized clusters over an interval of length at least aMinChannelTime using the cluster information from the current S-AP. The CDMG AP or PCP may identify a new intended cluster based on the signal quality of the DMG Beacon frames or the Available Cluster Offset Bitmap field in the ECAPC Policy element of the other clusters, if the intersection of 1) the Cluster Time Offset indices of the empty Beacon SPs with 2) the indices indicated by the Available Cluster Offset Bitmap field shows more common nonempty Beacon SPs. The second non-AP and non-PCP STA shall disassociate with the current S-AP and associate with the S-AP of the intended cluster, receive the Announce frame from the S-AP, and pass the contents of the Announce frame to the AP or PCP.
d) Upon receiving an Announce frame that includes the ECAPC Policy element, the AP or PCP shall select a cluster time offset index from the intersection of the cluster time offset indices of the empty Beacon SPs with the indices indicated by the Available Cluster Offset Bitmap field in the ECAPC Policy element. If the intersection is empty, the AP or PCP shall select a cluster time offset index of an empty Beacon SP. The selected cluster time offset index is passed to the second non-AP and non-PCP STA.
e) The second non-AP and non-PCP STA shall respond to the Announce frame with an Information Response frame that includes the Cluster Time Offset element containing the Cluster Time Offset Index field set to the selected index.
f) The AP or PCP shall join the cluster of S-AP at the selected cluster time offset on the channel of the S-AP and transmit DMG Beacon frames with the AP or PCP Clustering Control field.

After joining the centralized AP or PCP cluster, the CDMG member AP or member PCP shall transmit its DMG Beacon frames and include the ECAPC Policy element in (Re)Association Response, Announce, and Information Response frames following the rules as described in 10.37.2.2.

10.37a.3 Cluster maintenance

10.37a.3.1 General cluster maintenance

Regardless of whether a cluster starts on a 2.16 GHz channel or a 1.08 GHz channel, the member AP or member PCP is able to maintain synchronization with the S-AP or S-PCP and other member APs or member PCPs through receiving DMG Beacon frames from the S-AP or S-PCP on this channel.

If an AP or PCP cluster starts on a 1.08 GHz channel and the AP or PCP of this cluster involves in a synchronization pair with another AP or PCP operating in the adjacent 1.08 GHz channel at the same time, this pair of APs or PCPs shall also maintain synchronization according to the rules described in 10.60 unless one of them ceases its BSS.

10.37a.3.2 Decentralized CDMG AP or PCP cluster maintenance

In the case when the S-AP or S-PCP of a decentralized AP or PCP cluster on a 1.08 GHz channel is lost, or appears to a member AP or member PCP to have been lost, the S-AP or S-PCP handover procedures shall follow the rules in 10.37.3.2. In addition, the new S-AP or S-PCP shall also transmit the DMG Beacon frame during its NP of the allocated QP on the 2.16 GHz common channel as described in 10.60.5, even if there is no legacy non-AP and non-PCP DMG STA within its BSS or it does not involve in a synchronization pair with another AP or PCP operating in the adjacent 1.08 GHz channel.

If the S-AP or S-PCP of a decentralized AP or PCP cluster detects the presence of the S-AP or S-PCP of another decentralized AP or PCP cluster through receiving a DMG Beacon frame on either a 2.16 GHz channel or a 1.08 GHz channel or receiving a Probe Response frame including the Extended Cluster Report element on a 2.16 GHz channel with the DBC Present field set to 1 and the Channel Splitting subfield set to 1, it should become a member AP or member PCP of the other cluster on the corresponding channel according to the procedures described in 10.37a.2 if the values of its Adjacent Channel Occupancy subfield, Clustering Status subfield, and the Synchronizing AP or PCP MAC Address subfield in the Dynamic Bandwidth Control element are higher than those of the other S-AP or S-PCP.

If the S-AP or S-PCP of a decentralized AP or PCP cluster detects the presence of the S-AP or S-PCP of another decentralized AP or PCP cluster through receiving a DMG Beacon frame on either a 2.16 GHz channel or a 1.08 GHz channel or receiving a Probe Response frame including the Extended Cluster Report element on a 2.16 GHz channel with the DBC Present field set to 1 and the Channel Splitting subfield set to 0, it should become a member AP or member PCP of the other cluster on the corresponding channel according to the procedures described in 10.37a.2 if its Channel Splitting subfield is 1 or its Channel Splitting subfield is 0, but the MAC Address is higher than that of the other S-AP or S-PCP.

If the S-AP or S-PCP of a decentralized AP or PCP cluster detects the presence of the DMG S-AP or S-PCP of another decentralized AP or PCP cluster through receiving a DMG Beacon frame on a 2.16 GHz channel with the DBC Present field set to 0, it should become a member AP or member PCP of the other cluster on this 2.16 GHz channel according to the procedures described in 10.37.2 if its MAC address is higher than that of the other DMG S-AP or S-PCP.

If the S-AP or S-PCP operating on a 1.08 GHz channel detects the presence of the S-AP or S-PCP of another decentralized AP or PCP cluster starting on the 2.16 GHz common channel and intends to become a member AP or member PCP of the other cluster, it may transmit a DMG Beacon frame containing the Cluster Switch Announcement element to its member APs or member PCPs before it switches to the 2.16 GHz common channel. After that, the S-AP or S-PCP may continue transmitting DMG Beacon frames on the 1.08 GHz channel within a time period of (aMinBTIPeriod × BI + aMinChannelTime) to maintain the time reference for the cluster, where BI equals to the Reported BI Duration field in the Cluster Switch Announcement element. Then it shall monitor the 1.08 GHz channel for DMG Beacon frames within the next time interval of (aMinChannelTime + CDMG SBBI), where CDMG SBBI is its beacon interval on the 1.08 GHz channel.

If no DMG Beacon frames are received over the monitoring period, the S-AP or S-PCP shall cease operation on the 1.08 GHz channel. Otherwise, it may use the cluster coordination mechanism described in 10.37a.3.3 to mitigate interference between the cluster operating on the 1.08 GHz channel and the cluster operating on the 2.16 GHz common channel.

Upon receiving a DMG Beacon frame including a Cluster Switch Announcement element on a 1.08 GHz channel, a member AP or member PCP should switch to the corresponding 2.16 GHz common channel to become a member AP or member PCP of the cluster operating on this 2.16 GHz channel following the procedure described in 10.37.2.1. If the AP or PCP cannot detect the presence of the S-AP or S-PCP of another decentralized AP or PCP cluster operating on the 2.16 GHz channel or cannot discover an empty Beacon SP, it should switch back to the former 1.08 GHz channel. After that, the decentralized clustering enabled AP or PCP may monitor this 1.08 GHz channel and follow the same procedures defined in 10.37.2.1 to become a member AP or member PCP of the cluster corresponding to the former S-AP or S-PCP or start an S-AP or S-PCP handover process according to 10.37.3.2.

10.37a.3.3 Cluster coordination

The cluster coordination mechanism allows a CDMG S-AP or S-PCP of a decentralized cluster operating on the 1.08 GHz channel to be a member AP (or member PCP) or S-AP (or S-PCP) of a decentralized cluster operating on the 2.16 GHz channel simultaneously by transmitting and receiving DMG Beacon frames within both clusters. By this means, cluster synchronization and control information can be exchanged to mitigate interference and improve spatial sharing.

In the case when a decentralized clustering enabled CDMG AP or PCP using cluster coordination mechanism, it shall maintain schedule information for both clusters (i.e., beacon intervals, Beacon SPs or SPs) to switch alternatively between the 1.08 GHz channel and 2.16 GHz channel. For example, it should switch to the 2.16 GHz channel prior to a Beacon SP allocated on the 2.16 GHz channel and transmit or receive the DMG Beacon frames.

The decentralized clustering enabled CDMG AP or PCP using cluster coordination mechanism should schedule at least one SP within the cluster operating on the 2.16 GHz channel that has the source and destination DMG AIDs set to 255 and the AllocationType subfield set to 2 indicating the Beacon SP of the synchronization CDMG AP or PCP of the cluster operating on the 1.08 GHz channel. In addition, it may schedule more SPs indicating other nonempty Beacon SPs of the cluster operating on the 1.08 GHz channel.

As being an S-AP or S-PCP of the cluster operating on the 1.08 GHz channel, the AP or PCP using coordination mechanism shall adjust its TBTT to avoid overlapping with any Beacon SP of the cluster operating on the 2.16 GHz channel. In addition, it should schedule multiple SPs within the cluster operating on the 1.08 GHz channel that has the source and destination DMG AIDs set to 255 and the AllocationType subfield set to 0 indicating the schedule information of a nonempty Beacon SP_n of the cluster operating on the 2.16 GHz channel.

If a member AP or member PCP of a cluster operating on the 1.08 GHz channel receives an Extended Schedule element from an S-AP or S-PCP with the same cluster ID that includes at least one Allocation field with the AllocationType subfield set to 0 and the source and destination AIDs set to 255, it may switch to the 2.16 GHz channel according to the schedule information in an attempt to receive a DMG Beacon frame.

10.37a.3.4 Centralized CDMG AP or PCP cluster maintenance

In the case when the S-AP or S-PCP of a centralized AP or PCP cluster on a 1.08 GHz channel is lost, or appears to a member AP or member PCP to have been lost, the S-AP handover procedures shall follow the rules in 10.37.3.3. In addition, the new S-AP or S-PCP shall also transmit a DMG Beacon frame during its NP of the allocated QP on the 2.16 GHz common channel as described in 10.60.5, even if there is no legacy non-AP and non-PCP DMG STA within its BSS or it does not involve in a synchronization pair with another AP or PCP operating on the adjacent 1.08 GHz channel.

If a CDMG CCSR detects that a new S-AP that is joining the CCSS is a DMG AP or a CDMG AP operating on the 2.16 GHz channel and there is at least one S-AP operating on a 1.08 GHz channel in its CCSS, the CDMG CCSR shall announce the cluster information (including the cluster ID, cluster synchronization and control information, and the channel number of the new S-AP operating on the 2.16 GHz common channel) to each S-AP operating on 1.08 GHz channel to facilitate the detection of the presence of the new S-AP for the S-APs operating on 1.08 GHz channel.

If a CDMG S-AP operating on a 1.08 GHz channel receives the cluster information of the new S-AP operating on 2.16 GHz channel from the CCSR, it should measure the state and the signal quality of each Beacon SP and determine whether to join the centralized cluster of the new S-AP based on the state or signal quality of each Beacon SP.

The S-AP shall broadcast the cluster information of the new S-AP to all the member APs or member PCPs in its centralized cluster using the Extended Cluster Report element indicated in the DMG Beacon frame. The member APs or member PCPs on the 1.08 GHz channels should determine whether to join the centralized cluster of the new S-AP based on the cluster information and the monitoring results of the new S-AP operating on the 2.16 GHz channel.

If an S-AP or a member AP or member PCP operating on a 1.08 GHz channel decides to join the centralized cluster of the new S-AP operating on a 2.16 GHz channel, the S-AP or member AP or member PCP shall transmit a Cluster Switch Announcement element to all its cluster members using the DMG Beacon frame to broadcast the cluster information and its cluster switching determination to all the member APs or member PCPs in the centralized cluster. The remaining member APs or member PCPs can update the Available Cluster Offset Bitmap field by using the Cluster Switch Announcement element transmitted by a member AP or member PCP.

10.37a.3.5 Centralized CDMG AP or PCP cluster MAC requirements

Centralized CDMG AP or PCP cluster MAC requirements shall follow the rules described in 10.37.3.4.

10.37a.4 Cluster report and rescheduling

Regardless of whether an AP or PCP cluster starts on a 2.16 GHz channel or a 1.08 GHz channel, a CDMG STA shall follow the rules defined in 10.37.4 for the cluster report and rescheduling.

When an AP or PCP operating on a 1.08 GHz channel still experiences poor channel conditions after performing all the actions in an attempt to mitigate any interference, it may send an Information Request frame to one of the non-AP and non-PCP STAs within its BSS to monitor the corresponding 2.16 GHz common channel for a cluster monitoring period defined in 10.37.3.2. The non-AP and non-PCP STA operating on a 1.08 GHz channel that receives a DMG Beacon frame on the 2.16 GHz common channel shall report the monitoring results through sending a Cluster Report element contained in an Announce frame or Information Response frame to the AP or PCP if the received DMG Beacon frame meets the conditions given in 10.37.4.

Upon receiving a Cluster Report element included in the Announce frame from a non-AP and non-PCP STA operating on the 1.08 GHz channel with the Cluster Report field equal to 1 and the Cluster Channel Number field equal to 0, a decentralized cluster enabled AP or PCP operating on a 1.08 GHz channel may reserve multiple SPs on the 1.08 GHz channel to identify whether there is an empty Beacon SP. The AP or PCP may reschedule SPs and CBAPs in its beacon interval, or move the BTI if the clustering enabled AP or PCP is an S-AP or S-PCP in a decentralized AP or PCP cluster, or change the cluster time offset if the clustering enabled AP or PCP is a member AP or member PCP, or perform other actions, in an attempt to mitigate any interference from the transmissions as indicated in the received Cluster Report element. The AP or PCP may also create SPs in its beacon interval with the source and destination AIDs set to 255 to eliminate transmissions during specific periods in the beacon interval. In addition, the AP or PCP operating on a 1.08 GHz channel can reserve multiple SPs in a DTI based on the clustering synchronization and control information included in the Cluster Report element, monitoring the Beacon SPs on the 2.16 GHz channel, to identify whether there is an empty Beacon SP of the decentralized cluster operating on the channel indicated by the Cluster Channel Number field.

Upon receiving a Cluster Report element from a non-AP and non-PCP STA with the Cluster Report field set to 1 and the Cluster Channel Number field set to 0, a clustering enabled AP or PCP that is an S-AP or S-PCP or a member AP or member PCP may switch to the corresponding 2.16 GHz common channel and discover an empty Beacon SP to become a member AP or member PCP of this cluster following the procedures described in 10.37a.3.2. The AP or PCP should also broadcast a DMG Beacon frame containing the Cluster Switch Announcement element to other APs or PCPs of the same cluster before it switches to the 2.16 GHz common channel.

10.37a.5 Decentralized AP or PCP cluster request

Regardless of whether a BSS starts on a 2.16 GHz channel or a 1.08 GHz channel, a CDMG STA shall follow the rules defined in 10.37.4 for the cluster request.

To request AP or PCP clustering to be enabled in the BSS, the STA shall transmit a Cluster Report element with the Cluster Request subfield set to 1 to its AP or PCP. Upon receiving a Cluster Report element with the Cluster Request subfield set to 1, the AP or PCP should form and maintain decentralized AP or PCP clustering in the BSS according to the procedures described in 10.37.2, 10.37.3, 10.37a.2, and 10.37a.3.

10.37a.6 Spatial sharing in a CDMG AP or PCP cluster

This subclause describes mechanisms to enable spatial sharing and interference mitigation among CDMG infrastructure BSSs or PBSSs in a coordinated OBSS environment, i.e., in a CDMG AP or PCP clustering environment. By utilizing the schedule information of SP allocation in other BSSs in an AP or PCP cluster, an AP or PCP acquires and shares channel measurement results of STAs within its BSS by requesting STAs in its BSS to perform directional channel measurement during SPs of other BSSs. Therefore, APs or PCPs in different BSSs can allocate SPs in overlapping time periods in the same channel and achieve spatial sharing among BSSs.

If the SPSH in CDMG Cluster subfield in the CDMG Capabilities element of a CDMG AP or PCP is 1 and one of the Decentralized Cluster field and the Centralized Cluster field is 1, then the CDMG AP or PCP supports spatial sharing mechanism among BSSs in the AP or PCP cluster.

A CDMG STA that supports spatial sharing, as indicated by the SPSH in CDMG Cluster subfield set to 1 in the STA's CDMG Capabilities element, shall support the directional channel quality measurements described in 9.4.2.22.15 and 9.4.2.21.16.

The SP spatial sharing among BSSs in an AP or PCP cluster contains two phases: SPSH measurement phase and SP spatial sharing phase. The goal of setting an SPSH measurement phase is to allow APs or PCPs to find pairs of links in different BSSs that can coexist. Spatial reuse is not allowed in SPSH measurement phase. Only one pair of STAs participate directional channel quality measurement.

A CDMG S-AP or S-PCP that supports SPSH among BSSs should indicate whether all the member APs or member PCPs in a cluster are in the SPSH measurement phase or in the SP spatial sharing phase by setting the SPSH Measurement Enabled subfield in the Clustering Control field of the DMG Beacon frame to 1 or by setting the Clustering SPSH Enabled field within the Clustering Interference Assessment element to 1. The SPSH Measurement field is set to 1 to indicate that SPSH measurement phase starts. Each member AP or member PCP that supports SPSH among BSSs should request STAs in its BSS to perform directional channel quality measurement during SPs of other BSSs in the same cluster, as described in 11.11. The CDMG AP or PCP should send directional channel quality request to STAs in the same BSS and receive directional channel quality report from the STAs. The period of the directional channel quality measurement is indicated by the Channel Quality Measurement Duration subfield within the Clustering Interference Assessment element. The AP or PCP can obtain the interference information that indicates link(s) in its BSS experience interference from at least one link of other BSS within the AP or PCP cluster through channel measurement of STAs. The AP or PCP can determine the channel quality across STAs within multiple BSSs and implement spatial sharing based on the results of the measurements performed by the STAs associated with the AP or PCP. The S-AP or S-PCP should periodically set the SPSH Measurement Enabled subfield, generating and sending the indicated information of interference measurement.

In the SPSH measurement phase, each member AP or member PCP that supports SPSH among BSSs in an AP or PCP cluster shall schedule SPs in nonoverlapping period according to the clustering mechanism, as described in 10.37 and 10.37a. If one link in a BSS is transmitting data, link(s) in other BSSs keeps in directional channel measurement state. The determination of the interference from the measured link (existing SP) to the candidate SP is implementation dependent and beyond the scope of this standard.

Each member AP or member PCP in a cluster may record the information that links in other BSSs do not interfere with the link(s) in its BSS through channel measurement of STAs, and include the information in SPSH Report elements that are sent to other AP(s) or PCP(s) through DMG Beacon frames. Each member AP or member PCP can obtain interference information that indicates interference experienced by at least one link of other BSS(s) from link(s) of its BSS, after receiving the SPSH Report element from other APs or PCPs in the same cluster. Each AP or PCP is able to obtain a database of links that may perform SPSH, but the definition of the database is beyond the scope of this standard.

After SPSH measurement, the S-AP or S-PCP shall set the SPSH Measurement Enabled subfield in the Clustering Control field of the DMG Beacon frame to 0, indicating that BSSs in the cluster are allowed to conduct spatial sharing in overlapping SPs in SP spatial sharing phase.

In the SP spatial sharing phase, each AP or PCP in the cluster should schedule SPs to achieve spatial sharing according to the received SP allocation information that indicates scheduled SP allocation for link(s) of other BSS(s) in the same AP or PCP cluster and according to the interference information from link(s) of other BSS(s) to its BSS and the interference information from link(s) of its BSS to link(s) of other BSS(s) obtained in SPSH measurement phase. The SP allocation information is obtained by receiving the Extended Schedule element in the DMG Beacon frame of other AP(s) or PCP(s) in the AP or PCP cluster. The scheduled link(s) of the AP's or PCP's BSS and link(s) of other BSS(s) should not interfere with each other during the same SP.

If an AP or PCP discovers that a link in its BSS and a link in another BSS in the same cluster do not interfere with each other, then the AP or PCP can schedule overlapping SPs for the two links.

Through sending and receiving the SPSH Report element, an AP or PCP should schedule an overlapping candidate SP only after sharing the spatial reuse information including non-interfering links corresponding to the scheduled SPs and candidate SPs with a neighbor AP or PCP. If an AP or PCP cannot know the interference information between links in neighboring BSSs and its BSS, it should not conduct SP spatial sharing.

Figure 10-58d illustrates an example of the resulting SP schedule for the spatial sharing among three BSSs in a cluster.

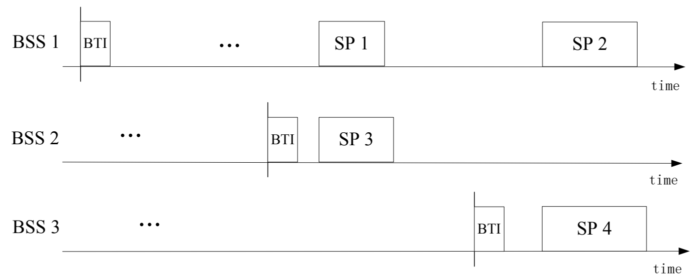


Figure 10-58d—Example of spatial sharing with interference mitigation among multiple BSSs

10.38 DMG beamforming

10.38.1 General

Insert the following paragraphs after the last paragraph in 10.38.1:

A CMMG STA shall follow the DMG beamforming rules as described in 10.38 where a BF frame transmitted by a CMMG STA is contained in a CMMG PPDU.

A CDMG STA shall follow the DMG beamforming rules as described in 10.38, including the rules of CDMG enhanced beam tracking as described in 10.38.9.

Insert the following subclause, 10.38.9 (including Figure 10-84a and Figure 10-84b), after 10.38.8:

10.38.9 CDMG enhanced beam tracking

In addition to the beam tracking mechanism in 10.38.7, the CDMG enhanced beam tracking mechanism enables CDMG communicating STA pairs to measure and switch to an alternative link to reduce the link outage probability induced by an unexpected blockage or a rapid antenna rotation. The alternative link is a suboptimal link configured by a pair of CDMG STAs during the SLS phase or the BRP phase. The enhanced beam tracking mechanism extends the capabilities on the basis of the beam tracking mechanism in 10.38.7 (Beam tracking). A pair of CDMG STAs may perform beam tracking (see 10.38.7) and enhanced beam tracking described in this subclause simultaneously.

The Enhanced Beam Tracking Supported subfield in the CDMG STA Capabilities Information field of a CDMG STA's CDMG Capabilities element is set to 1 to indicate that the CDMG STA supports enhanced beam tracking.

The initial alternative link of the peer STA under enhanced beam tracking is configured in the BRP phase. Specifically, in the first BRP phase after the SLS, the initiator STA returns the sector and antenna IDs of the alternative link to the responder STA, via transmitting the SSW Report element or the Enhanced Beam Tracking element in the BRP frame(s). The responder STA shall specify the alternative TX AWV according to the received Report Info field in the SSW Report element or the Peer TX Antenna Parameter field in the Enhanced Beam Tracking element. For the BRP phase, the index of the TRN-T field that was received with the second best quality in the last received BRP-TX PPDU is included in the Enhanced Beam Tracking element to specify the alternative TX AWV. The alternative link is not used for the current data transmission.

During the enhanced beam tracking phase, if a pair of STAs is operating on the link that is selected with best quality after SLS or BRP phase, switching to alternative link may be required if the signal quality of the current link deteriorates significantly based on the measurement results of e-TRN-R/T. If switching to alternative link is required, the initiator shall set the Switching to Backup AWV Request subfield of the Enhanced Beam Tracking element of the transmitted BRP frame to 1. If the initiator receives an Enhanced Beam Tracking element with the Switching to Backup AWV Enabled subfield set to 1 in the following BRP frame from the responder, the initiator and responder shall switch to the alternative link before transmitting the next frame. After switching to the alternative link, the initiator and responder shall set the last link as the new alternative link.

A CDMG STA (beam tracking initiator) may request a peer CDMG STA (beam tracking responder) to perform enhanced receive beam tracking by setting, in a transmitted packet, the TXVECTOR parameter ENHANCED_BEAM_TRACKING_REQUEST to enhanced beam tracking requested, the TRN-LEN parameter to the number of requested TRN-Units as described in 24.9.2.2.3, and packet type to TRN-R-PACKET. Otherwise, the ENHANCED_BEAM_TRACKING_REQUEST parameter shall be set to enhanced beam tracking not requested.

An enhanced beam tracking responder that receives a packet with the Enhanced Beam Tracking Request field in the PHY header set to 1 (corresponding to the ENHANCED_BEAM_TRACKING_REQUEST parameter in the RXVECTOR set to enhanced beam tracking requested) and the Packet Type field in the PHY header set to 0 (corresponding to the PACKET-TYPE field in the RXVECTOR set to TRN-R-PACKET) shall follow the rules described in 24.9.2.2 and shall include a beam refinement AGC field, TRN-R subfields, STF, and CE field appended to the following packet transmitted to the initiator. The value of TRN-LEN parameter in the following packet from the responder to the initiator shall be set to the value of the TRN-LEN parameter in the RXVECTOR of the packet from the initiator.

An enhanced beam tracking initiator requesting enhanced transmit beam tracking shall set the ENHANCED_BEAM_TRACKING_REQUEST parameter in the TXVECTOR to enhanced beam tracking requested, the Packet Type field to TRN-T-PACKET, and the TRN-LEN parameter to the number of TRN-Units as described in 24.9.2.2.3 and append an AGC field, TRN-R subfields, an STF, and a CE field to the packet. The enhanced beam tracking responder may append the feedback to any packets from the responder to the initiator. The initiator may allocate time for the feedback through a reverse direction grant, provided the reverse direction protocol is supported by both the initiator and responder. The Feedback Type field shall be set to the value of the Feedback Type field in the last BRP frame that was transmitted from the initiator to the responder with the TX-TRN-REQ subfield set to 1. If the responder has never received a BRP frame from the initiator with the TX-TRN-REQ subfield is equal to 1, the responder shall respond with all subfields of the FBCK-TYPE field set to 0 and set the BS-FBCK field to the best sector. If switching to the alternative link is required, the initiator shall set the Switching to Backup AWV Request subfield to 1 within the Enhanced Beam Tracking element within the transmitted BRP frame. The responder should respond with an Enhanced Beam Tracking element with the Switching to Backup AWV Enabled subfield set to 1 in the following BRP frame. If the Enhanced Beam Tracking element with the Switching to Backup AWV Enabled subfield set to 1 is transmitted or received, the initiator and responder shall switch to the alternative link before the next frame. After switching to the alternative link, the initiator and responder shall both set the last link as the new alternative link.

An enhanced beam tracking initiator may also request a beam tracking responder to perform receive beam tracking by setting, in the PHY header of a transmitted packet, the Enhanced Beam Tracking Request field to 1, the Training Length field to a nonzero value, and the Packet Type field to 0 and appending an AGC field, TRN-R subfields, an STF, and a CE field to the transmitted packet.

A beam tracking responder that receives a packet with the Enhanced Beam Tracking Request field in the PHY header set to 1, the Training Length field in the PHY header nonzero, and the Packet Type field in the PHY header set to 0 shall follow the rules described in 24.9.2.2 and may use the beam refinement AGC field, TRN-R subfields, STF, and CE field appended to the received packet to perform receive beam tracking. If the switching to the alternative link is required, the responder shall set the Switching to Backup AWV Request subfield within the Enhanced Beam Tracking element within the transmitted BRP frame to 1. The initiator should respond with an Enhanced Beam Tracking element with the Switching to Backup AWV Enabled subfield set to 1 in the following BRP frame. If the Enhanced Beam Tracking element with the Switching to Backup AWV Enabled subfield set to 1 is transmitted or received, the initiator and responder shall switch to the alternative link before the next frame. After switching to the alternative link, the initiator and responder shall both set the last link as the new alternative link.

The CDMG STAs that switched to the alternative link that is a suboptimal link after SLS or BRP phase should measure the quality of the original optimal beam link (the new alternative link) during the subsequent frames exchange. The initiator should transmit a beam tracking request to the responder to switch to the new alternative link if the new alternative link has a better link quality. The decision process of switching to the alternative link is implementation dependent and beyond the scope of this standard.

BRP frames transmitted during enhanced beam tracking may be aggregated within A-MPDUs. Figure 10-84a illustrates a beam tracking frame exchange sequence when the beam tracking initiator requests TRN-R fields, while Figure 10-84b illustrates a beam tracking frame exchange sequence when the beam tracking initiator requests TRN-T fields.

An example of beam tracking and switching for enhanced beam tracking is shown in W.3.

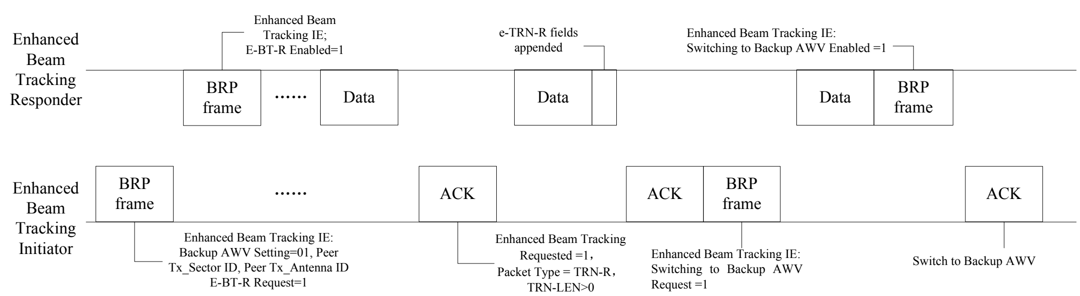


Figure 10-84a—Example of an enhanced beam tracking procedure with the initiator requesting TRN-R

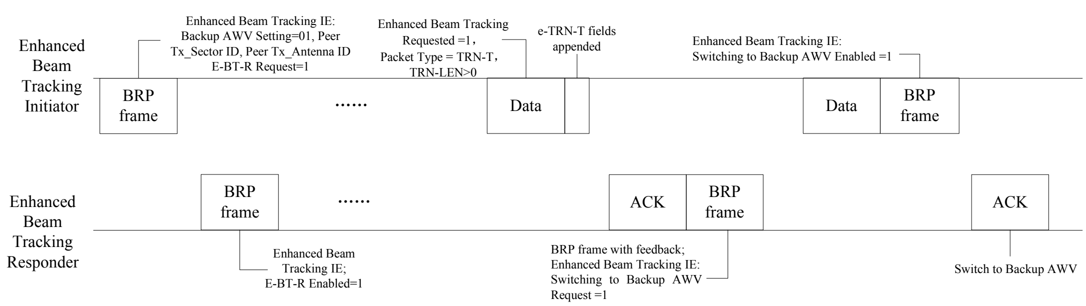


Figure 10-84b—Example of an enhanced beam tracking procedure with the initiator requesting TRN-T

Insert the following subclause, 10.39a, after 10.39.3:

10.39a Link adaptation using the CMMG link measurement

10.39a.1 General

A STA may transmit a Link Measurement Request frame to request a STA indicated in the RA field of the frame to respond with a Link Measurement Report frame (9.6.7.5) in SC transmission. If the Link Measurement Request frame is sent within a PPDU defined in Clause 25, the Link Measurement Report frame shall contain the CMMG Link Margin element. The requesting STA may use values of the MCS, of the SNR, and of the link margin to transmit frames to the STA indicated in the RA field of the Link Measurement Request frame.

The requesting STA may aggregate a Link Measurement Request frame in an A-MPDU as defined in Table 9-425 and Table 9-428.

If the Dialog Token field in the Link Measurement Request frame is equal to a nonzero value, the responding STA shall perform the measurement on the next frame received from the requesting STA and shall send back a Link Measurement Report frame corresponding to the received frame.

The responding STA may aggregate a Link Measurement Report frame in a A-MPDU as defined in Table 9-425 and Table 9-428.

A CMMG STA with MAC address that is equal to the value of the Link Measurement Request frame RA field shall transmit a Link Measurement Report frame addressed to the requesting STA. The RA field of the Link Measurement Report frame shall be equal to the TA field of the Link Measurement Request frame.

If the Dialog Token field in the Link Measurement Report frame is equal to the nonzero Dialog Token field of the Link Measurement Request frame, the MCS, SNR, and Link Margin fields of the Link Measurement Report frame shall be computed using the measurements of the PPDU that is the subsequent frame following the Link Measurement Request frame.

If the Dialog Token field in the Link Measurement Request frame is equal to 0, the responding STA may set the MCS field in the Link Measurement Report frame to the MCS value computed based on any of the received frames from the requesting STA.

The SNR field and Link Margin field in the Link Measurement Report frame shall indicate the corresponding measurements based on the reception of the PPDU that was used to generate the MCS feedback contained in the same Link Measurement Report frame.

The Link Measurement Request and Link Measurement Report frames can be used to obtain link margin information, which can be used to determine appropriate action by the requesting STA (e.g., change MCS or control transmit power or initiate FST).

A STA may send an unsolicited Link Measurement Report frame with the Dialog Token field set to 0.

10.39a.2 CMMG TPC

A CMMG STA that receives a Link Measurement Report frame containing a CMMG Link Margin element that indicates Increase or Decrease Transmit power behaves according to the following rules:

— If the CMMG STA intends to implement the recommendation indicated in the Activity field of the Link Measurement Report frame, it shall implement the change and send a Link Measurement Report containing a CMMG Link Adaptation Acknowledgment element not later than

2×aPPDUMaxTime after it acknowledged the reception of the Link Measurement Report frame. The Activity field of the CMMG Link Adaptation Acknowledgment element shall be set to the value of the Activity field in the received CMMG Link Margin subelement.

— If the CMMG STA does not implement the recommendation indicated in the Activity field of the Link Measurement Report frame, it may send the Link Measurement report containing a CMMG Link Adaptation Acknowledgment element no later than 2×aPPDUMaxTime after it acknowledges the reception of the Link Measurement Report frame. The Activity field of the CMMG Link Adaptation Acknowledgment element shall be set to 0, indication the STA prefers to not change transmit power.

A CMMG STA shall not include the CMMG Link Adaptation Acknowledgment element in a Link Measurement Report frame unless it is in response to a Link Measurement Report with the Activity field set to increase or decrease transmit power.

10.39a.3 CMMG fast link adaptation

A CMMG STA supports fast link adaptation if the Fast Link Adaptation field in the STA's CMMG Capabilities Info field is 1. Otherwise, the STA does not support fast link adaptation. A STA that supports fast link adaptation shall not use fast link adaptation with a peer STA that does not support fast link adaptation.

A STA that supports fast link adaptation shall support the reverse direction protocol (see 10.28).

The STA that transmits a Link Measurement Request frame as part of fast link adaptation shall be the RD initiator, and the STA that responds with a Link Measurement Report frame shall be the RD responder. Transmission of Link Measurement Request frame, Link Measurement Report frame, and the frames defined below shall follow the rules of the reverse direction protocol.

A STA initiates fast link adaptation by transmitting a Link Measurement Request frame that is of subtype Action No Ack and that has the Dialog Token field set to 0. The PPDU containing the frame shall have the AGGREGATION parameter in the TXVECTOR set to AGGREGATED, shall not contain any other frame that requires immediate response, and shall have a duration (as determined by the PHY-TXTIME.confirm primitive defined in 6.5.6) that is greater than 5.27 µs.

NOTE–The PPDUs have the AGGREGATION parameter in the TXVECTOR set to AGGREGATED to allow padding of the PSDUs with MPDU delimiters of size 0, therefore meeting the transmission duration requirement.

A STA that supports fast link adaptation and that receives a Link Measurement Request frame of subtype Action No Ack with the Dialog Token field equal to 0 and contained in a PPDU with the AGGREGATION parameter in the RXVECTOR equal to AGGREGATED shall respond with a Link Measurement Report frame in no longer than BRPIFS from the reception of the Link Measurement Request frame. The TPC Report element, CMMG Link Margin element and other fields transmitted in the Link Measurement Report frame shall reflect measurements on the PPDU that contained the last received Link Measurement Request frame from the initiating STA.

The STA responding with the Link Measurement Report frame shall keep the IFS not longer than a SIFS by transmitting PPDUs that do not contain frames requiring immediate response and that have a duration that is greater than 5.27 µs. All transmitted PPDUs should use the same MCS and the same transmit power.

The transmitted Link Measurement Report frame shall be of subtype Action No Ack, shall be sent using MCS 1, and shall be sent within a PPDU with the AGGREGATION parameter in the TXVECTOR set to AGGREGATED. In addition, the PPDU shall not contain any frame that requires immediate response and shall have a duration that is greater than 5.27 µs.

If at least one of the conditions above for the transmission of the Link Measurement Report frame is not met, the STA may follow the rules in 10.31.1 to respond to the received Link Measurement Request frame.

A STA that supports fast link adaptation and that receives a Link Measurement Report frame should respond with an unsolicited Link Measurement Report frame in no longer than BRPIFS from the reception of the Link Measurement Report frame. The TPC Report element, CMMG Link Margin element, and other fields transmitted in the unsolicited Link Measurement Report frame shall reflect measurements taken on one or more of the PPDUs received by the STA transmitting the unsolicited Link Measurement Report frame, starting with the received Link Measurement Report frame itself. If the unsolicited Link Measurement Report frame is transmitted longer than a SIFS from the reception of the Link Measurement Report frame, the STA transmitting the unsolicited Link Measurement Report frame shall keep the IFS not longer than a SIFS by transmitting one or more PPDUs before issuing the unsolicited Link Measurement Report frame.

Insert the following subclause, 10.60 (including Figure 10-104 through Figure 10-115), after 10.59:

10.60 DBC mechanism for CDMG STAs

10.60.1 General

A CDMG STA supports the operation of variable bandwidth channels according to the channelization specified in E.1. A CDMG infrastructure BSS or PBSS can operate on a 1.08 GHz or 2.16 GHz bandwidth channel. As specified in E.1, each 2.16 GHz channel encompasses two 1.08 GHz channels. A CDMG infrastructure BSS or PBSS shall use the following DBC mechanism when operating in the country that requires the support of variable bandwidth channels operation to mitigate interference between other CDMG and DMG BSSs.

A CDMG AP or PCP shall follow the procedures in 11.1.4.4.2 to initialize a CDMG BSS on a 1.08 GHz or a 2.16 GHz bandwidth channel. An AP or PCP operating the BSS on a 1.08 GHz channel shall periodically transmit DMG Beacon frames (10.3.4.2) on the 2.16 GHz channel that encompasses the 1.08 GHz channel on which the BSS is operating. A CDMG AP or PCP may change the operating bandwidth of its BSS dynamically from 1.08 GHz to 2.16 GHz or vice versa.

A CDMG AP or PCP may request the AP or PCP of an existing CDMG BSS operating on a 2.16 GHz channel (e.g., channel 2) to shift its operating channel to one of the 1.08 GHz channels (e.g., channel 35) within its original 2.16 GHz channel by sending a Channel Splitting Request frame (9.6.29.4) or an Extended Channel Splitting Request frame (9.6.8.43). If the existing CDMG BSS changed its operating channel to one of the 1.08 GHz channels (e.g., channel 35), the CDMG AP or PCP that sends the request frame may then operate a new BSS on the other adjacent 1.08 GHz channel (i.e., channel 36) within the 2.16 GHz channel (i.e., channel 2).

A pair of CDMG APs or PCPs operating on the adjacent 1.08 GHz channels (e.g., channel 35 and channel 6) within a 2.16 GHz channel (i.e., channel 2) should maintain synchronization with each other to mitigate the interference caused by the transmission of the DMG Beacon frame and other frames on the 2.16 GHz channel (i.e., channel 2) according to 10.60.2.3.

10.60.2 CDMG channel access

10.60.2.1 CDMG BSS operating on a 2.16 GHz channel

A CDMG AP or PCP operating an infrastructure BSS or PBSS on a 2.16 GHz channel (e.g., channel 2) shall follow the channel access rules as described in 10.36.

10.60.2.2 CDMG BSS operating on a 1.08 GHz channel

A CDMG AP or PCP operating an infrastructure BSS or PBSS on a 1.08 GHz channel (e.g., channel 35) shall periodically transmit DMG Beacon frames (9.3.4.2) on the 2.16 GHz channel (i.e., channel 2) that encompasses its operating channel (i.e., channel 35). The time interval between two consecutive DMG Beacon frames transmitted on the 2.16 GHz channel shall be no more than aMaxBIDuration. The generation of the DMG Beacon frames shall follow the rules in (11.1.3.3.3).

The AP or PCP that starts an infrastructure BSS or PBSS on a 1.08 GHz channel (e.g., channel 35) shall set a TSF timer to track the beacon interval (BI) on the encompassing 2.16 GHz channel (i.e., channel 2). At the beginning of a beacon interval on the 2.16 GHz channel, the AP or PCP shall schedule a notification period (NP) or a BHI (10.36.2) indicated by the DBC Option subfield of the Dynamic Bandwidth Control element (9.4.2.218) contained in each DMG Beacon frame as shown in Figure 10-104 and Figure 10-105, respectively. If a NP is scheduled on the 2.16 GHz channel, at least one BHI shall be scheduled on the 1.08 GHz channel. The NP may include the BTI, A-BFT, and ATI.

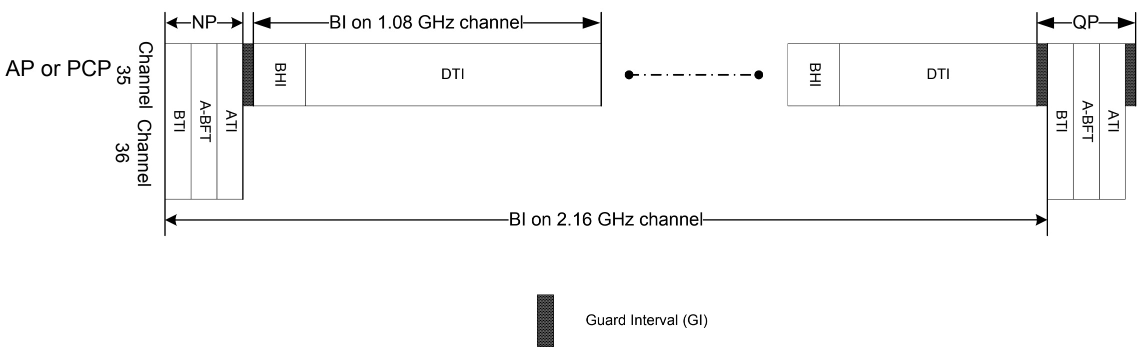


Figure 10-104—Example of an AP or PCP that starts its infrastructure BSS or PBSS on channel 35 by transmitting DMG Beacon frames on both channel 2 and channel 35

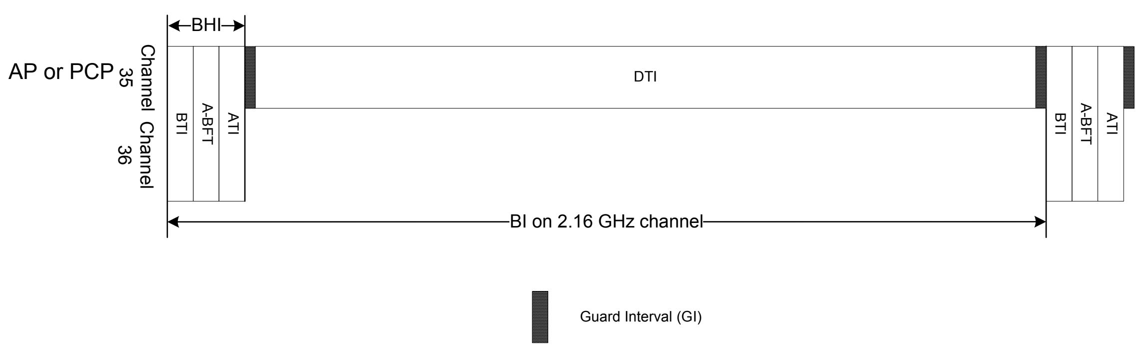


Figure 10-105—Example of a CDMG AP or PCP that starts its infrastructure BSS or PBSS on channel 35 by transmitting DMG Beacon frames on channel 2 only

During the BTI on the 2.16 GHz channel, the AP or PCP shall transmit a DMG Beacon frame containing the Dynamic Bandwidth Control element (9.4.2.218) that includes information on the operating status of the BSS through the DBC Control field and Channel Number field. The beacon interval length on the 2.16 GHz channel is indicated by the Beacon Interval field (9.4.1.3) contained in each DMG Beacon frame.

The AP or PCP may also establish an independent beacon interval on its operating 1.08 GHz channel and set another TSF timer to track it. As illustrated in Figure 10-104, the beacon interval length on 1.08 GHz channel shall be set as an integer factor of the beacon interval length on 2.16 GHz channel in units of TUs. The maximum length shall be the beacon interval length on the 2.16 GHz channel. The channel access on the 1.08 GHz shall follow the rules described in 10.36 with a BHI period within each BI. If BHIs are present on the 1.08 GHz channel, the DBC Option subfield of the Dynamic Bandwidth Control element within the DMG Beacon frame is set to 0; otherwise, it is set to 1.

A guard interval (GI) that is an interframe space follows a NP/BHI on the 2.16 GHz channel as shown in Figure 10-104 and Figure 10-105 for CDMG STAs to switch from transmitting and receiving frames on the 2.16 GHz channel to transmitting and receiving frames on the 1.08 GHz channel. The determination of the length of the GI is implementation dependent. At the end of the GI (or the NP/BHI if the GI is not present), the AP or PCP shall be ready to transmit or receive frames on the 1.08 GHz channel indicated by the Channel Number field of the Dynamic Bandwidth Control element.

If a CDMG AP or PCP transmits a DMG Beacon frame with the DBC Option subfield of the Dynamic Bandwidth Control element set to 0, it shall schedule quiet periods (QPs) on a 1.08 GHz channel by scheduling SPs with the AllocationType subfield set to 2 in the Allocation field and the Source AID subfield and Destination AID subfield set to its own AID. The starting times and durations of these QPs shall coincide with the starting times and durations of the NPs on the 2.16 GHz channel. The AP or PCP may also schedule the starting times of the QPs to be earlier than the NPs and the durations of the QPs to be greater than the durations of the NPs to establish a GI before and after each NP as shown in Figure 10-104.

If a CDMG AP or PCP transmits a DMG Beacon frame with the DBC Option subfield of the Dynamic Bandwidth Control element set to 1, it may schedule QPs before and after the BHIs to serve as GIs as shown in Figure 10-105. The GIs in this case should be longer than the time taken for all the CDMG STAs to switch from transmitting and receiving frames on the 2.16 GHz channel to transmitting and receiving frames on the 1.08 GHz channel. The determination of the length of the GIs is, however, implementation dependent.

If a non-AP and non-PCP CDMG STA receives a DMG Beacon frame from the CDMG AP or PCP with the BSSID equal to the BSSID of the BSS of which the STA is a member and with the DBC Option subfield of the Dynamic Bandwidth Control element set to 0, the STA shall switch to the 1.08 GHz channel indicated by the Channel Number field of the received Dynamic Bandwidth Control element to receive the DMG Beacon frame transmitted on the corresponding 1.08 GHz channel and follow the beamforming rules in 10.38 and the channel access rules in 10.39a on the 1.08 GHz channel. The non-AP and non-PCP STA may use the BI Offset subfield of the Dynamic Bandwidth Control element in the received DMG Beacon frame to predict the starting time of the BTI on the 1.08 GHz channel. In the following medium time, the non-AP and non-PCP STA should be prepared to receive and transmit frames on the 1.08 GHz channel unless it is assigned by the AP or PCP to monitor the 2.16 GHz common channel, or it communicates with other DMG STAs, or it leaves the current infrastructure BSS or PBSS, or the infrastructure BSS or PBSS ceases its services.

Alternatively, if a non-AP and non-PCP CDMG STA receives a DMG Beacon frame from the CDMG AP or PCP with the BSSID equal to the BSSID of the BSS of which the STA is a member and with the DBC Option subfield of the Dynamic Bandwidth Control element set to 1, the STA shall follow the beamforming rules in 10.38 and the channel access rules in 10.36 within the 2.16 GHz channel during the BHI duration. During the DTI, the STA shall switch to the 1.08 GHz operating channel indicated by the Channel Number field of the received Dynamic Bandwidth Control element to receive and transmit frame following the channel access rules in 10.36 on the 1.08 GHz channel.

10.60.2.3 Synchronization of CDMG infrastructure BSS or PBSSs on the adjacent 1.08 GHz channels within a 2.16 GHz channel

A CDMG AP or PCP setting up an infrastructure BSS or PBSS on a 1.08 GHz channel (e.g., channel 35) that has a CDMG BSS established on the adjacent 1.08 GHz channel (i.e., channel 36) within the same 2.16 GHz channel (i.e., channel 2) should follow the procedures below to maintain synchronization.

A CDMG AP or PCP shall scan the 2.16 GHz channel (e.g., channel 2) that encompasses the 1.08 GHz channel (e.g., channel 36) on which the CDMG AP or PCP is going to set up its BSS for DMG Beacon frames. If the CDMG AP or PCP received a DMG Beacon frame containing a Dynamic Bandwidth Control element with the Channel Splitting subfield set to 1, the Channel Number field indicating the existing AP or PCP works on a 1.08 GHz channel, and the Adjacent Channel Occupancy subfield set to 1, the AP or PCP may send an Extended Notification Period Request frame (9.6.8.41) during the following ATI of the BSS indicated by the BSSID field of the received DMG Beacon frame to request the existing AP or PCP to allocate time for NPs/BHI to transmit DMG Beacon frames on the encompassing 2.16 GHz channel with the NP/BHI Duration field in the Extended Notification Period Request frame indicating the requested duration of NPs/BHIs.

Alternatively, the scanning AP or PCP may attempt to associate with the infrastructure BSS or PBSS indicated by the BSSID field of the received DMG Beacon frame following the rules in 11.3 and subsequently send a Notification Period Request frame (9.6.29.2). A non-AP and non-PCP CDMG STA within an infrastructure BSS or PBSS operating on a 1.08 GHz channel may send a Notification Period Request frame (9.6.29.2) during the ATI, SP, or CBAP to request the AP or PCP to allocate time for NPs/BHIs to transmit DMG Beacon frames on the encompassing 2.16 GHz channel with the -NP/BHI Duration field in the Notification Period Request frame indicating the requested duration of NPs/BHIs.

If a CDMG AP or PCP receives a Notification Period Request frame or an Extended Notification Period Request frame, it may allocate QPs on its operating 1.08 GHz channel at the same recurring position in each beacon interval of the 2.16 GHz channel and reply with a Notification Period Response frame (9.6.29.3) or an Extended Notification Period Response frame (9.6.8.42) containing a Dynamic Bandwidth Control element with the TBTT Offset field indicating the target starting time of the allocated NPs/BHIs and the NP/BHI Duration field and the Adjacent NP/BHI Duration field indicating the lengths of the NPs/BHIs on the 2.16 GHz channel of itself and the scanning AP or PCP. The CDMG AP or PCP may schedule the starting times of the QPs to be earlier than the NPs and the durations of the QPs to be greater than the durations of the NPs to establish a GI before and after each NP/BHI as shown in Figure 10-106 and Figure 10-107. The AP or PCP shall scan for DMG Beacon frames in the allocated NPs to determine if a new BSS has been established on the adjacent 1.08 GHz channel.

If a CDMG STA receives a Notification Period Response frame or Extended Notification Period Response frame addressed to itself, it may establish an infrastructure BSS or PBSS on the 1.08 GHz channel adjacent to the channel indicated in the Channel Number field of the Dynamic Bandwidth Control element and become the AP or PCP using the following steps. The scanning AP or PCP shall start to transmit DMG Beacon frames at the start of the allocated NP/BHI indicated by the TBTT Offset field of the Dynamic Bandwidth Control element and set a TSF timer to track its beacon interval on the 2.16 GHz channel. The duration of the beacon interval on the 2.16 GHz channel shall be equal to the Beacon Interval field in the received Notification Period Response frame or an Extended Notification Period Response frame. The duration of NP/BHI on the 2.16 GHz channel shall be set to the value of the Adjacent NP/BHI Duration field of the Dynamic Bandwidth Control element in the received Notification Period Response frame or an Extended Notification Period Response frame. The scanning AP or PCP shall continue to receive the DMG Beacon frames from the existing AP or PCP during the NPs/BHIs starting at the time obtained from the Beacon Interval field minus the TBTT Offset field from the beginning of each beacon interval on the 2.16 GHz channel with the length indicated by the NP/BHI Duration field of the Dynamic Bandwidth

Control element in the previously received Notification Period Response frame or Extended Notification Period Response frame and maintain synchronization by adjusting its TSF to match the Timestamp field (9.4.1.10) in the received DMG Beacon frames transmitted in these NPs/BHIs. The scanning AP or PCP shall also use the DBC Option subfield of the Dynamic Bandwidth Control element in each DMG Beacon frame to announce whether the beacon interval on its 1.08 GHz operating channel is present or not as described in 10.60.2.2.

A CDMG AP or PCP operating on a 1.08 GHz channel may also actively allocate reserved NPs/BHIs on the 2.16 GHz channel to allow a new CDMG BSS to be established on the adjacent 1.08 GHz channel. The CDMG AP or PCP may allocate QPs on its operating 1.08 GHz channel at the same recurring position in each beacon interval of the 2.16 GHz channel and announce the presence of the reserved NPs/BHIs by transmitting DMG Beacon frames on the 2.16 GHz channel containing a Dynamic Bandwidth Control element with the Channel Splitting subfield equal to 1, the Adjacent Channel Occupancy subfield equal to 1, and the Adjacent NP/BHI Duration field nonzero. The TBTT Offset field and the Adjacent NP/BHI Duration field in the Dynamic Bandwidth Control element indicate the target starting time and the duration of the reserved NPs/BHIs, respectively. The AP or PCP shall scan for DMG Beacon frames in the reserved NPs to determine if a new BSS has been established on the adjacent 1.08 GHz channel.

If a CDMG AP or PCP receives a DMG Beacon frame on the 2.16 GHz channel containing a Dynamic Bandwidth Control element with the Channel Splitting subfield set to 1, the Adjacent Channel Occupancy field set to 1, and the Adjacent NP/BHI Duration field nonzero, it may establish an infrastructure BSS or PBSS on the 1.08 GHz channel adjacent to the channel indicated in the Channel Number field of the Dynamic Bandwidth Control element using the following steps. The AP or PCP shall continue to scan for DMG Beacon frames on the 2.16 GHz channel during the reserved NPs/BHIs indicated by the TBTT Offset field of the Dynamic Bandwidth Control element for an interval of at least aMinChannelTime. If it does not receive any valid DMG Beacon frame, it may start a new BSS by transmitting a DMG Beacon frame at the start of the reversed NP/BHI and set a TSF timer to track its beacon interval on the 2.16 GHz channel. The duration of the beacon interval on the 2.16 GHz channel shall be equal to the Beacon Interval field in the received DMG Beacon frame of the existing AP or PCP. The scanning AP or PCP shall continue to receive the DMG Beacon frames in NPs/BHIs of the existing AP or PCP operating on the adjacent 1.08 GHz channel to maintain synchronization by adjusting its TSF to match the Timestamp field (9.4.1.10) in the received DMG Beacon frames. The scanning AP or PCP shall also use the DBC Option subfield of the Dynamic Bandwidth Control element contained in each DMG Beacon frame to announce whether the beacon interval on its 1.08 GHz operating channel is present or not described in 10.60.2.2.

The NPs/BHIs of the two APs or PCPs operating on the adjacent 1.08 GHz channels within a 2.16 GHz channel may be arranged consecutively without interspaces to reduce the number of times they need to switch between transmitting and receiving frames on the 2.16 GHz channel and the 1.08 GHz channels.

Figure 10-106 shows an example of two APs establishing BSSs on channels 35 and 36, respectively, with two NPs, NP 1 of AP 1 and NP 2 of AP 2, arranged consecutively without interspaces. The same arrangement might apply to PCPs establishing PBSSs. Figure 10-107 shows another example of two APs establishing BSSs on channels 35 and 36, respectively, with two BHIs, BHI 1 of AP 1 and BHI 2 of AP 2, arranged arbitrarily apart from each other. The same arrangement might apply to PCPs establishing PBSSs.

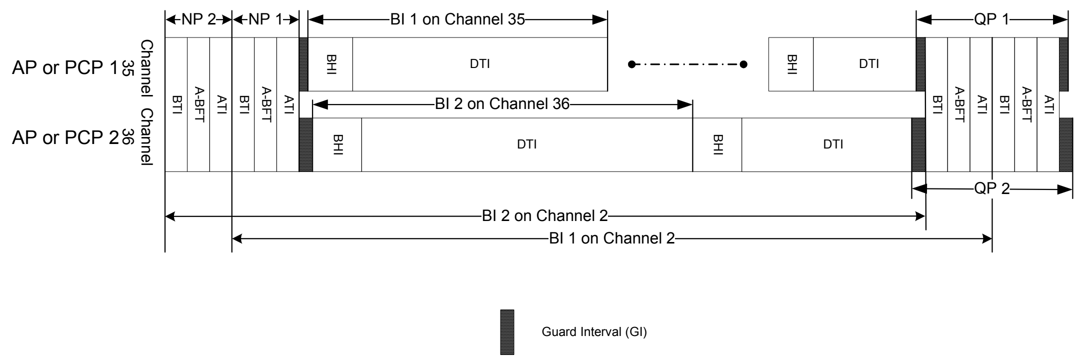


Figure 10-106—Two APs or PCPs with NPs arranged consecutively

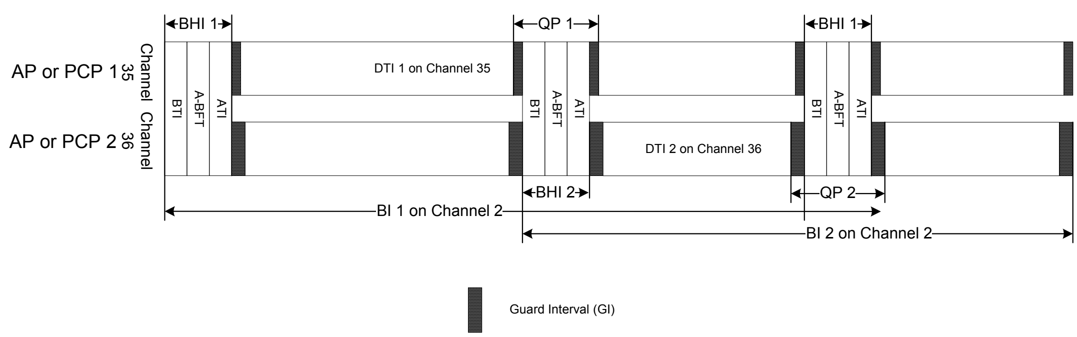


Figure 10-107—Two APs or PCPs with BHIs arranged apart from each other

If a CDMG AP or PCP operating on a 1.08 GHz channel with the adjacent 1.08 GHz channel occupied by another CDMG BSS does not receive any DMG Beacon frame transmitted by the CDMG AP or PCP operating on the adjacent 1.08 GHz channel in the assigned NPs/BHIs for a period of 4×aMinBTIPeriod beacon intervals on the 2.16 GHz channel, starting from when the last frame is received from the neighboring AP or PCP, it may proceed to make changes to the assigned NPs/BHIs on the 2.16 GHz channel. The AP or PCP may continue to allocate a NP/BHI on 2.16 GHz channel at the same position to allow another AP or PCP to establish a new BSS on the adjacent 1.08 GHz channel as described above or it may stop allocating QPs on its operating channel that correspond to the NPs/BHIs on 2.16 GHz channel of the BSS operating on the adjacent 1.08 GHz channel. Figure 10-108 shows an example that an AP or PCP can cease its service on channel 35, a 1.08 GHz channel.

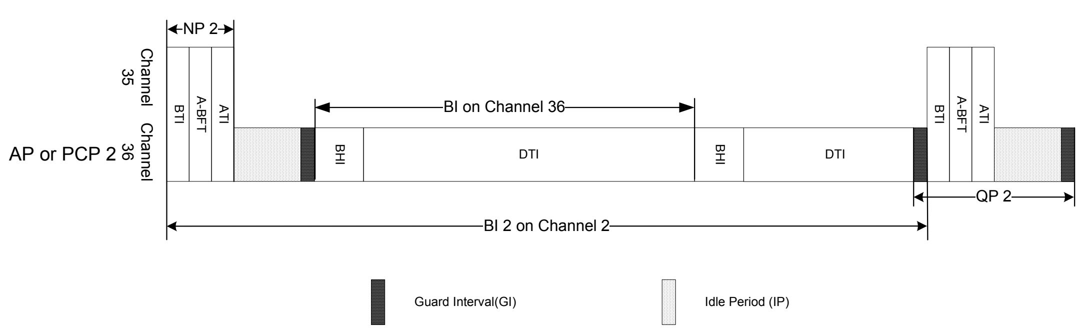


Figure 10-108—Service cessation for an AP or PCP on channel 35

The CDMG AP or PCP may also move its TBTT (11.31.2) on the 2.16 GHz channel (e.g., channel 2) backward so that its NPs/BHIs are followed closely by the BHI on its 1.08 GHz operating channel (e.g., channel 36) as illustrated in Figure 10-109.

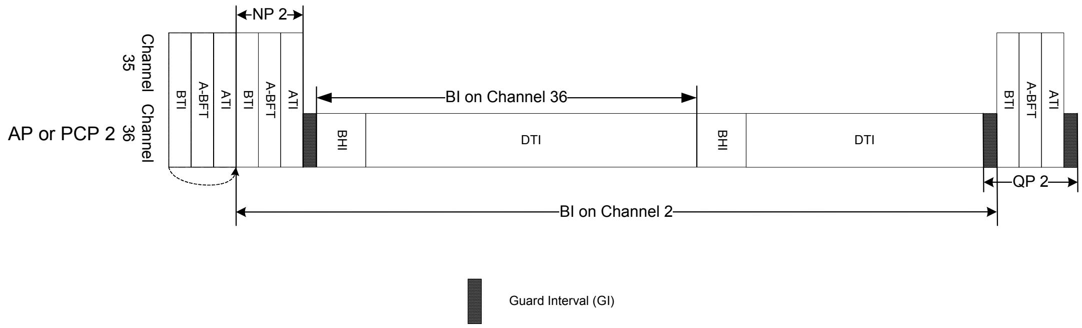


Figure 10-109—Moving TBTT by a neighboring AP or PCP on channel 2

10.60.3 Channel splitting of a 2.16 GHz channel

If a CDMG STA receives a DMG Beacon frame from a CDMG AP or PCP operating on a 2.16 GHz channel (e.g., channel 2), it may request the AP or PCP to shift its operating channel to one of the 1.08 GHz channels (e.g., channel 35) within its original 2.16 GHz channel by sending an Extended Channel Splitting Request frame (9.6.8.43) during the following ATI or it may associate with the infrastructure BSS or PBSS indicated by the BSSID field of the received DMG Beacon frame following the rules in 11.3 and subsequently send a Channel Splitting Request frame (9.6.29.4).

A non-AP and non-PCP CDMG STA within an infrastructure BSS or PBSS operating on a 2.16 GHz channel (e.g., channel 2) may send a Channel Splitting Request frame (9.6.29.4) during the ATI, SP, or CBAP, to request the AP or PCP to shift its operating channel to one of the 1.08 GHz channels (e.g., channel 35) within its original 2.16 GHz channel. If the existing CDMG BSS changed its operating channel to one of the 1.08 GHz channels (e.g., channel 35), the CDMG STA that sends the Channel Splitting Request frame may then operate a new BSS on the other adjacent 1.08 GHz channel (i.e., channel 36) within the 2.16 GHz channel (i.e., channel 2) as the role of AP or PCP.

The Channel Splitting Request frame or Extended Channel Splitting Request frame shall use the NP/BHI Duration field to indicate the required length of NP/BHI on a 2.16 GHz channel.

If a CDMG AP or PCP receives a Channel Splitting Request frame (9.6.29.4) or Extended Channel Splitting Request frame (9.6.8.43), the AP or PCP may follow the rules in 11.9.8.6 to switch its operating channel to a 1.08 GHz channel (e.g., channel 35) within its original 2.16 GHz channel (i.e., channel 2). If the AP or PCP switches the operating channel after receiving a Channel Splitting Request frame, it shall inform all its non-AP and non-PCP STAs of the DBC option it selects to operate on the 1.08 GHz channel after channel splitting, the target 1.08 GHz channel number to which it switches, and the starting time of the first beacon interval on 2.16 GHz channel when the channel splitting begins through the DBC Option subfield of the Dynamic Bandwidth Control element and the New Channel Number field and the Channel Switching Count field of the Channel Switch Announce element contained in the DMG Beacon and/or Announce frames. The AP or PCP shall also send a Channel Splitting Response frame (9.6.29.5) or Extended Channel Splitting Response frame (9.6.8.44) to announce the target 1.08 GHz channel number to which it switches and the starting time of the first beacon interval on 2.16 GHz channel when the channel splitting begins through the New Channel Number field and the Channel Switching Count field of the Channel Switch Announce element, the length of its beacon interval on 2.16 GHz channel after channel splitting through the Beacon Interval field, and the time offset of the scanning AP's or PCP's beacon interval relative to the existing AP's or PCP's beacon interval on 2.16 GHz channel and the lengths of NP/BHI durations for both APs or PCPs on 2.16 GHz channel through the TBTT Offset field, the NP/BHI Duration field, and the Adjacent NP/BHI Duration field of the Dynamic Bandwidth Control element to the CDMG STA indicated in the Source AID field in the received Channel Splitting Request frame or Extended Channel Splitting Request frame.

If a CDMG AP or PCP receives a Channel Splitting Request frame or Extended Channel Splitting Request frame but is not switching its operating channel, it may reply a Channel Splitting Response frame or an Extended Channel Splitting Response frame to reject the request.

If a CDMG STA sends a Channel Splitting Request frame or Extended Channel Splitting Request frame and then receives Channel Splitting Response frame or an Extended Channel Splitting Response frame with the Channel Splitting subfield set to 1, it shall follow the procedures described in 10.60.2.3 to maintain synchronization with the CDMG AP or PCP that sends the Channel Splitting Response frame or an Extended Channel Splitting Response frame when it starts a new BSS on the adjacent 1.08 GHz channel as the role of AP or PCP.

10.60.4 Channel expansion of a 1.08 GHz channel

A CDMG AP or PCP operating an infrastructure BSS or PBSS services on a 1.08 GHz channel (e.g., channel 35) may expand its operating bandwidth by switching to the 2.16 GHz channel (i.e., channel 2) encompassing its original operating channel without interruption to its BSS services.

If a CDMG AP or PCP operating an infrastructure BSS or PBSS on a 1.08 GHz channel (e.g., channel 35) transmits DMG Beacon frames on the 2.16 GHz channel containing a Dynamic Bandwidth Control element with the Channel Splitting subfield set to 1 and the Adjacent Channel Occupancy subfield set to 1, the AP or PCP may follow 11.9.8.6 to switch its operating channel to the 2.16 GHz channel (e.g., channel 2).

If a CDMG AP or PCP operating an infrastructure BSS or PBSS on a 1.08 GHz channel (e.g., channel 35) transmits DMG Beacon frames on the 2.16 GHz channel containing a Dynamic Bandwidth Control element with the Channel Splitting subfield set to 1 and the Adjacent Channel Occupancy subfield set to 0 but does not receive any DMG Beacon frame during the allocated NPs/BHI from another CDMG AP or PCP for a time period of 4×aMinBTIPeriod beacon intervals on the 2.16 GHz channel, the AP or PCP may follow 11.9.8.6 to switch its operating channel to the 2.16 GHz channel (e.g., channel 2).

If a CDMG AP or PCP operating an infrastructure BSS or PBSS on a 1.08 GHz channel (e.g., channel 35) transmits DMG Beacon frames on the 2.16 GHz channel containing a Dynamic Bandwidth Control element with the Channel Splitting subfield set to 1 and the Adjacent Channel Occupancy subfield set to 0 and receives a DMG Beacon frame during a NP/BHI from another CDMG AP or PCP operating on the adjacent 1.08 GHz channel (e.g., channel 36) within a 2.16 GHz channel (i.e., channel 2), it shall not expand its operating bandwidth by switching to the 2.16 GHz channel.

If the CDMG AP of PCP is switching the operating channel, it shall transmit DMG Beacon frames during the scheduled NPs on the 2.16 GHz channel containing a Dynamic Bandwidth Control element with the Channel Splitting subfield equal to 1 and the Adjacent Channel Occupancy subfield equal to 0 until the intended channel switch time. The AP or PCP shall inform all the non-AP and non-PCP STAs in the BSS with the target 2.16 GHz channel number to which it switches and the starting time of the first beacon interval on the 2.16 GHz channel after the channel expansion through the New Channel Number field and the Channel Switching Count field of the Channel Switch Announce element contained in the DMG Beacon and/or Announce frames. Here, the starting time is set until to the end of a subsequent beacon interval on the 2.16 GHz channel. Note that the beacon interval length after channel expansion might be different with that before channel expansion.

Figure 10-110 and Figure 10-111 illustrate the examples that an AP or PCP (e.g., AP or PCP 1) operating on channel 35 switches to channel 2. In Figure 10-110, the AP or PCP 1 established an independent beacon interval on channel 35 while in Figure 10-111, the AP or PCP 1 does not.

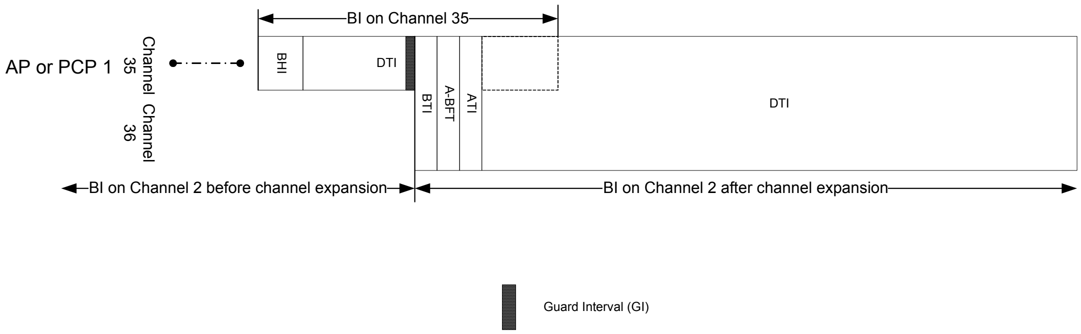


Figure 10-110—AP or PCP operating on channel 35 with independent beacon interval expanding the operating bandwidth to channel 2

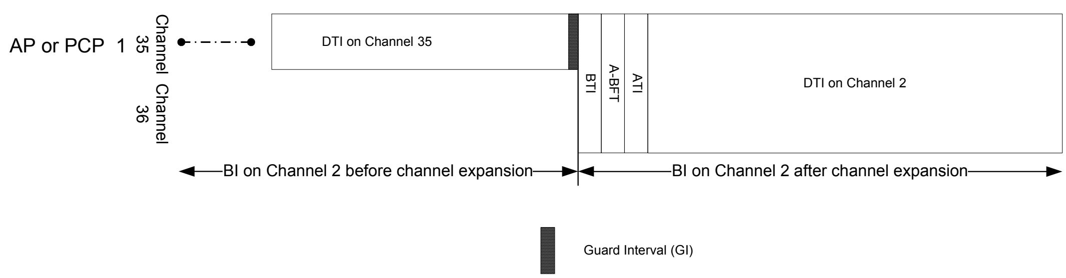


Figure 10-111—AP or PCP operating on channel 35 without independent beacon interval expanding the operating bandwidth to channel 2

10.60.5 Backward compatibility and interoperation

A CDMG AP or PCP operating an infrastructure BSS or PBSS shall provide interoperability to DMG STAs regardless of the BSS's operating channel. If a CDMG BSS is operating on a 2.16 GHz channel, the CDMG AP or PCP shall follow the channel access rules as described in 10.36 to provide services to non-AP and non-PCP DMG STAs.

A CDMG STA should not establish a 1.08 GHz BSS within a 2.16 GHz channel on which it received a DMG Beacon frame from a DMG AP or PCP. A CDMG AP or PCP operating on a 1.08 GHz channel shall transmit DMG Beacon frames on both the 1.08 GHz channel and the corresponding 2.16 GHz channel. A DMG STA can request to join a CDMG BSS. If the DMG STA successfully joins the CDMG BSS, the CDMG AP or PCP of the BSS shall schedule SPs and/or CBAPs for the DMG STA on the 2.16 GHz channel. The length of the scheduled SPs or CBAPs for DMG STAs on the 2.16 GHz channel is variable and may be up to the entire DTI. In other words, all STAs in the CDMG BSS operate on the 2.16 GHz channel if SPs and/or CBAPs are scheduled only on the 2.16 GHz channel during the DTI. The algorithm to schedule SPs or CBAPs for DMG STAs in a CDMG BSS is implementation dependent and beyond the scope of this standard but should aim to improve the network efficiency.

During an SP or a CBAP, the source and destination CDMG STAs operating on a 1.08 GHz channel in a CDMG BSS shall transmit an RTS frame and a DMG CTS or DMG DTS frame, respectively, on the corresponding 2.16 GHz channel after successfully transmitting and receiving an RTS frame and a DMG CTS or DMG DTS frame, respectively, on the 1.08 GHz channel if the 2.16 GHz channel is idle. Then the DMG STAs can set their NAVs by receiving the RTS or DMG CTS or DMG DTS frames transmitted on the 2.16 GHz channel by the CDMG STAs. After transmitting a CF-END frame to truncate a SP or TXOP on a 1.08 GHz channel within a 2.16 GHz channel, a CDMG STA shall also transmit a corresponding CF-END frame on the 2.16 GHz channel if it is idle.

If a CDMG infrastructure BSS or PBSS is operating on a 1.08 GHz channel, the CDMG AP or PCP shall follow the channel access rules in the BHI as described in 10.36 during the NPs/BHIs on the 2.16 GHz channel to admit non-AP and non-PCP DMG STAs into the BSS and provide scheduling information to DMG STAs. In the following medium time, the CDMG AP or PCP shall follow the rules in 9.36.6 to schedule the SPs or CBAPs for non-AP and non-PCP DMG STAs on the 2.16 GHz channel. If the CDMG AP or PCP establishes an independent beacon interval on its operating 1.08 GHz channel, it shall schedule SPs or CBAPs with non-AP and non-PCP DMG STAs as the source or destination STAs such that the scheduled SPs or CBAPs shall not be overlapped in time with the BHI periods on the 1.08 GHz channel. The CDMG AP or PCP may also schedule SPs or CBAPs on the 2.16 GHz channel for DMG STAs within the BSS to communicate with CDMG STAs within the BSS.

If a CDMG AP or PCP that is operating on a 1.08 GHz channel, with another CDMG BSS operating on the adjacent 1.08 GHz channel within a 2.16 GHz channel, the CDMG AP or PCP shall schedule only SPs or CBAPs with non-AP and non-PCP DMG STAs as the source or destination STAs in time periods that has been reported as unoccupied by the other CDMG AP or PCP through the Extended Schedule element in its DMG Beacon frames. The CDMG AP or PCP shall announce all its allocated SPs and CBAPs for the other CDMG AP or PCP, and the other CDMG AP or PCP can allocate SPs or CBAPs on the common 2.16 GHz channel in the unallocated time. The CDMG AP or PCP that intends to allocate time on the 2.16 GHz channel may also transmit a CDMG Allocation Request frame (9.6.29.6) during the ATI of the other AP's or PCP's NP/BHI on the 2.16 GHz channel to request for the available time for allocations on the 2.16 GHz channel. A CDMG AP or PCP that receives a CDMG Allocation Request frame from a CDMG AP or PCP operating on its adjacent 1.08 GHz channel shall reply with a CDMG Allocation Response frame (9.6.29.7) with an Extended Schedule element to indicate the schedule of all its allocations.

A CDMG AP or PCP that is operating on a 1.08 GHz channel, with another CDMG BSS operating on the adjacent 1.08 GHz channel within a 2.16 GHz channel, should appropriately reserve and schedule the available time for the AP or PCP operating on the adjacent 1.08 GHz channel and itself to allocate SPs or CBAPs on the 2.16 GHz channel, but the method to determine the reservation is implementation dependent. Four cases of backward compatibility and interoperation between DMG STAs and CDMG STAs are illustrated as follows.

A CDMG AP or PCP establishing an infrastructure BSS or PBSS on channel 35, with one or more beacon intervals starting on this channel, allows DMG STAs to join as non-AP and non-PCP STAs and allocates their SPs or CBAPs on channel 2 only, as shown in Figure 10-112.

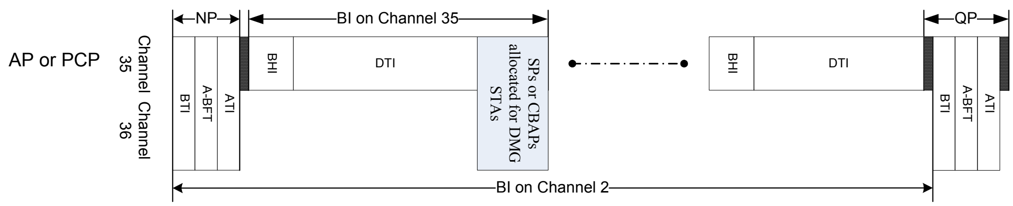


Figure 10-112—SPs or CBAPs allocated for DMG STAs on channel 2 with beacon intervals starting on channel 35

A CDMG AP or PCP establishing an infrastructure BSS or PBSS on channel 35, without starting a beacon interval on this channel, allows the DMG STAs to join as non-AP and non-PCP STAs and allocates their SPs or CBAPs on channel 2 only, as shown in Figure 10-113.

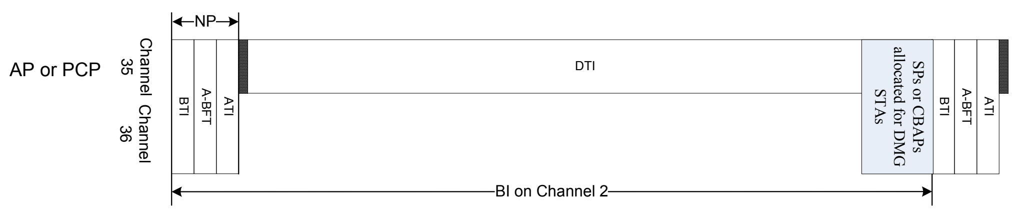


Figure 10-113—SPs or CBAPs allocated for DMG STAs on channel 2 without starting a beacon interval on channel 35

CDMG APs or PCPs establishing infrastructure BSSs or PBSSs on channels 35 and 36, respectively, with beacon intervals starting on this channel, allow the DMG STAs to join any of the BSSs or PBSSs as non-AP and non-PCP STAs and allocate their SPs or CBAPs on channel 2 only, as shown in Figure 10-114.

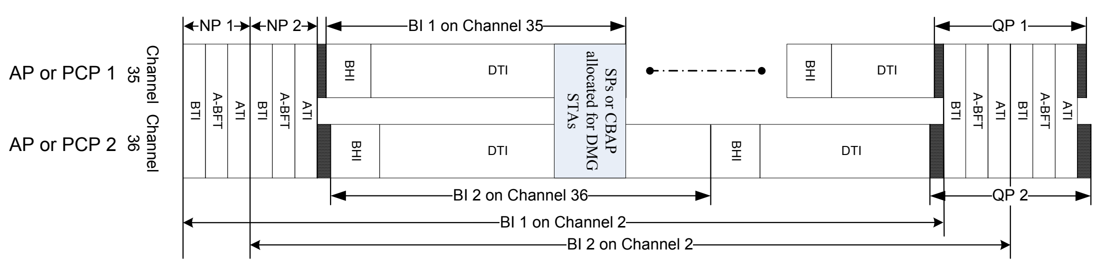


Figure 10-114—SPs or CBAPs allocated for DMG STAs on channel 2 with beacon intervals starting on channels 35 and 36

CDMG APs or PCPs establishing infrastructure BSSs or PBSSs on channels 35 and 36, respectively, without starting a beacon interval on this channel, allow the DMG STAs to join any of the BSSs or PBSSs as non-AP and non-PCP STAs and allocate their SPs or CBAPs on channel 2 only, as shown in Figure 10-115.

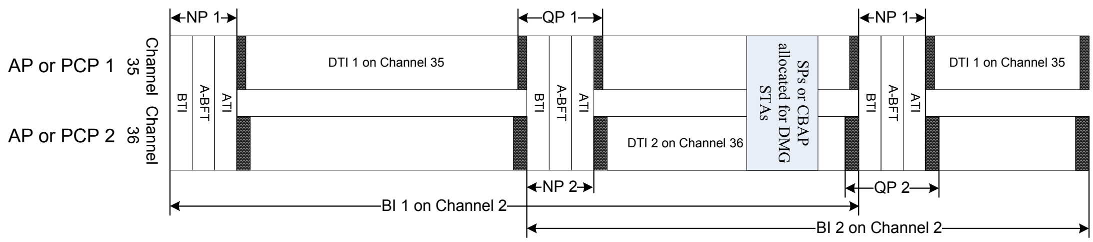


Figure 10-115—SPs or CBAPs allocated for DMG STAs on channel 2 without starting a beacon interval on channels 35 and 36

11. MLME

11.1 Synchronization

11.1.4 Acquiring synchronization, scanning

11.1.4.3 Active scanning

11.1.4.3.6 PCP selection in a PBSS

Change the second paragraph in 11.1.4.3.6 as follows:

The decision of whether a STA or its peer STA is the PCP depends on a comparison of their respective PCP factors (self_PCP_factor and peer_PCP_factor). The PCP factor for a DMG STA and a CDMG STA operating on a 2.16 GHz channel, defined in Figure 11-6 (PCP factor for a DMG STA), is the concatenation of the value of some of the fields from the DMG Capabilities element transmitted by the STA (see 9.4.2.128). The PCP factor for a CDMG STA operating on a 1.08 GHz channel is constructed by concatenating the value of select fields present in the STA's DMG Capabilities element and the Supported Channel Width Set field. The PCP factor for a CDMG STA operating on a 1.08 GHz channel is defined in Figure 11-6a.

Insert Figure 11-6a, the following paragraph, and Table 11-a after Figure 11-6:

	B0 B4	B5 B12	B13 B19	B20	B21	B22	B23 B24	B25	B26 B31
	Reserved	MAX Associated STA Number	Total Number of Sectors	Pseudo-Static Allocations	TDDTI	Decentralized AP or PCP clustering	Supported Channel Width Set	Power Source	Reserved
Bits:	5	8	7	1	1	1	2	1	6

Figure 11-6a—PCP factor for a CDMG STA operating on a 1.08 GHz channel

The Supported Channel Width Set field in Figure 11-6a is obtained via encoding based on the supported channel widths that are indicated by the Operating Classes field of the received Country element or the Supported Operating Classes element of the peer STA. The encoding of the Supported Channel Width Set field is given in Table 11-a.

Table 11-a—Encoding of the Supported Channel Width Set field

Bit 23	Bit 24	Meaning
0	0	The CDMG STA supports 1.08 GHz channel width in 60 GHz band.
0	1	The CDMG STA supports both the 1.08 GHz and 2.16 GHz channel widths in 60 GHz band.
All other combinations		Reserved

11.2 Power management

11.2.3 Power management in a non-DMG infrastructure network

Insert the following subclause, 11.2.3.21, after 11.2.3.20:

11.2.3.21 CMMG TXOP power save

A CMMG AP supports the operation of non-AP CMMG STAs in TXOP power save mode in a BSS when the dot11CMMGTXOPPowerSaveOptionImplemented at the AP is true. Non-AP CMMG STAs that are in Active mode (see Table 11-1) and have dot11CMMGTXOPPowerSaveOptionImplemented equal to true operate in TXOP power save mode. A STA that has dot11CMMGTXOPPowerSaveOptionImplemented equal to true shall set the CMMG TXOP Power Save field in the CMMG Capabilities element to 1; otherwise, the STA shall set the field to 0. A CMMG AP may allow non-AP CMMG STAs in TXOP power save mode to enter the doze state during a TXOP. A CMMG AP shall indicate this by transmitting a CMMG PPDU with the TXVECTOR parameter TXOP_PS_NOT_ALLOWED set to 0. The value of this parameter in the TXVECTOR of all CMMG PPDUs transmitted by the CMMG AP may be changed from 1 to 0 during the TXOP to enable TXOP PS for the remainder of the TXOP. The value of this parameter in the TXVECTOR of all CMMG PPDUs transmitted by CMMG AP shall not be changed from 0 to 1 during the TXOP. If the dot11CMMGTXOPPowerSaveOptionImplemented at CMMG AP is false then the CMMG AP shall set the TXOP_PS_NOT_ALLOWED to 1 in the TXVECTOR of the frames.

If the AP allows non-AP CMMG STAs to enter doze state during a TXOP, then a non-AP CMMG STA that is in CMMG TXOP power save mode may enter the doze state until the end of that TXOP when any of the following conditions is met:

- On receipt of a PPDU, the STA determines that the RXVECTOR parameter UPLINK_INDICATION is equal to 0, but the RXVECTOR parameter COLOR does not match the COLOR indicated by the AP to which the STA is associated.
- The STA finds that the COLOR in the RXVECTOR parameter matches the COLOR indicated by the AP to which the STA is associated but the RXVECTOR parameter PARTIAL_AID is not equal to 0 nor does it match the STA's partial AID.
- The STA finds that the PARTIAL_AID in the RXVECTOR matches its partial AID but the RA in the MAC header of the corresponding frame that is received correctly does not match the MAC address of the STA.
- In a received PSMP frame, the STA finds that the STA_AID field in the PSMP STA Info field is not its AID nor does the PSMP Group Address ID subfield match its group address.
- The STA receives a frame intended for it with the More Data field equal to 0 and the Ack Policy subfield in the QoS Control field equal to No Ack or sends an acknowledgment if Ack Policy subfield is not equal to No Ack.
- On receipt of a PPDU, the non-AP STA determines that the RXVECTOR parameter UPLINK_INDICATION is equal to 1.

The CMMG AP shall include a NAV-set sequence (e.g., RTS/CTS) at the beginning of such a TXOP with the Duration/ID value set to the remainder of the TXOP duration. A CMMG AP shall not transmit frames to a non-AP CMMG STA that has been allowed to enter doze state according to the conditions above for the remainder of the TXOP.

NOTE—A CMMG AP does not transmit CMMG PPDUs in the current TXOP if the AP has already transmitted a CMMG PPDU with the TXVECTOR parameter TXOP_PS_NOT_ALLOWED set to 0 in the same TXOP and does not want the STAs that are in Awake state to enter the doze state.

If a CMMG AP truncates the TXOP in which it allowed STAs to enter doze state, then the CMMG AP shall not transmit frames to the STAs that were allowed to enter the doze state until the NAV set at the start of the TXOP has expired.

If the AP does not receive an acknowledgment after transmitting an individually addressed frame containing all or part of an MSDU, A-MSDU, or MMPDU sent with the More Data field equal to 0 to a non-AP CMMG STA that is in CMMG TXOP power save mode and the AP had set the TXVECTOR parameter TXOP_PS_NOT_ALLOWED to 0, it shall retransmit that frame at least once within the same TXOP, subject to applicable retry, lifetime limit, or TXOP limit. If an acknowledgment to the retransmission of this last frame in the same TXOP is not received, it may wait until the next TXOP to further retransmit that frame, subject to its applicable retry or lifetime limit.

NOTE—An AP that receives from a CMMG STA in TXOP power save mode a BlockAck frame that is a response to an A-MPDU containing MPDUs with the More Data field equal to 0 cannot expect to receive a response to subsequent MPDUs retransmitted in the same TXOP because the CMMG STA might be in the doze state.

A CMMG STA that is in TXOP power save mode and has entered doze state shall continue to operate its NAV timer during doze state and shall transition into Awake state on expiry of the NAV timer.

NOTE—The STA can contend for access to the medium immediately on the expiry of the NAV timer.

11.2.7 Power management in a PBSS and DMG infrastructure BSS

11.2.7.3 PCP power management mode

11.2.7.3.3 PCP operation with a wakeup schedule

Change the ninth paragraph of 11.2.7.3.3 as follows:

The PCP may enter and remain in the doze state for any portion of an SP if it is not a source or a destination of the SP. The PCP shall remain in the awake state for any portion of a truncatable or extendable SP (9.4.2.132). <u>The CDMG PCP shall remain in the awake state for any portion of an extendable SP or a truncatable SP whose Truncation Type subfield is 0 (9.4.2.132).</u> The availability of the PCP during a CBAP in the awake BI shall be announced by setting the PCP Active subfield within the Allocation Control field to 1 for a CBAP allocation made through the Extended Schedule element.

11.32 Spatial sharing and interference mitigation for DMG STAs

11.32.1 General

Insert the following paragraph at the end of 11.32.1:

An AP or PCP may use the beamforming training information between any pair of STAs within the BSS obtained through the SSW Report element (9.4.2.220) to achieve spatial sharing and interference mitigation. The AP or PCP can transmit an Information Request frame (9.6.20.4) addressed to a STA for a response with an SSW Report element (9.4.2.220) contained in an Information Response frame (9.6.20.5). A non-AP and non-PCP STA can also send an unsolicited Information Response frame with an SSW Report element after the STA has completed the beamforming procedure with at least another STA. The SSW Report element may be used to facilitate the selection of candidates for spatial sharing as described in W.1.

Insert the following subclauses, 11.49 and 11.50 (including Figure 11-54, Figure 11-55, and Table 11-28), after 11.48:

11.49 DCS procedure

11.49.1 General

Radio regulations that apply to the 60 GHz band in China allow radio local area networks (RLANs) operating in the Chinese 60 GHz band to operate on a 1.08 GHz or a 2.16 GHz channel, which requires a mechanism to coordinate the allocation of operating channel between two CDMG infrastructure BSSs or CDMG PBSSs. This subclause describes such a mechanism, referred to as dynamic channel selection (DCS). This mechanism is used to improve the flexibility and channel efficiency when RLANs operate in Chinese 60 GHz frequency band, in case that there is no available channel or the bandwidth (e.g., 1.08 GHz) of idle channel(s) cannot satisfy the operating requirements of RLANs. This subclause describes the DCS procedures that can be used to satisfy CDMG regulatory requirements.

Figure 11-54 illustrates a number of use cases for DCS procedure:

- In cases 1, 2, and 3, a CDMG AP or PCP that intends to start a new BSS can request one of the two BSSs operating on two occupied 1.08 GHz channels to move to one of the two idle channels. Case 1 for example, the BSS operating on channel 36 can move to channel 37; or the BSS operating on channel 37 can move to channel 35. Then a 2.16 GHz channel 2 or 3 is idle, and the CDMG AP or PCP can start its BSS on it.
- In cases 4 and 5, a CDMG AP or PCP that intends to start a new BSS can request one or two BSSs operating on a 2.16 GHz channel to move to operate on a 1.08 GHz channel. Case 4 for example, the BSS operating on the channel 2 (2.16 GHz) can move to the channel 38 (1.08 GHz). Then the 2.16 GHz channel 2 is idle, and the CDMG AP or PCP can start its BSS on it.

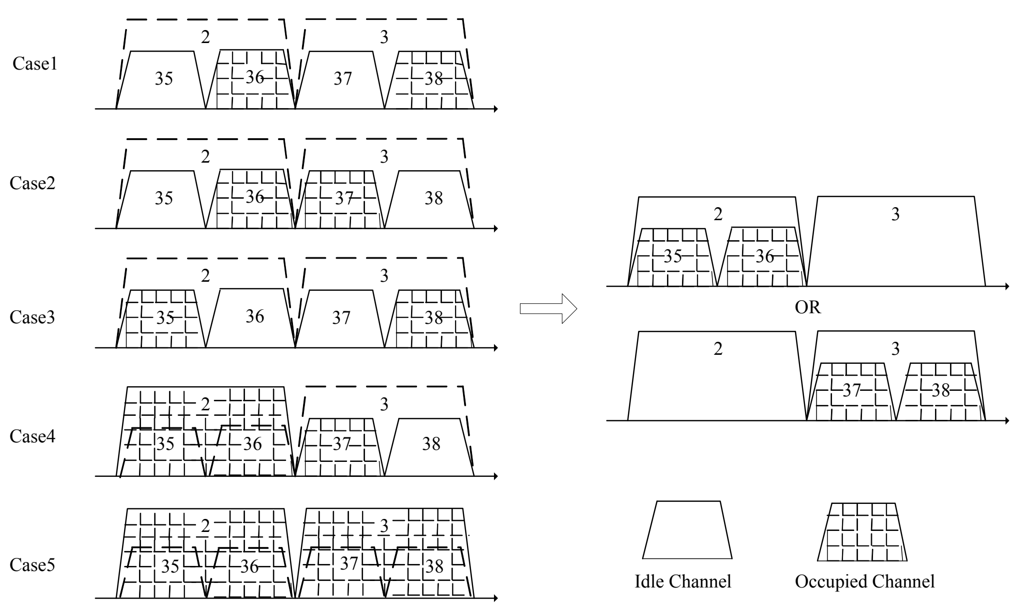


Figure 11-54—Examples of using DCS procedure

A CDMG STA is DCS capable if the value of dot11DynamicChannelTransferImplemented is true. A CDMG DCS capability STA advertises the capability by including the DCS capability element in DMG Beacon, (Re)Association Request, (Re)Association Response, Information Request, Information Response, Probe Request, Probe Response, Announce, DCS Measurement Request, DCS Measurement Response, DCS Request, and DCS Response frames.

A CDMG AP or PCP shall use the DCS procedures defined in 11.49.1 to 11.49.6 if the value of dot11DynamicChannelTransferActivated is true. The value of dot11DynamicChannelTransferActivated shall be set to true when a CDMG AP or PCP requires DCS procedures. The DCS procedures provide for the following:

- — Assessing current channel condition (see 11.49.2)
- — Requesting of measurements for new channel for the DCS responder BSS (see 11.49.3)
- — Reporting of the result of measurements (see 11.49.3)
- — Requesting existing BSS to migrate to a new channel (see 11.49.5)
- — Operating on the target channel (see 11.49.6)

Figure 11-55 depicts an example of the procedure of the dynamic channel selection. In the figure, the parameter n corresponds to the number of DCS Measurement Request and DCS Measure Response frame exchanges until the requirement of operating channel or bandwidth for the DCS requester AP or PCP is met. The detailed procedure of dynamic channel selection is described in 11.49.2 to 11.49.6.

Although the DCS procedure is defined for CDMG STAs according to the Chinese regulations, it can be used by other STAs defined in IEEE 802.11 specification to negotiate operating channels between BSSs.

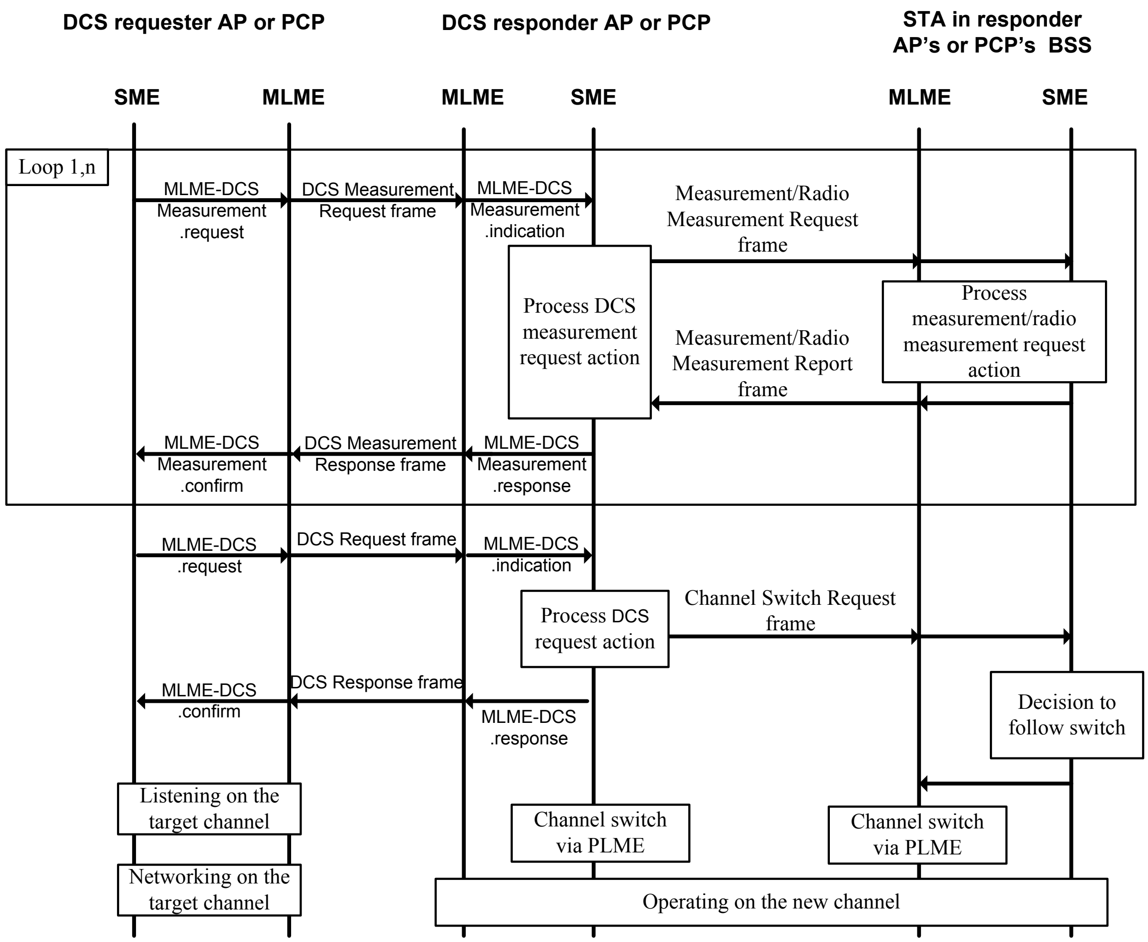


Figure 11-55—Procedure of dynamic channel selection

11.49.2 Assessing current channel condition

A DCS requester AP or PCP that intends to start a new BSS can assess an available channel passively by performing a channel scan or clear channel assessment (CCA) or by receiving one or more DMG Beacon frames sent by one or more APs or PCPs within one or more existing infrastructure BSSs or PBSSs. If the available channel bandwidth could not satisfy the operating requirements for RLANs, its AP or PCP can use the DCS procedure to request one or more existing infrastructure BSSs or PBSSs to move to a new operating channel.

11.49.3 Requesting measurements for new operating channel

A DCS requester AP or PCP shall send a DCS Measurement Request frame (see 9.6.8.37) to a DCS responder AP or PCP to request one or more STAs in the DCS responder AP's or PCP's BSS to measure all other channels within its supported operating class if the DCS Measurement Request Mode field is equal to 1 or to measure one or more channels indicated by the Optional Subelements field if the DCS Measurement Request Mode field is equal to 0. The responder AP or PCP can decide to measure one or more channels requested by the DCS requester AP or PCP after receiving the DCS measurement request. The algorithm to choose the channel to be measured is beyond the scope of this standard.

A DCS responder AP or PCP can use radio measurement procedures (see 11.11) to perform channel measurement.

11.49.4 Reporting measurements

After receiving the results of channel measurement from all STAs, the DCS responder AP or PCP shall transmit a DCS Measurement Response frame (see 9.6.8.38) to the DCS requester AP or PCP to report the results for the received DCS Measurement Request frame. The Measurement Report Mode field is set to 0 to indicate that there is no clear channel to which the DCS responder AP's or PCP's BSS to move within the operating class specified in the following Operating Class field, or the DCS responder AP or PCP has declined the DCS measurement request. The Measurement Report Mode field is set to 1 to indicate that all other channels within the operating class specified in the following Operating Class field are available for the DCS responder AP's or PCP's BSS. The Measurement Report Mode field is set to 2 to indicate that the clear channel that is available to the DCS responder AP's or PCP's BSS is indicated in the Optional Subelements field in the DCS Measurement Response frame.

A DCS Measurement Response frame shall contain the same value of the Dialog Token field as in the corresponding DCS Measurement Request frame.

A DCS responder AP or PCP can assess a DCS measurement request against its capabilities and the impact on its BSS's performance. The DCS responder AP or PCP may refuse the DCS measurement request for some reason such as the BSS is busy. The reasons for refusing a DCS measurement request are beyond the scope of this standard but may include reduced quality of service, unacceptable power consumption, measurement scheduling conflicts, or other significant factors.

11.49.5 Requesting existing BSS to migrate to a new channel

In order to operate on an occupied channel, a DCS requester AP or PCP should use the information of Supported Operating Class and the results of measurements undertaken by a DCS responder AP or PCP and other STA(s) within the same BSS to assist the selection of a new available channel for the DCS responder AP's or PCP's BSS. The algorithm to choose a new channel is beyond the scope of this standard, but shall satisfy applicable regulatory requirements, including uniform spreading rules and channel testing rules. A DCS requester AP or PCP shall request a DCS responder AP or PCP and other STA(s) in its BSS to migrate to a new available channel indicated in the received DCS Measurement Response frame by transmitting a DCS Request frame (see 9.6.8.39) to the DCS responder AP or PCP.

The decision to switch to a new operating channel in a BSS shall be made by a DCS responder AP or PCP. If the DCS responder AP or PCP accepts the DCS request to change the operating channel after receiving a DCS Request frame, the DCS responder AP or PCP shall transmit a DCS Response frame (see 9.6.8.40) to the DCS requester AP or PCP to confirm the received DCS request and then shall inform associated STAs that the AP or PCP is moving to a new channel and maintain the association by advertising the switch using Channel Switch Announcement elements or Extended Channel Switch Announcement element in one or more DMG Beacon frames, Probe Response frames, and Channel Switch Announcement frames until the intended channel switch time.

A DCS responder AP or PCP can assess a DCS request against its capabilities and the impact on its BSS's performance. A DCS request may be refused by a DCS responder AP or PCP for some reason such as the BSS is busy. The reasons for refusing a DCS request are beyond the scope of this standard but may include reduced quality of service, unacceptable power consumption, measurement scheduling conflicts, or other significant factors.

11.49.6 Networking on the target channel

A DCS requester AP or PCP shall listen on the target channel after the intended channel switch time indicated by the Channel Switch Count field in a DCS Response frame. Once the PHY-CCA.INDICATION primitive indicates that the target channel is idle, the DCS requester AP or PCP can operate on the target channel with other STA(s) in its BSS.

11.50 CMMG BSS operation

11.50.1 Basic CMMG BSS functionality

A CMMG STA has dot11CMMGOptionImplemented equal to true.

A STA that is starting a CMMG BSS shall be able to receive and transmit at each of the <CMMG MCS, NSS> tuple values indicated by the Basic CMMG MCS and NSS Set field of the CMMG Operation parameter of the MLME-START.request primitive and shall be able to receive at each of the <CMMG MCS, NSS> tuple values indicated by the Supported CMMG MCS and NSS Set field of the CMMG Capabilities parameter of the MLME-START.request primitive.

A STA that is a CMMG AP or a CMMG mesh STA declares its channel width capability in the Supported Channel Width Set subfield of the CMMG Capabilities element CMMG Capabilities Info field as described in Table 9-262aa.

A STA that is a CMMG AP or a CMMG mesh STA shall set the Channel Width subfield in the CMMG Operation element CMMG Operation Information field to indicate the BSS operating channel width as defined in Table 11-28.

Table 11-28—CMMG BSS operating channel width

CMMG Operation element Channel Width field	BSS operating channel width (MHz)
0	540
1	1080

A CMMG STA that is a member of a CMMG BSS shall not transmit a 540 MHz CMMG PPDU on a channel other than the primary 540 MHz channel of the BSS, except for a 540 MHz CMMG PPDU transmission on an off-channel TDLS direct link as constrained by 11.2.

A CMMG STA shall not transmit to a second CMMG STA using a bandwidth that is not indicated as supported in the CMMG Capabilities element received from that CMMG STA.

11.50.2 Channel selection methods for a CMMG BSS

Before a STA starts a CMMG BSS, the STA shall perform a minimum of dot11CMMGOBSSScanCount OBSS scan operations to search for existing BSSs (see 11.40.3).

If an AP or a mesh STA starts a CMMG BSS that occupies some or all channels of any existing BSSs, the AP or mesh STA may select a primary channel of the new CMMG BSS that is identical to the primary channel of any one of the existing BSSs.

If an AP or a mesh STA selects a primary channel for a new CMMG BSS with a 1080 MHz operating channel width from among the channels on which no beacons are detected during the OBSS scans, then the selected primary channel meets the following conditions:

— It shall not be identical to the secondary 540 MHz channel of any existing BSSs with a 1080 MHz operating channel width.

NOTE—An AP or a mesh STA operating a CMMG BSS with a 1080 MHz operating channel width, on detecting an OBSS whose primary channel is the AP's or the mesh STA's secondary 540 MHz channel, might switch to 540 MHz BSS operation and/or move to a different channel.

11.50.3 Scanning requirements for CMMG STAs

An OBSS scan operation is a passive or active scan of a set of channels that are potentially affected by CMMG BSS operation (see 11.1). Each channel in the set may be scanned more than once during a single OBSS scan operation. OBSS scans are performed by STAs that start a CMMG BSS.

During an individual scan within an OBSS scan operation, the minimum per-channel scan duration is dot11OBSSScanPassiveDwell TUs (for a passive scan) or dot11OBSSScanActiveDwell TUs (for an active scan). During an OBSS scan operation, each channel in the set is scanned at least once per dot11BSSWidthTriggerScanInterval seconds, and the minimum total scan time (i.e., the sum of the scan durations) per channel within a single OBSS scan operation is dot11OBSSScanPassiveTotalPerChannel TUs (for a passive scan) or dot11OBSSScanActiveTotalPerChannel TUs (for an active scan).

NOTE—The values provided in the previous paragraph are minimum requirements. For some combinations of parameter values, the minimum might be exceeded for some parameters in order to meet the minimum value constraints of other parameters.

11.50.4 Channel switching methods for a CMMG BSS

A CMMG AP announces a switch of operating channel by either of the following:

— Using the Channel Switch Announcement element, Channel Switch Announcement frame, or both, following the procedure described in 11.9.

— Using the Extended Channel Switch Announcement element, Extended Channel Switch Announcement frame, or both, following the procedure described in 11.10).

A CMMG mesh STA announces a switch attempt of operating channel by either of the following:

— Using the Channel Switch Announcement element, Channel Switch Announcement frame, or both, following the procedure described in 11.9.8.4.

— Using the Extended Channel Switch Announcement element, Extended Channel Switch Announcement frame, or both, following the procedure described in 11.10.

A CMMG AP or a CMMG mesh STA may also announce a switch of operating channel width, a new Country String field (possibly including a new Operating Class table number), new operating classes, or new TPC parameters for the BSS that come into effect at the same time as the switch of operating channel.

NOTE—Other means to switch the operating channel width are described in 11.42.

The New Channel Number field in the Channel Switch Announcement element, Extended Channel Switch Announcement element, Channel Switch Announcement frame, or Extended Channel Switch Announcement frame identifies the primary 540 MHz channel after the switch. The value of the New Channel Number field is set to the value that dot11CurrentPrimaryChannel (see 25.10) has after the switch.

If a Channel Switch Announcement element in a Beacon frame or Probe Response frame is used to announce a switch to a 540 MHz operating channel width, then the Wide Bandwidth Channel Switch subelement in a Channel Switch Wrapper element shall not be present in the same frame.

If an Extended Channel Switch Announcement element in a frame or an Extended Channel Switch Announcement frame is used to announce a switch to a 540 MHz operating channel width, then the Wide Bandwidth Channel Switch subelement shall not be present in the same frame.

NOTE—The indicated operating class within the Extended Channel Switch Announcement element or frame is used to differentiate between a BSS operating channel width of 540 MHz and a BSS operating channel width greater than 540 MHz as well as indicate the location of the secondary 540 MHz channel. When switching to a 540 MHz operating channel width, the operating class indicated within the Extended Channel Switch Announcement element or frame has a channel spacing of 540 MHz. When switching to an operating channel width greater than 540 MHz, the operating class indicated within the Extended Channel Switch Announcement element or frame has a channel spacing of 1080 MHz.

If a Channel Switch Announcement element is used in a Beacon or Probe Response frame to announce a switch to a 1080 MHz operating channel width, then the Wide Bandwidth Channel Switch subelement in the Channel Switch Wrapper element shall also be present in the same frame.

If an Extended Channel Switch Announcement element is used in a Beacon or Probe Response frame to announce a switch to a 1080 MHz operating channel width, then the Wide Bandwidth Channel Switch subelement in the Channel Switch Wrapper element may be present in the same frame.

NOTE—The indicated operating class within the Extended Channel Switch Announcement element identifies the bandwidth and the relative position of the primary 540 MHz and secondary 540 MHz channels. Hence a Wide Bandwidth Channel Switch subelement is unnecessary when the Extended Channel Switch Announcement element is used for a channel switch to a 1080 MHz bandwidth.

If new BSS TPC parameters are announced that come into effect at the same time as the channel switch, then a STA that is a CMMG AP, a CMMG STA in an IBSS, or a CMMG mesh STA in an MBSS shall include

— At least one New CMMG Transmit Power Envelope element in a transmitted Channel Switch Announcement frame or Extended Channel Switch Announcement frame and
— At least one New CMMG Transmit Power Envelope subelement in a transmitted Channel Wrapper element in Beacon and Probe Response frames.

A recipient CMMG STA in the BSS that has dot11SpectrumManagementRequired or dot11RadioMeasurementActivated equal to true and that maintains association with the BSS after the switch shall use the parameters in these received elements and subelements in the recipient STA's TPC calculations for the new operating channel and operating channel width (see 11.8). If both New CMMG Transmit Power Envelope elements and New CMMG Transmit Power Envelope subelements are transmitted for the switch, the set of New CMMG Transmit Power Envelope elements and set of subelements shall contain the same set of values for the Local Maximum Transmit Power Unit Interpretation subfield, and New CMMG Transmit Power Envelope elements and subelements that have the same value for the Local Maximum Transmit Power Unit Interpretation subfield shall also have the same values for their other fields.

If a new country string, new operating classes or both, are coming into effect at the same time as the channel switch, then a STA that is a CMMG AP, a CMMG STA in an IBSS, or a CMMG mesh STA in an MBSS shall include

— A New Country element in a transmitted Extended Channel Switch Announcement frame and
— A New Country subelement in a transmitted Channel Wrapper element.

The New Country element or subelement shall contain all the Operating Classes for the BSS after the switch. The New Country element or subelement, transmitted in an Extended Channel Switch Announcement frame or in the same frame as an Extended Channel Switch Announcement element, respectively, shall include one Operating Triplet field that contains the same Operating Class as the New Operating Class field in the Extended Channel Switch Announcement frame or Extended Channel Switch Announcement element.

A recipient CMMG STA in the BSS that has dot11MultiDomainCapabilityActivated, dot11SpectrumManagementRequired, or dot11RadioMeasurementActivated equal to true and that maintains association with the BSS after the switch shall use the parameters in these received elements and subelements in order to maintain regulatory compliance. If both New Country elements and New Country subelements are transmitted for the switch, their fields shall be the same.

A Channel Switch Wrapper element shall not be included in Beacon frames or Probe Response frames if the element contains zero subelements.

NOTE—Channel Switch Wrapper is not defined to carry subelements in the case of a switch to 540 MHz and when no change to the country string, operating classes, or TPC parameters are announced.

An AP that switches the BSS to a lower operating channel width may recalculate the TS bandwidth budget and may delete one or more active TSs by invoking the MLME-DELTS.

11.50.5 NAV assertion in a CMMG BSS

A CMMG STA shall update its NAV as described in 10.3.2.4 using the Duration/ID field value in any frame that does not have an RA matching the STA’s MAC address and that was received in a 540 MHz PPDU in the primary 540 MHz channel or received in a 1080 MHz PPDU.

NOTE—The PHY might filter out a PPDU as described in 25.13 or not receive a PPDU due to TXOP power saving described in 11.2.3.21. If so, frames in the PPDU are not received by the MAC and have no effect on the NAV.

11.50.6 CMMG STAs antenna indication

A CMMG STA that does not change its Rx antenna pattern after association shall set the Rx Antenna Pattern Consistency subfield in the CMMG Capabilities Info field to 1; otherwise, the STA shall set the Rx Antenna Pattern Consistency subfield in the CMMG Capabilities Info field to 0.

A CMMG STA that does not change its Tx antenna pattern after association shall set the Tx Antenna Pattern Consistency subfield in the CMMG Capabilities Info field to 1; otherwise, the STA shall set the Tx Antenna Pattern Consistency subfield in the CMMG Capabilities Info field to 0.

11.50.7 BSS basic CMMG MCS and NSS set operation

The BSS basic CMMG MCS and NSS set is the set of <CMMG MCS, NSS> tuples that are supported by all CMMG STAs that are members of a CMMG BSS. It is established by the STA that starts the CMMG BSS, indicated by the Basic CMMG MCS and NSS Set field of the CMMG Operation element in the MLME-START.request primitive. Other CMMG STAs determine the BSS basic CMMG MCS and NSS set from the Basic CMMG MCS and NSS Set field of the CMMG Operation element in the BSSDescription derived through the scan mechanism (see 11.1.4.1).

A CMMG STA shall not attempt to join (MLME-JOIN.request primitive) a BSS unless it supports (i.e., is able to both transmit and receive using) all the <CMMG MCS, NSS> tuples in the BSS basic CMMG MCS and NSS set.

A CMMG STA shall not attempt to (re)associate (MLME-ASSOCIATE.request and MLME-REASSOCIATE. request primitives) with a CMMG AP unless the STA supports (i.e., is able to both transmit and receive using) all the <CMMG MCS, NSS> tuples in the Basic CMMG MCS and NSS Set field in the CMMG Operation element transmitted by the AP.

12. Security

12.2 Framework

12.2.2 Security methods

Insert the following paragraph at the end of 12.2.2:

The RSN operations in a CMMG BSS shall be the same as the RSN operations in a DMG BSS.

Insert the following text, Clause 24 and Clause 25, after Clause 23:

24. China directional multi-gigabit (CDMG) PHY specification

24.1 CDMG PHY introduction

24.1.1 Scope

The CDMG PHY supports a 1.08 GHz channel width in comparison with the DMG PHY in Clause 20, which supports a 2.16 GHz channel width. As many aspects of CDMG PHY are the same as DMG PHY, this clause mainly lists the new features corresponding to Clause 20.

The CDMG PHY supports two modulation methods:

— A control modulation using MCS 0 of the CDMG Control mode defined in 24.4

— A single carrier (SC) modulation using MCS 1 to MCS 16 of the CDMG SC mode defined in 24.5 and MCS 17 to MCS 23 of the CDMG low-power SC mode defined in 24.6

All CDMG modulation methods share a similar preamble (see 24.3.6).

The services provided to the MAC by the CDMG PHY consist of the following protocol functions, defined as follows:

a) A function that defines a method of mapping the PHY service data units (PSDU) into a framing format (PPDU) suitable for sending and receiving PSDUs between two or more STAs.

b) A function that defines the characteristics and method of transmitting and receiving data through a wireless medium between two or more STAs. Depending on the MCSs, these STAs support a mixture of CDMG SC mode, CDMG low-power SC mode, and CDMG control mode.

24.1.2 CDMG PHY functions

24.1.2.1 General

The CDMG PHY contains two functional entities: the PHY and the layer management function (PLME). Each of these functions is described in detail in 24.3 to 24.9. The CDMG PHY service is provided to the MAC through the PHY service primitives defined in Clause 8.

24.1.2.2 PHY management entity (PLME)

The PLME performs management of the local PHY functions in conjunction with the MLME.

24.1.2.3 Service specification method

The description for service specification method is the same as that contained in 20.1.2.2.

24.2 CDMG PHY service interface

24.2.1 Introduction

The introduction for CDMG PHY service interface is the same as that contained in 20.2.1.

24.2.2 TXVECTOR and RXVECTOR parameters

The parameters in Table 24-1 are defined as part of the TXVECTOR parameter list in the PHY-TXSTART.request primitive and/or as part of the RXVECTOR parameter list in the PHY-RXSTART.indication primitive.

Table 24-1—TXVECTOR and RXVECTOR parameters

Parameter	Value	TXVECTOR	RXVECTOR
MCS	The MCS parameter is an enumerated type that indicates the modulation and coding scheme used in the transmission of the packet. Values are integers in the range 0–23. — A MCS value of 0 indicates the use of CDMG control mode or CDMG robust PHY mode. — MCS values of 1 to 16 indicate use of Single Carrier modulations. The value is an index to Table 24-9. — MCS values of 17–23 indicate use of CDMG low-power SC mode. The value is an index to Table 24-11.	Y	Y
LENGTH	Indicates the number of octets in the PSDU in the range 1–262 143.	Y	Y
ADD-PPDU	Enumerated type: — ADD-PPDU indicates that this PPDU is immediately followed by another PPDU with no IFS or preamble on the subsequent PPDU. — NO-ADD-PPDU indicates no additional PPDU follows this PPDU.	Y	Y
PACKET-TYPE	Enumerated type: — TRN-R-PACKET indicates either a packet whose data part is followed by one or more TRN subfields, or a packet that is requesting TRN subfields to be appended to a future response packet. — TRN-T-PACKET indicates a packet whose data part is followed by one or more TRN subfields. The transmitter may change AWV configuration at the beginning of each TRN subfield. This parameter is reserved if TRN-LEN is 0.	Y	Y
TRN-LEN	TRN-LEN indicates the length of the training field. Values are in the range 0–16 (see 24.9.2.2.3).	Y	Y
AGGREGATION	Indicates whether the PSDU contains an A-MPDU. Enumerated type: — AGGREGATED indicates this is a PSDU with A-MPDU aggregation. — NOT_AGGREGATED indicates this is a PSDU without A-MPDU aggregation.	Y	Y
RSSI	The allowed values for the RSSI parameter are in the range from 0 through RSSI maximum. This parameter is a measure by the PHY of the power observed at the input of the antennas plus the antenna gain, or equivalent antenna gain foa a phased-array antenna, used to receive the current PPDU. RSSI shall be measured during the reception of the PHY preamble. RSSI is intended to be used in a relative manner, and it shall be a monotonically increasing function of the received power.	N	Y
SNR	This parameter indicates the SNR measured during the reception of a CDMG control mode packet. Values are –10 dB to 53.75 dB in 0.25 dB steps.	N	Y

Table 24-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Value	TXVECTOR	RXVECTOR
ANT_CONFIG	Indicates which antenna configuration(s) is to be used throughout the transmission of the packet and when to switch between configurations. Values are implementation dependent.	Y	N
CHAN_MEASUREMENT	Channel as measured during the reception of the TRN subfields. Each measurement includes 63 complex numbers.	N	Y
TIME_OF_DEPARTURE_REQUESTED	Enumerated type: — true indicates that the MAC entity requests that the PHY entity measure and report time of departure parameters corresponding to the time when the first frame energy is sent by the transmitting port. — false indicates that the MAC entity requests that the PHY entity neither measure nor report time of departure parameters.	O	N
RX_START_OF_FRAME_OFFSET	0 to 2^{32}–1. An estimate of the offset (in 10 nanosecond units) from the point in time at which the start of the preamble corresponding to the incoming frame arrived at the receive antenna connector to the point in time at which this primitive is issued to the MAC.	N	See NOTE
DTP_TYPE	Enumerated: — STATIC indicating static tone paring. — DYNAMIC indicating dynamic tone pairing.	Y	Y
DTP_INDICATOR	An update to the DTP tone map is indicated by changing the values of this parameter from 0 or 1 or from 1 to 0 (see 10.40).	Y	Y
BEAM_TRACKING_REQUEST	This parameter indicates whether beam tracking is requested. Enumerated type: — Beam tracking requested or beam tracking not requested.	Y	Y
LAST_RSSI	In the TXVECTOR, LAST_RSSI indicates the received power level of the last packet with a valid PHY header that was received a SIFS before transmission of the current packet; otherwise, it is 0 (10.3.2.3.3). In the RXVECTOR, LAST_RSSI indicates the value of the LAST_RSSI field from the PCLP header of the received packet.Valid values are integers in the range 0 to 15: — Values of 2 to 14 represent power levels (–74+value×2) dBm. — A value of 15 represents power greater than or equal to –45 dBm. — A value of 1 represents power less than or equal to –71 dBm. — A value of 0 indicates that the previous packet was not received a SIFS before the current transmission.	Y	Y
Turnaround	Set to 1 or 0 as specified in 10.3.2.3.3.	Y	Y
ENHANCED_BEAM_TRACKING_REQUEST	This parameter indicates whether enhanced beam tracking is requested. Enumerated type: — Enhanced beam tracking requested or enhanced beam tracking not requested.	Y	Y

Table 24-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Value	TXVECTOR	RXVECTOR
ROBUST_MODE	This parameter incorporating with the MCS parameter is an enumerated type that indicates CDMG control mode or CDMG robust PHY mode used in the transmission of the packet. It is present if MCS index is 0. Values are integers in the range 0–2. — A CDMG ROBUST_MODE value of 0 indicates the use of CDMG control mode. — A CDMG ROBUST_MODE value of 1 indicates the use of CDMG robust PHY mode 0. — A CDMG ROBUST_MODE value of 2 indicates the use of CDMG robust PHY mode 1. This parameter is not present if MCS index is not 0.	Y	Y
NOTE—“Y” if dot11TimingMsmtActivated is true; otherwise, “N”.			

24.2.3 TXSTATUS parameters

The parameters listed in Table 24-2 are defined as part of the TXSTATUS parameter list in the PHY-TXSTART.confirm(TXSTATUS) primitive.

Table 24-2—TXSTATUS parameters

Parameter	Value
TIME_OF_DEPARTURE	When the first frame energy is sent by the transmitting port, in units equal to 1/TIME_OF_DEPARTURE_ClockRate. This parameter is present only if TIME_OF_DEPARTURE_REQUESTED is true in the corresponding request.
TIME_OF_DEPARTURE_ClockRate	0 to 2^{16}–1. The clock rate, in units of MHz, is used to generate the TIME_OF_DEPARTURE value. This parameter is present only if TIME_OF_DEPARTURE_REQUESTED is true in the corresponding request.
TX_START_OF_FRAME_OFFSET	0 to 2^{32}–1. An estimate of the offset (in 10 nanosecond units) from the point in time at which the start of the preamble corresponding to the frame was transmitted at the transmit antenna connector to the point in time at which this primitive is issued to the MAC.

24.3 Common parameters

24.3.1 Channelization

The CDMG PHY operates in the channels defined in Annex E and shall support at least channel numbers 2, 35, and 36.

The channel center frequency is defined as:

$$\textit{Channel center frequency} = \textit{Channel starting frequency} + \textit{Channel spacing} \times (\textit{Channel number mod } 32)$$

where channel starting frequency, channel spacing, and channel number are as defined in Annex E.

24.3.2 Transmit mask

The transmitted spectrum shall adhere to the transmit spectrum mask shown in the Figure 24-1. The transmit spectrum shall have a 0 dBr (dB relative to the maximum spectral density of the signal) bandwidth not exceeding 0.94 GHz, –17 dBr at a 0.6 GHz offset, –22 dBr at a 1.35 GHz offset, and –30 dBr at a 1.53 GHz offset and above, inside the channels allowed for the regulatory domain in which the STA is transmitting. The measurement shall be made using a 1 MHz resolution bandwidth and a 300 kHz video bandwidth.

The transmitted spectrum shall be measured on data packets longer than 10 µs without the training fields.

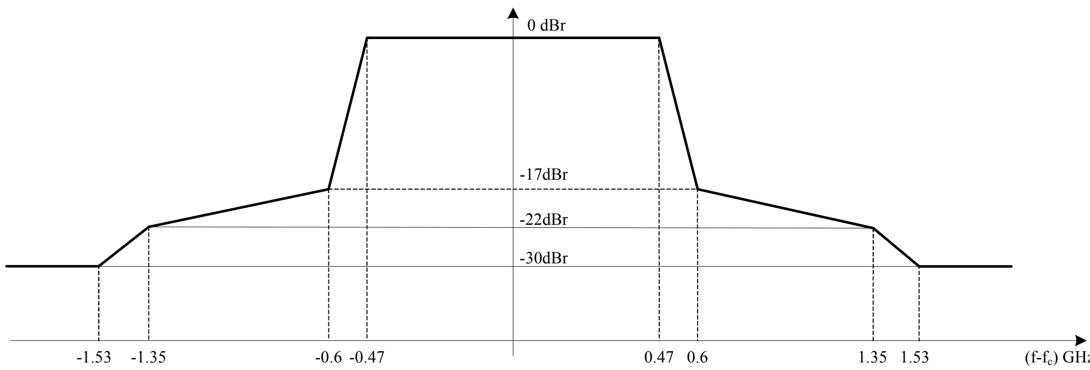


Figure 24-1—Transmit mask

24.3.3 Common requirements

24.3.3.1 Introduction

This subclause describes the common requirement from all three CDMG modes: control, SC, and low-power SC.

In all of the modes, all defined fields are transmitted bit 0 first in time.

24.3.3.2 Center frequency tolerance

24.3.3.2.1 General

The transmitter center frequency tolerance shall be ± 20 ppm maximum.

24.3.3.2.2 Center frequency convergence

The transmitter center frequency shall converge to within 1 ppm of its final value within 0.9 µs from the start of the packet.

24.3.3.3 Symbol clock tolerance

The symbol clock frequency tolerance shall be ± 20 ppm maximum.

The transmit center frequency and the symbol clock frequency shall be derived from the same reference oscillator.

24.3.3.4 Transmit center frequency leakage

The transmitter center frequency leakage shall not exceed –23 dB relative to the overall transmitted power.

24.3.3.5 Transmit rampup and rampdown

The description for transmit rampup and rampdown for CDMG PHY is the same as that contained in 20.3.3.5.

24.3.3.6 Antenna setting

Antenna setting shall remain constant for the transmission of the entire packet except for the case of transmission of BRP-TX packets (see 24.9.2.2). During the transmission of BRP-TX packets it shall remain constant for the transmission of the STF, CE field, and Data field.

24.3.3.7 Maximum input requirement

The receiver maximum input level is the maximum power level at the receive antenna(s) of the incoming signal, in dBm, present at the input of the receiver for which the error rate criterion (defined in 24.3.3.8) is met. A receiver shall have a receiver maximum input level at the receive antenna(s) of at least 10 microwatts/cm^2 for each of the modulation formats that the receiver supports.

24.3.3.8 Receive sensitivity

For MCS 0, the PER shall be less than 5% for a PSDU length of 256 octets with the MCS dependent input levels listed in Table 24-3 defined at the antenna connector(s). For the other MCSs, the PER shall be less than 1% for a PSDU length of 4096 octets with the MCS dependent input levels listed in Table 24-3 defined at the antenna connector(s).

NOTE—For RF power measurements performed over the air, the input level is corrected to compensate for the antenna gain in the implementation. The gain of the antenna is the maximum estimated gain by the manufacturer. In the case of the phased-array antenna, the gain of the phased-array antenna is the maximum sum of estimated element gain minus 3 dB implementation loss.

Table 24-3 assumes 5 dB implementation loss and 10 dB noise factor (Noise Figure).

Table 24-3—Receiver sensitivity

MCS	Receive sensitivity (dBm)
0	–81
1	–71
2	–69
3	–68
4	–67
5	–65
6	–66
7	–65
8	–64

Table 24-3—Receiver sensitivity *(continued)*

MCS	Receive sensitivity (dBm)
9	–62
10	–58
11	–57
12	–56
13	–54
14	–49
15	–48
16	–46
17	–67
18	–63
19	–60
20	–60
21	–60
22	–60
23	–60

24.3.4 Timing-related parameters

Table 24-4 defines timing-related parameters.

Table 24-4—Timing-related parameters

Parameter	Value
N_{GI}:	64
N_{SPB}:	448
F_c: SC chip rate	880 MHz = ⅔ F_s
T_c: SC chip time	1.14 ns = 1 / F_c
T_{GI}: Guard interval duration	97 ns = T_{DFT} / 4
T_{seq}:	14.6 ns = 128 × T_c
T_{STF}: Detection sequence duration	2618.2 ns = 18 × T_{seq}
T_{CE}: Channel estimation sequence duration	1309.1 ns = 9 × T_{seq}
T_{HEADER}: Header duration	1.75 µs = 3 × 512 × T_c (SC and low-power SC)
F_{CCP}: Control mode chip rate	880 MHz

Table 24-4—Timing-related parameters *(continued)*

Parameter	Value
T_{CCP}: Control mode chip time	1.14 ns = $1/F_{CP}$
$T_{STF\text{-}CP}$: Control mode short training field duration	7.272 7 µs = 50 × $Tseq$
$T_{CE\text{-}CP}$: Control mode channel estimation field duration	1309.1 ns = 9 × T_{seq}
T_{Data}	N_{BLKS} × (512+64) × T_c (SC) NOTE—N_{BLKS} is defined in 20.6.3.2.3.3.

24.3.5 Mathematical conventions in the signal description

24.3.5.1 General

The description for CDMG PHY packet structure and related equations is the same as that contained in 20.3.5.1.

24.3.5.2 Windowing function

The description for CDMG PHY windowing function is the same as that contained in 20.3.5.2.

24.3.6 Common preamble

24.3.6.1 General

The preamble is the part of the PPDU that is used for packet detection, AGC, frequency offset estimation, synchronization, I/Q imbalance estimation, indication of modulation (SC), and channel estimation. The SFS field in the preamble enables the receiver to perform estimation and compensation for the packet in a time domain and frequency domain according to the STF. The format of the preamble consists of a Short Training field followed by a Channel Estimation field. Figure 24-2 illustrates the SC packet preamble.

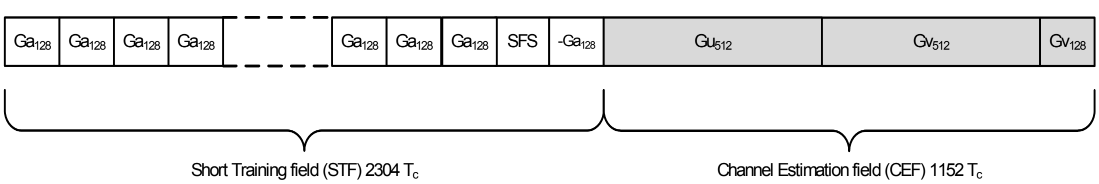


Figure 24-2—CDMG SC mode preamble

24.3.6.2 Short Training field

The Short Training field is composed of 16 repetitions of sequences $\mathrm{Ga}_{128}(n)$ of length 128 defined in 20.11, a single frequency sequence (SFS) of length 256 that used for I/Q imbalance estimation, followed by a single sequence $-\mathrm{Ga}_{128}(n)$. The SFS is defined as

$$SFS(n) = \exp\left(j\pi\frac{n}{2}\right), n = 0, 1, \ldots$$

The waveform for the Short Training field is

$$r_{STF}(nT_c) = \begin{cases} (Ga_{128}(n \bmod 128))\exp\left(j\pi\frac{n}{2}\right), n = 0, 1, \ldots, 16 \times 128 - 1 \\ \exp\left(j\pi\frac{n}{2}\right), n = 16 \times 128, \ldots, 17 \times 128 - 1 \\ (-Ga_{128}(n \bmod 128))\exp\left(j\pi\frac{n}{2}\right), n = 17 \times 128, \ldots, 18 \times 128 - 1 \end{cases}$$

24.3.6.3 Channel Estimation field

The Channel Estimation field is used for channel estimation, as well as indication of which modulation is going to be used for the packet, and enables the receiver to suppress nonlinear impact generated in a power amplification process according to the CE field. The Channel Estimation field is composed of a concatenation of two sequences $Gu_{512}(n)$ and $Gv_{512}(n)$ where the last 128 samples of $Gu_{512}(n)$ are equal to the last 128 samples used in the Short Training field. They are followed by a 128 samples sequence $Gv_{128}(n)$ equal to the first 128 samples of both $Gu_{512}(n)$ and $Gv_{512}(n)$.

The Gu_{512} and Gv_{512} sequences are defined as

$$Gu_{512} = \left[-Gb_{128}\ -Ga_{128}\ Gb_{128}\ -Ga_{128}\right]$$

$$Gv_{512} = \left[-Gb_{128}\ Ga_{128}\ -Gb_{128}\ -Ga_{128}\right]$$

When the data field of the packet is modulated using single carrier, the Gu_{512} and Gv_{512} fields are concatenated in the order illustrated in Figure 24-3.

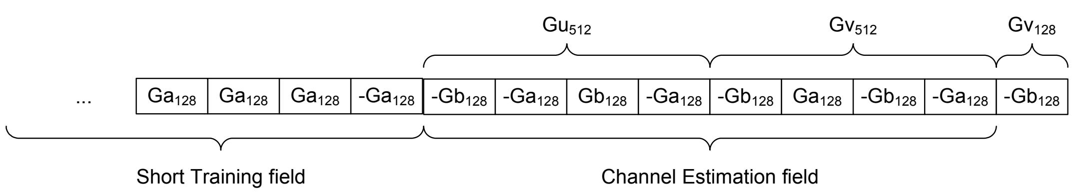


Figure 24-3—Channel Estimation field for SC packets

The waveform for the channel estimation sequence is

$$r_{CE_{SC}}(nT_c) = (Gu_{512}(n) + Gv_{512}(n - 512) + Gv_{128}(n - 1024))\exp\left(j\pi\frac{n}{2}\right), n = 0, 1, \ldots, 1151$$

Note that sequences $Gu_{512}(n)$ and $Gv_{512}(n)$ are defined for $0 \le n \le 511$. For other values of n, $Gu_{512}(n)$ and $Gv_{512}(n)$ are set to 0.

24.3.7 HCS calculation for headers of CDMG control mode and CDMG SC mode

The description for HCS calculation for headers of CDMG control mode and CDMG SC mode is the same as that contained in 20.3.7.

24.3.8 Common LDPC parity matrices

The description for common LDPC parity matrices for CDMG PHY is the same as that contained in 20.3.8.

24.3.9 Scrambler

The description for CDMG PHY scrambler is the same as that contained in 20.3.9.

24.3.10 Received channel power indicator (RCPI) measurement

The description for received channel power indicator (RCPI) measurement for CDMG PHY is the same as that contained in 20.3.10.

24.4 CDMG control mode

24.4.1 Introduction

Transmission and reception of control mode PPDUs are mandatory. CDMG control mode uses the same chip rate as the CDMG SC mode. CDMG control mode is transmitted when the TXVECTOR indicates MCS 0.

The modulation and coding scheme for the CDMG control mode is shown in Table 24-5.

Table 24-5—CDMG control mode modulation and coding scheme

MCS index	Modulation	Code rate	Data rate
0	DBPSK	1/2[a]	13.75 Mb/s[a]

[a] Code rate and data rate might be lower due to codeword shortening.

24.4.2 PPDU format

The CDMG control mode PPDU is composed of the Preamble, Header, Data field, and possibly AGC and TRN subfields. This is shown in Figure 24-4.

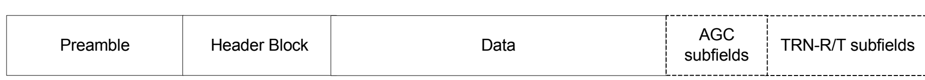


Figure 24-4—CDMG control mode PPDU format

24.4.3 Transmission

24.4.3.1 Preamble

24.4.3.1.1 General

The preamble is the part of the CDMG control mode PPDU that is used for packet detection, AGC, frequency offset estimation, synchronization, indication of frame type, and channel estimation.

The preamble is composed of two parts as shown in Figure 24-5: the Short Training field and the Channel Estimation field.

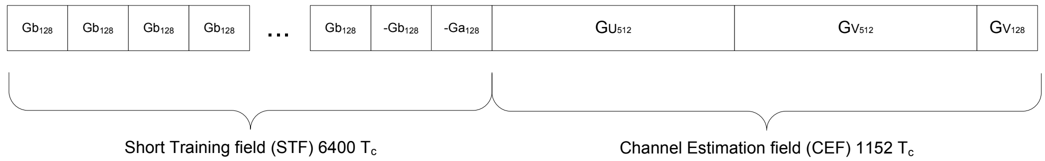


Figure 24-5—CDMG control mode preamble

24.4.3.1.2 Short Training field

The Short Training field is composed of 48 repetitions of sequences $\mathrm{Gb}_{128}(n)$ of length 128, followed by a single $-\mathrm{Gb}_{128}(n)$ sequence (for synchronization) and then a single $-\mathrm{Ga}_{128}(n)$ sequence. The sequences $\mathrm{Ga}_{128}(n)$ and $\mathrm{Gb}_{128}(n)$ are defined in 20.11.

The waveform for the Short Training field is

$$r_{STF}(nT_c) = \begin{cases} Gb_{128}(n \bmod 128)\exp\left(j\pi\frac{n}{2}\right), & n = 0, 1, \ldots, 48 \times 128 - 1 \\ -Gb_{128}(n \bmod 128)\exp\left(j\pi\frac{n}{2}\right), & n = 48 \times 128, \ldots, 49 \times 128 - 1 \\ -Ga_{128}(n \bmod 128)\exp\left(j\pi\frac{n}{2}\right), & n = 49 \times 128, \ldots, 50 \times 128 - 1 \end{cases}$$

Note that sequences $\mathrm{Ga}_{128}(n)$ and $\mathrm{Gb}_{128}(n)$ are defined for $0 \le n \le 127$. For other values of n, they are set to 0.

24.4.3.1.3 Channel Estimation field

The Channel Estimation field is the same as the Channel Estimation field of the CDMG SC mode, as defined in Figure 24-3 of 24.3.6.3.

24.4.3.2 Header

24.4.3.2.1 General

In the CDMG control mode, the preamble is followed by the header block. The header consists of several fields that define the details of the PPDU to be transmitted.

The header fields are described in Table 24-6.

Table 24-6—CDMG control mode header fields

Field name	Number of bits	Starting bit	Description
Differential encoder initialization	1	0	Used to initialize the differential encoding.
Scrambler Initialization	4	1	Bits X1–X4 of the initial scrambler state.

Table 24-6—CDMG control mode header fields *(continued)*

Field name	Number of bits	Starting bit	Description
Length	10	5	Number of data octets in the PSDU. Range 14–1023.
Packet Type	1	15	As defined in Table 24-8.
Training Length	5	16	Length of the training field. The use of this field is defined in 24.9.2.2.3.
Turnaround	1	21	As defined in Table 24-1.
Robust PHY Mode Indication/Reserved bits	2	22	— Set to 00: control mode. — Set to 01: robust PHY mode 0. — Set to 10: robust PHY mode 1. — Set to 11: Reserved.
HCS	16	24	Header check sequence. Calculation of the header check sequence is defined in 24.3.7.

All of the numeric fields are encoded in unsigned binary, least significant bit first.

Reserved bits are set to 0 by the transmitter and shall be ignored by the receiver.

24.4.3.2.2 Generation of HCS bits

The header check sequence (HCS) is calculated over bits 0–23 and uses CRC 16-CCITT as described in 24.3.7.

24.4.3.2.3 Header encoding and modulation

The header bits followed by the HCS bits are prepended to the data field bits and passed into the data field encoder per 24.4.3.3. The minimal payload length is 14 octets.

24.4.3.3 Data field

The description for Data field for CDMG control mode is the same as that contained in 20.4.3.3.

24.4.4 Performance requirements

24.4.4.1 Transmit requirements

24.4.4.1.1 Introduction

Transmitter performance requirements of the CDMG control mode are defined in 24.4.4.1.2.

24.4.4.1.2 Transmit EVM

The description for transmit EVM for CDMG control mode is the same as that contained in 20.4.4.1.2.

24.4.4.2 Receive requirements

24.4.4.2.1 Introduction

This subclause describes the performance requirement from the CDMG control mode receiver.

24.4.4.2.2 CCA

The start of a valid CDMG control mode transmission at a receive level greater than –71 dBm shall cause CCA to indicate busy with a probability > 90% within 3 μs.

24.5 CDMG SC mode

24.5.1 Introduction

Transmission and reception of CDMG SC mode PPDUs are mandatory for selected MCSs.

24.5.2 PPDU format

A SC frame is composed of the Short Training field (STF), the Channel Estimation (CE) field, the Header, SC blocks and optional training fields, as shown in Figure 24-6.

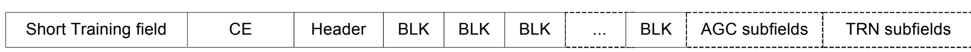


Figure 24-6—SC frame format

The robust PHY modes use the CDMG control mode with short spreading sequences for the data. (See Table 24-7.) The following Golay complementary sequences Ga(8) and Ga(4) are used as spreading sequences for robust PHY mode 0 and 1, respectively.

Ga(8)=(+1, +1, +1, −1, +1, +1, −1, +1)

Ga(4)=(+1, +1, +1, −1)

Table 24-7—CDMG robust PHY modes

CDMG-Robust mode	Modulation	Code rate	Spreading sequence	Data rate (Mb/s)
0	DBPSK	1/2	Ga(8)	55
1	DBPSK	1/2	Ga(4)	110

24.5.3 Transmission

24.5.3.1 Header

24.5.3.1.1 General

In the CDMG SC mode, the preamble is followed by the header. The header consists of several fields that define the details of the PPDU to be transmitted. The encoding and modulation of the header are described in 24.5.3.1.4.

The header fields are described in Table 24-8.

Table 24-8—CDMG SC mode header fields

Field name	Number of bits	Start bit	Description
Scrambler Initialization	7	0	Bits X1–X7 of the initial scrambler state.
MCS	6	7	Modulation and coding scheme (see Table 24-9).
Length	18	13	Number of data octets in the PSDU. Range 1–262 143.
Additional PPDU	1	31	Contains a copy of the parameter ADD-PPDU from the TXVECTOR. A value of 1 indicates that this PPDU is immediately followed by another PPDU with no IFS or preamble on the subsequent PPDU. A value of 0 indicates that no additional PPDU follows this PPDU.
Packet Type	1	32	Corresponds to the TXVECTOR parameter PACKET-TYPE. — Packet Type = 0 (BRP-RX packet, see 20.10.2.2.3), indicates either a packet whose data part is followed by one or more TRN subfields (when the Beam Tracking Request field is 0 or in CDMG control mode), or a PPDU that contains TRN subfields to be appended to a future response PPDU (when the Beam Tracking Request field is 1). — Packet Type = 1 (BRP-RX packet, see 20.10.2.2.3), indicates a PPDU whose data part is followed by one or more TRN subfields. The transmitter may change AWV at the beginning of each TRN subfield. The field is reserved when the Training Length field is 0.
Training Length	5	33	Corresponds to the TXVECTOR parameter TRN-LEN. If the Beam Tracking Request field is 0, the Training Length field indicates the length of the training field. The use of this field is defined in 24.9.2.2.3. A value of 0 indicates that no training field is present in this PPDU. If the Beam Tracking Request field is 1 and the Packet Type field is 1, the Training Length field indicates the length of the training field appended to this PPDU. If the Packet Type field is 0, the Training Length field indicates the length of the training field requested for receive training.
Aggregation	1	38	Set to 1 to indicate that the PPDU in the data portion of the packet contains an A-MPDU; otherwise, set to 0.

Table 24-8—CDMG SC mode header fields *(continued)*

Field name	Number of bits	Start bit	Description
Beam Tracking Request	1	39	Corresponds to the TXVECTOR parameter BEAM_TRACKING_REQUEST. Set to 1 to indicate the need for beam tracking (10.38.7); otherwise, set to 0. The Beam Tracking Request field is reserved when the Training Length field is 0.
Last RSSI	4	40	Contains a copy of the parameter LAST_RSSI from the TXVECTOR. The value is an unsigned integer: Values of 2 to 14 represent power levels (–74+value×2) dBm. A value of 15 represents a power greater than or equal to –45 dBm. A value of 1 represents a power less than or equal to –71 dBm. A value of 0 indicates that the previous packet was not received a SIFS period before the current transmission.
Turnaround	1	44	As defined in Table 24-1.
Enhanced Beam Tracking Request	1	45	Corresponds to the TXVECTOR parameter ENHANCED_BEAM_TRACKING_REQUEST. Set to 1 to indicate that one STF and CE field are appended to the Data and TRN fields. Otherwise, set to 0.
Reserved	2	46	
HCS	16	48	Header check sequence. Definition of this field calculation is in 24.5.3.1.3.

All of the numeric fields are encoded in unsigned binary, least significant bit first.

Reserved bits are set to 0 by the transmitter and shall be ignored by the receiver.

If the Additional PPDU field is equal to 1, the Training Length field shall be set to 0.

24.5.3.1.2 Modulation and coding scheme

The modulation and coding scheme (MCS) field specifies the modulation and code rate that is used in the PPDU. The modulation and coding schemes for the SC mode are defined in Table 24-9.

Table 24-9—CDMG SC mode modulation and coding schemes

MCS index	Modulation	N_{CBPS}	Repetition	Code rate	Data rate (Mb/s)
1	π/2-BPSK	1	2	1/2	192.5
2	π/2-BPSK	1	1	1/2	385
3	π/2-BPSK	1	1	5/8	481.25
4	π/2-BPSK	1	1	3/4	577.5
5	π/2-BPSK	1	1	13/16	625.625
6	π/2-QPSK	2	1	1/2	770

Table 24-9—CDMG SC mode modulation and coding schemes *(continued)*

MCS index	Modulation	N_{CBPS}	Repetition	Code rate	Data rate (Mb/s)
7	π/2-QPSK	2	1	5/8	962.5
8	π/2-QPSK	2	1	3/4	1155
9	π/2-QPSK	2	1	13/16	1251.25
10	π/2-16-QAM	4	1	1/2	1540
11	π/2-16-QAM	4	1	5/8	1925
12	π/2-16-QAM	4	1	3/4	2310
13	π/2-16-QAM	4	1	13/16	2502.5
14	π/2-64-QAM	6	1	5/8	2887.5
15	π/2-64-QAM	6	1	3/4	3465
16	π/2-64-QAM	6	1	13/16	3453.75

Transmit and receive support for MCS 9 and below is mandatory. Other MCSs are optional.

24.5.3.1.3 Generation of the HCS bits

Calculation of the HCS for bits 0–47 of the header is defined in 24.3.7.

24.5.3.1.4 Header encoding and modulation

The description for header encoding and modulation for CDMG SC mode is the same as that contained in 20.6.3.1.4.

24.5.3.2 The Data field

24.5.3.2.1 General

The data field consists of the payload data of the PSDU and possible padding. The data are padded with zeros, scrambled, encoded, and modulated as described in the following subclauses. The amount of padding is defined in 24.5.3.2.3.

24.5.3.2.2 Scrambler

The description for CDMG SC mode scrambler is the same as that contained in 20.6.3.2.2.

24.5.3.2.3 Encoding

The description for CDMG SC mode encoding is the same as that contained in 20.6.3.2.3.

24.5.3.2.4 Modulation mapping

24.5.3.2.4.1 General

The coded and padded bit stream is converted into a stream of complex constellation points according to the modulation specified in the MCS table.

24.5.3.2.4.2 π/2-BPSK modulation

The description for CDMG SC mode π/2-BPSK modulation is the same as that contained in 20.6.3.2.4.2.

24.5.3.2.4.3 π/2-QPSK modulation

The description for CDMG SC mode π/2-QPSK modulation is the same as that contained in 20.6.3.2.4.3.

24.5.3.2.4.4 π/2-16-QAM modulation

The description for CDMG SC mode π/2-16-QAM modulation is the same as that contained in 20.6.3.2.4.4.

24.5.3.2.4.5 π/2-64-QAM modulation

In π/2-64-QAM modulation, the input bit stream is grouped into sets of 6 bits and mapped according to the following equation:

$$\begin{aligned}\tilde{s}(k) &= \frac{1}{\sqrt{42}}((8c_{6k}-4)-(2c_{6k}-1)(4c_{6k+1}-2)+(2c_{6k}-1)(2c_{6k+1}-1)(2c_{6k+2}-1)) \\ &\quad +j\frac{1}{\sqrt{42}}((8c_{6k+3}-4)-(2c_{6k+3}-1)(4c_{6k+4}-2)+(2c_{6k+3}-1)(2c_{6+4}-1)(2c_{6k+5}-1))\end{aligned}$$

where k is the output symbol index, k = 0, 1, …. Each output symbol is then rotated according to the following equation: $s_k = \tilde{s}_k \cdot e^{j \cdot \pi \cdot k/2}$.

The constellation bit encoding for 64-QAM is shown in Figure 24-7.

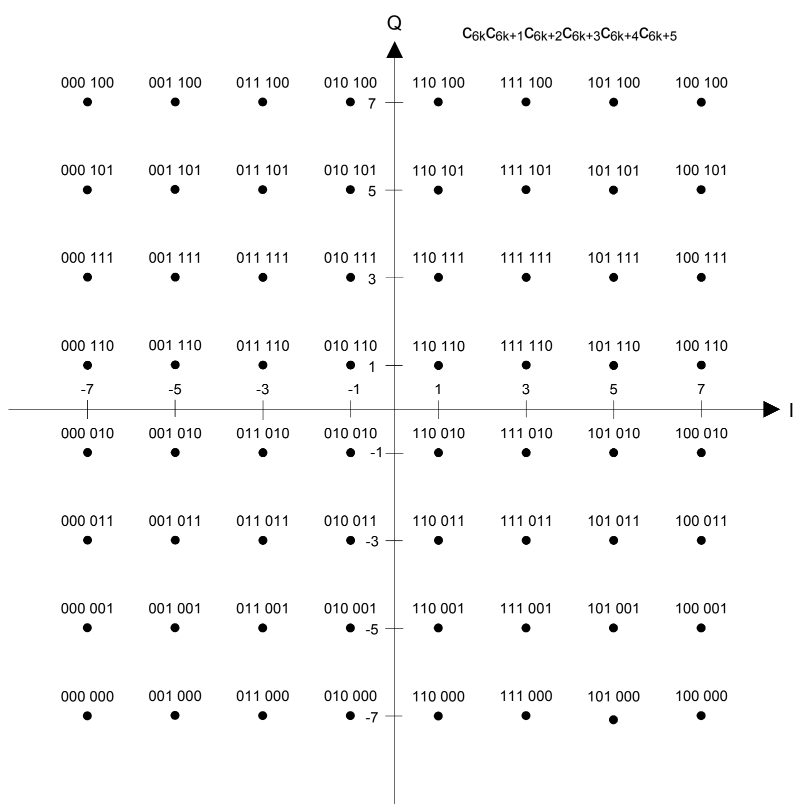


Figure 24-7—64-QAM constellation bit encoding

24.5.3.2.5 Symbol blocking and guard insertion

The description for CDMG SC mode symbol blocking and guard insertion is the same as that contained in 20.6.3.2.5.

24.5.4 Performance requirements

24.5.4.1 Transmit requirements

24.5.4.1.1 Transmit EVM

The transmit EVM accuracy test shall be performed by instrumentation capable of converting the transmitted signal into a stream of complex samples, with sufficient accuracy in terms of I/Q arm amplitude and phase balance, dc offsets, phase noise, etc.

The instrumentation shall perform carrier lock, symbol timing recovery, and amplitude adjustment while making the measurements. The equalizer shall be trained using information in the SC preamble (STF and/or CE field). For the CDMG SC mode EVM, measuring N_s samples at the sample rate, the measured symbols should not contain the first and the last hundred symbols of a given packet (ramp up/down). The EVM is calculated according to the formula below:

$$EVM = 20\log_{10}\left(\sqrt{\left(\frac{1}{N_s P_{avg}} \sum_{i=1}^{N_S} [(I_i - I_i^* - I_0)^2 + (Q_i - Q_i^* - Q_0)^2]\right)}\right)$$

where

N_s	is the number of samples to be measured and N_s should be 1000
P_{avg}	is the average power of the constellation
(I_i, Q_i)	is the complex coordinates of the measured symbol i
(I_i^*, Q_i^*)	is the complex coordinates of the ideal constellation point for the measured symbol i
(I_0, Q_0)	is the complex DC term chosen to reduce EVM

The test equipment should use a root-raised cosine filter with roll-off factor of 0.25 for the pulse shaping filter when conducting EVM measurement.

The transmit pulse shaping used is left to the implementer.

The relative constellation error (EVM) shall not exceed a MCS dependent value according to Table 24-10.

Table 24-10—CDMG SC mode EVM requirements

MCS index	Modulation	Coding rate	EVM value (dB)
1	π/2-BPSK	1/2 with repetition	–6
2	π/2-BPSK	1/2	–7
3	π/2-BPSK	5/8	–9
4	π/2-BPSK	3/4	–10

Table 24-10—CDMG SC mode EVM requirements *(continued)*

MCS index	Modulation	Coding rate	EVM value (dB)
5	π/2-BPSK	13/16	–12
6	π/2-QPSK	1/2	–11
7	π/2-QPSK	5/8	–12
8	π/2-QPSK	3/4	–13
9	π/2-QPSK	13/16	–15
10	π/2-16-QAM	1/2	–19
11	π/2-16-QAM	5/8	–20
12	π/2-16-QAM	3/4	–21
13	π/2-16-QAM	13/16	–23
14	π/2-64-QAM	5/8	–25
15	π/2-64-QAM	3/4	–26
16	π/2-64-QAM	13/16	–28

24.5.4.1.2 Time of Departure accuracy

The Time of Departure accuracy test evaluates TIME_OF_DEPARTURE against aTxPHYTxStartRMS and aTxPHYTxStartRMS against TIME_OF_DEPARTURE_ACCURACY_TEST_THRESH as defined in Annex P with the following test parameters:

— MULTICHANNEL_SAMPLING_RATE is 880×10^6 sample/s.
— FIRST_TRANSITION_FIELD is Short Training field.
— SECOND_TRANSITION_FIELD is Channel Estimation field.
— TRAINING_FIELD is Channel Estimation field.
— TIME_OF_DEPARTURE_ACCURACY_TEST_THRESH is 80 ns.

NOTE—The indicated windowing applies to the time of departure accuracy test equipment, and not the transmitter or receiver.

24.5.4.2 Receive requirements

24.5.4.2.1 Introduction

This subclause describes the receiver requirements of the CDMG SC mode.

24.5.4.2.2 CCA

The start of a valid CDMG SC mode transmission at a receive level greater than the minimum sensitivity for MCS 1 (–71 dBm) shall cause CCA to indicate busy with a probability > 90% within 1 µs. The receiver shall hold the carrier sense signal busy for any signal 20 dB above the minimum sensitivity for MCS 1.

24.6 CDMG low-power SC mode

24.6.1 Introduction

The CDMG low-power SC mode is an optional SC mode. This mode can provide lower processing power requirements for CDMG transceivers.

24.6.2 Transmission

24.6.2.1 Preamble

The CDMG low-power SC mode uses the same preamble as the CDMG SC mode.

24.6.2.2 Header

24.6.2.2.1 General

The CDMG low-power SC mode header fields are the same fields as in the CDMG SC mode (see Table 24-8 in 24.5.3.1).

The CDMG low-power SC mode modulation and coding schemes are listed in Table 24-11.

Table 24-11—CDMG low-power SC mode modulation and coding schemes

MCS	Modulation	Effective code rate	Coding scheme	N_{CPB}	Rate (Mb/s)
17	π/2-BPSK	13/28	RS(224,208)+Block-Code(16,8)	392	313
18	π/2-BPSK	13/21	RS(224,208)+Block-Code(12,8)	392	417
19	π/2-BPSK	52/63	RS(224,208)+SPC(9,8)	392	556
20	π/2-QPSK	13/28	RS(224,208)+Block-Code(16,8)	392	625.5
21	π/2-QPSK	13/21	RS(224,208)+Block-Code(12,8)	392	834
22	π/2-QPSK	52/63	RS(224,208)+SPC(9,8)	392	1112
23	π/2-QPSK	13/14	RS(224,208)+Block-Code(8,8)	392	1251.5

24.6.2.2.2 Header encoding and modulation

The description for header encoding and modulation for CDMG low-power SC mode is the same as that contained in 20.7.2.2.2.

24.6.2.3 Data field

The description for CDMG SC mode Data field is the same as that contained in 20.7.2.3.

24.7 PHY transmit procedure

The PHY transmit procedure is shown in Figure 20-20. In order to transmit data, a PHY-TXSTART.request primitive shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME, as specified in 24.10. Other transmit parameters, such as MCS and transmit power, are set via the PHY SAP with the PHY-TXSTART.request(TXVECTOR) primitive, as described in 24.2.2.

Transmission of the PHY preamble may start if TIME_OF_DEPARTURE_REQUESTED is false and shall start immediately if TIME_OFDEPARTURE_REQUESTED is true, based on the parameters passed in the PHY-TXSTART.request primitive.

The preamble format (control or SC mode) depends on the MCS in the PHY-TXSTART.request primitive. The PHY shall calculate the length of the packet according the MCS and the length specified in the PHY-TXSTART.request primitive, adding padding bits if necessary.

The PHY continues with the encoding and transmission of the header according to the parameters of the PHY-TXSTART.request(TXVECTOR) primitive. The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The data are encoded as described in 20.4.3.3.3, 20.5.3.2.3, and 20.6.3.2.3. The encoded data are then modulated as described in 24.4, 24.5, and 24.6, depending on the MCS requested in the PHY-TXSTART.request primitive. Transmission can be prematurely terminated by the MAC through the PHY-TXEND.request primitive. PHY-TXSTART shall be disabled by receiving a PHY-TXEND.request primitive.

Transmission of the PSDU is completed with the transmission of the last bits of the (encoded) PSDU. If no TRN units are specified in the PHY-TXSTART.request primitive, the PHY shall issue a PHY-TXEND primitive after the transmission of the last bits. If TRN units are requested in the PHY-TXSTART.request primitive, the transmission continues with the transmission of the AGC subfields and TRN units. The PHY issues the PHY-TXEND.confirm primitive to the MAC after the transmission of the last TRN unit. The packet transmission shall be completed, and the PHY entity shall enter the receive state (i.e., PHY-TXSTART shall be disabled). Each PHY-TXEND.request primitive is acknowledged with a PHY-TXEND.confirm primitive from the PHY.

A typical transmit state machine is shown in Figure 24-8.

24.8 PHY receive procedure

A CDMG STA shall follow the DMG receive procedure defined in 20.9 when a DMG PPDU is detected on a 2.16 GHz channel.

The CDMG PHY receive procedure follows similar rules as descrived in 20.9.

24.9 Beamforming

24.9.1 Beamforming concept

The beamforming concept is the same as that contained in 20.10.1.

24.9.2 Beamforming frame format

24.9.2.1 Sector-level sweep

PPDUs transmitted during transmit sector sweep are CDMG control mode PPDUs. PPDUs transmitted during receive sector sweep are CDMG control mode or CDMG SC mode PPDUs.

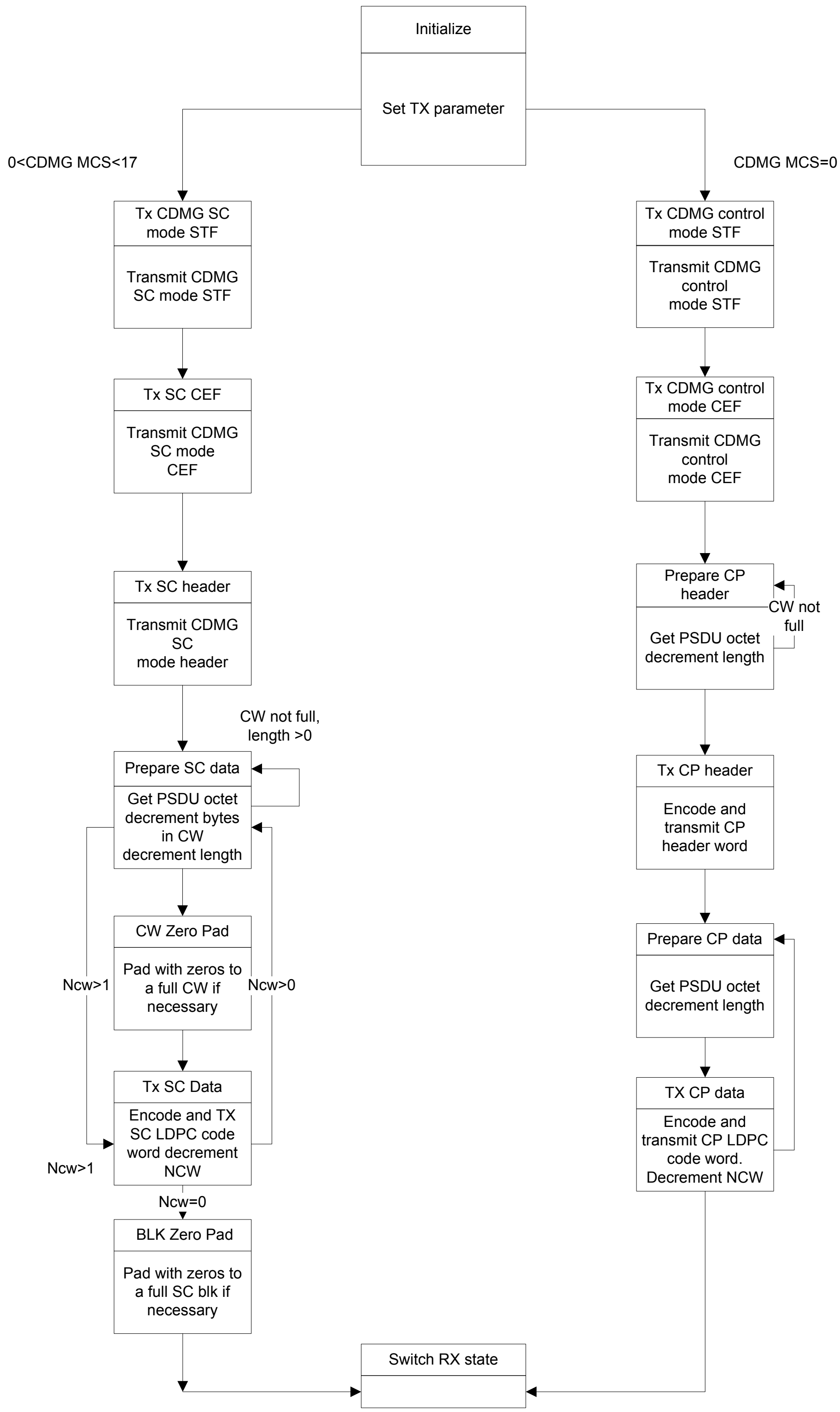


Figure 24-8—Typical Tx state machine (Training Length=0 is assumed; some optional features such as CDMG SC low-power mode are not shown)

24.9.2.2 Beam refinement

24.9.2.2.1 General

See 20.10.2.2.1 for the general description of beam refinement.

In addition to DMG beam refinement features, enhanced beam tracking is a process that the CDMG STAs can use to improve their antenna configurations (or antenna weight vectors) both for transmission and reception and measure the backup channel performance of an alternative link via beam tracking. Once the current link has poor quality due to blockage or antenna rotation, the CDMG STAs can switch to an alternative link. Only if the alternative link has been set and enhanced beam tracking is enabled, can CDMG STAs perform enhanced beam tracking. The procedure of enhanced beam tracking is described in 10.38.9.

In addition to TRN training sequences appended, CDMG enhanced beam tracking uses BRP-RX or BRP-TX packets that have an STF and a CE field appended to them.

- BRP-RX packets are packets that have e-TRN-R/TRN-R training sequences appended to them. These packets with TRN-R sequences enable receiver antenna weight vector training, and these packets with e-TRN-R sequences enable receiver antenna weight vector training and measuring one alternative link.
- BRP-TX packets are packets that have e-TRN-T/TRN-T training sequences appended to them. The transmitting STA may change antenna configuration at the beginning of each sequence. The receiving STA performs measurements on these sequences and sends feedback to the STA that transmits the BRP-TX packet, including the measurement results of alternative link.

24.9.2.2.2 BRP packet structure

If the Enhanced Beam Tracking Request field in the PHY header is 0, each beam refinement packet is composed of an STF, a CE field, and a Data field followed by a training field containing an AGC training field and a receiver training field, as shown in Figure 20-24.

If the Enhanced Beam Tracking Request field in the PHY header is equal to 1, each BRP packet is composed of an STF, a CE field, and a data field followed by a training field containing an AGC training field, a receiver training field (TRN-R/T), an STF, and a CE field. The collection of the AGC training field, TRN field, STF, and CE field at the end of BRP packet is termed an *e-TRN field*. The AGC training fields and TRN fields are used to train the current link and the adjacent links of the current link during beam tracking process. The alternative link is a beam link with different propagation characteristic that cannot be measured accurately by the AGC field and the training field (TRN-R/T) that are used for measuring the adjacent beam links. The STF and the CE field at the end of BRP packet are used for measuring and training the alternative link of CDMG STAs during enhanced beam tracking (see 10.38.9). The BRP packet structure for CDMG STAs that perform enhanced beam tracking is shown in Figure 24-9.

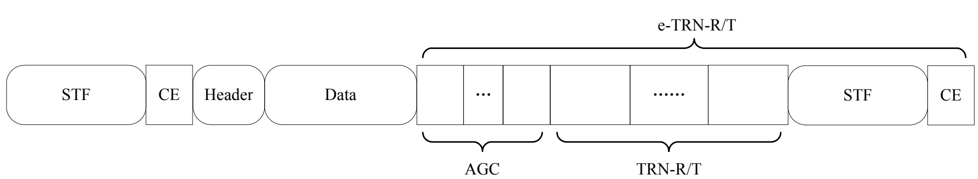


Figure 24-9—BRP packet structure (CDMG STAs)

24.9.2.2.3 BRP packet header fields

The description for BRP packet header fields is the same as that contained in 20.10.2.2.3.

24.9.2.2.4 BRP packet duration

The minimum duration of the data field of a BRP packet when sent in an SC mode is aBRPminSCblocks SC blocks (see 24.5.3.2.5), and, if needed, the data field of the packet shall be extended by extra 0 padding to generate the required number of SC blocks. Table 24-12 contains the values of NCWmin for MCSs 1 to 9 necessary to compute the padding described in 20.6.3.2.3.3.

Table 24-12—Zero filling for SC BRP packets with MCSs 1 to 9

MCS index	Modulation	N_{CBPS}	Repetition	Code rate	Data rate (Mb/s)	N_{CWmin}
1	π/2-BPSK	1	2	1/2	192.5	12
2	π/2-BPSK	1	1	1/2	385	12
3	π/2-BPSK	1	1	5/8	481.25	12
4	π/2-BPSK	1	1	3/4	577.5	12
5	π/2-BPSK	1	1	13/16	625.625	12
6	π/2-QPSK	2	1	1/2	770	23
7	π/2-QPSK	2	1	5/8	962.5	23
8	π/2-QPSK	2	1	3/4	1155	23
9	π/2-QPSK	2	1	13/16	1251.25	23

The minimum duration of the data field of a BRP packet when sent with the low-power SC mode is N_{BLK_MIN} low-power SC blocks (see 20.7.2.3.3).

24.9.2.2.5 AGC field

The beam refinement AGC fields are composed of 4*N* repetitions of the sequence [Ga_{64} Ga_{64} Ga_{64} Ga_{64} Ga_{64}] when the packet is transmitted using the SC mode and [Gb_{64} Gb_{64} Gb_{64} Gb_{64} Gb_{64}] when the packet is transmitted using the control mode. The sequences Ga64 and Gb64 are defined in 20.11. The sequences are transmitted using rotated π/2-BPSK modulation. Any transmit signal transients that occur due to this TX AWV configuration change shall completely settle by the end of the first Ga64 or Gb64 subsequence.

In a BRP-TX packet, the transmitter may change the TX AWV configuration at the beginning of each AGC field. The set of AWVs used for the AGC subfields should be the same as that used for the TRN-T fields. In a BRP-RX packet, the transmitter shall use the same TX AWV as in the preamble and data fields of the packet.

24.9.2.2.6 TRN field

The description for TRN field is the same as that contained in 20.10.2.2.6.

24.9.2.2.7 Channel measurement

The description for channel measurement is the same as that contained in 20.10.2.2.7.

24.10 CDMG PLME

24.10.1 PLME SAP sublayer management primitives

Table 24-13 lists the MIB attributes that may be accessed by the PHY entities and the intra-layer of higher level LMEs. These attributes are accessed via the PLME-GET, PLME-SET, PLME-RESET, and PLME-CHARACTERISTICS primitives defined in 6.5.

24.10.2 CDMG PHY MIB

All CDMG PHY MIB attributes are defined in Annex C, with specific values defined in Table 24-13. The column titled “Operational semantics” in Table 24-13 contains two types: static and dynamic. Static MIB attributes are fixed and cannot be modified for a given PHY implementation. Dynamic MIB attributes can be modified by some management entity.

Table 24-13—CDMG PHY MIB attribute default values

Managed object	Default value/range	Operational semantics
dot11PHYOperationTable		
dot11PHYtype	cdmg(12)	Static
dot11PHYCDMGTable		
dot11LowPowerSCPHYImplemented	Boolean	Static
dot11LowPowerSCPHYActivated	Boolean	Dynamic

24.10.3 TXTIME calculation

The value of the TXTIME parameter returned by the PLME-TXTIME.confirm primitive shall be calculated according to the following equations.

For the CDMG SC PHY (N_{TRN} is Training Length field defined in the header; see, for example, Table 24-8):

$$TXTIME = \begin{cases} T_{STF} + T_{CE} + T_{header} + T_{Data} & N_{TRN} = 0 \\ T_{STF} + T_{CE} + T_{header} + \max\{T_{Data}, (\alpha \times \beta + \gamma) \times T_C\} + N_{TRN} \times T_{TRN-Unit} & N_{TRN} > 0 \text{ and SC} \end{cases}$$

where
α = aBRPminSCblocks
β = aSCBlockSize
γ = aSCGILength
$T_{TRN-Unit}$ = aBRPTRNBlock $\times T_C$

For the CDMG control PHY:

$$TXTIME = T_{STF-CP} + T_{CE-CP} + (11 \times 8 + (Length - 6) \times 8 + N_{CW} \times 168) \times T_C \times 32 + N_{TRN} \times T_{TRN-Unit}$$

where N_{CW} calculation is defined in 20.4.3.3.3.

24.10.4 PHY characteristics

The static CDMG PHY characteristics, provided through the PLME-CHARACTERISTICS service primitive, shall be as shown in Table 24-14. The definitions for these characteristics are given in 6.5.4.

Table 24-14—CDMG PHY characteristics

PHY parameter	Value
aDataPreambleLength	3927 ns
aControlPHYPreambleLength	8582 ns
aPPDUMaxTime	4 ms
aPSDUMaxLength	262 143 octets

25. China millimeter-wave multi-gigabit (CMMG) PHY specification

25.1 Introduction

25.1.1 Introduction to the CMMG PHY

Clause 25 specifies the PHY entities for China millimeter-wave multi-gigabit (CMMG) single carrier (SC) and orthogonal frequency division multiplexing (OFDM) systems.

The maximum number of space-time streams supported in CMMG SC and OFDM system is four.

The CMMG PHY provides support for 540 MHz and 1080 MHz channel widths.

The CMMG PHY data are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), and 64-QAM. Forward error correction (FEC) coding (LDPC coding) is used with coding rates of 1/2, 3/4, 5/8, and 13/16.

A CMMG STA shall support the following features:

- 540 MHz channel width
- Control mode and SC mode (directional transmit and receive)
- Single spatial stream MCS 0 (control mode transmit and receive) in all supported channel widths
- Single spatial stream MCSs 1 to 3 (SC mode transmit and receive) in all supported channel widths
- LDPC coding with length 672
- Normal guard interval as defined in Table 25-3

A CMMG STA may support the following features:

- Support for 1080 MHz channel width
- CMMG MCSs 4 to 8 (SC mode transmit and receive)
- CMMG MCSs 9 to 16 (OFDM mode transmit and receive)
- Two or more spatial streams (transmit and receive)
- Short guard interval (transmit and receive)
- LDPC coding with length 2016
- Support MIMO transmission (SC mode and OFDM mode with omnidirectional antenna pattern or quasi-omni antenna pattern transceiver)
- STBC (transmit and receive)
- Transmit beamforming sounding (by sending a CMMG NDP)
- Responding to transmit beamforming sounding

NOTE—MIMO transmission only applies in the case where the antenna pattern is the omnidirectional antenna pattern or quasi-omni antenna pattern.

25.1.2 Scope

The CMMG PHY supports three modulation methods:

- A control modulation using MCS 0 (the CMMG control mode; see 25.4)
- A single carrier (SC) modulation using MCS 1 to MCS 8 (the CMMG SC mode; see 25.5)
- An OFDM modulation using MCS 9 to MCS 16 (the CMMG OFDM mode; see 25.6)

All these modulation methods share a common preamble (see 25.3.5).

The services provided to the MAC by the CMMG PHY consist of the following protocol functions:

a) A function that defines a method of mapping the PSDUs into a framing format (PPDU) suitable for sending and receiving PSDUs between two or more STAs.
b) A function that defines the characteristics and method of transmitting and receiving data through a wireless medium between two or more STAs. Depending on the PPDU format, these STAs support a mixture of CMMG Control mode, CMMG SC mode, and CMMG OFDM mode.

25.1.3 CMMG PHY functions

25.1.3.1 General

The CMMG PHY contains two functional entities: the PHY function and the physical layer management function (PLME). Each of these functions is described in detail in 25.4 (for CMMG control mode), 25.5 (for CMMG SC mode), 25.6 (for CMMG OFDM mode), and 25.14 (for CMMG PLME). The CMMG PHY service is provided to the MAC through the PHY service primitives defined in Clause 6.

25.1.3.2 PHY management entity (PLME)

The PLME performs management of the local PHY functions in conjunction with the MLME.

25.1.3.3 Service specification method

The models represented by figures and state diagrams are intended to be illustrations of the functions provided. It is important to distinguish between a model and a real implementation. The models are optimized for simplicity and clarity of presentation; the actual method of implementation is left to the discretion of the CMMG PHY compliant developer. The service of a layer or sublayer is the set of capabilities that it offers to a user in the next higher layer (or sublayer). Abstract services are specified here by describing the service primitives and parameters that characterize each service. This definition is independent of any particular implementation.

25.1.3.4 PPDU formats

The structure of the PPDU transmitted by a CMMG STA is determined by the TXVECTOR parameters as defined in Table 25-1.

A CMMG PPDU can be further categorized as a CMMG control mode PPDU, a CMMG SC mode PPDU, or a CMMG OFDM mode PPDU.

25.2 CMMG PHY service interface

25.2.1 Introduction

The PHY provides an interface to the MAC through an extension of the generic PHY service interface defined in 7.3.4. The interface includes TXVECTOR, RXVECTOR, and PHYCONFIG_VECTOR.

The TXVECTOR supplies the PHY with per-PPDU transmit parameters. Using the RXVECTOR, the PHY informs the MAC of the received PPDU parameters. Using the PHYCONFIG_VECTOR, the MAC configures the PHY for operation, independent of frame transmission or reception.

25.2.2 TXVECTOR and RXVECTOR parameters

The parameters in Table 25-1 are defined as part of the TXVECTOR parameter list in the PHYTX-START.request primitive and/or as part of the RXVECTOR parameter list in the PHYRXSTART.indication primitive.

Table 25-1—TXVECTOR and RXVECTOR parameters

Parameter	Value	TXVECTOR	RXVECTOR
MCS	The MCS field indicates the modulation and coding scheme used in the transmission of the packet. Values are integers in the range from 0 to 31. — An MCS value of 0 indicates the use of control mode. — MCS values of 1 to 8 indicate use of single carrier modulations. The value is an index to Table 25-38 to Table 25-45. — MCS values of 9 to 16 indicates use of OFDM modulations. The value is an index to Table 25-46 to Table 25-53.	Y	Y
LENGTH	Indicates the number of octets in the PSDU in the range from 0 to 262 143. A value of zero indicates a packet in which no data part follows the SIG.	Y	Y
N_TX	Indicates the number of transmit chains.	Y	N
NSS	Indicates the number of spatial streams.	Y	N
EXPANSION_MAT	If PPDU transmission mode is OFDM mode, contains a set of compressed beamforming feedback matrices as defined in 25.6.8.13.2. The number of elements depends on the number of spatial streams and the number of transmit chains. Otherwise, not present.	Y	N
CHAN_MAT	If PSDU LENGTH equals 0, contains a set of compressed beamforming feedback matrices as defined in 25.6.8.13.2 based on the channel measured during the training symbols of the received PPDU. The number of elements depends on the number of spatial streams and the number of transmit chains. Otherwise, not present.	N	Y
ADD-PPDU	Enumerated type: — ADD-PPDU indicates that this PPDU is immediately followed by another PPDU with no IFS or preamble on the subsequent PPDU. — NO-ADD-PPDU indicates no additional PPDU follows this PPDU.	Y	Y
AGGREGATION	Indicates whether the PSDU contains an A-MPDU. Enumerated type: — AGGREGATED indicates this is a packet with A-MPDU aggregation. — NOT_AGGREGATED indicates this is a packet without A-MPDU aggregation.	Y	Y
RSSI	The allowed values for the RSSI parameter are in the range from 0 through RSSI maximum. This parameter is a measure by the PHY of the power observed at the antennas used to receive the current PPDU. RSSI shall be measured during the reception of the PHY preamble. RSSI is intended to be used in a relative manner, and it shall be a monotonically increasing function of the received power.	N	Y
REC_MCS	Indicates the MCS that the STA's receiver recommends.	N	O

Table 25-1—TXVECTOR and RXVECTOR parameters ***(continued)***

Parameter	Value	TXVECTOR	RXVECTOR
SNR	Contains an array of received SNR measurements for each spatial stream. SNR indications of 8 bits are supported. SNR shall be the sum of the decibel values of SNR per tone divided by the number of tones represented in each stream as described in 9.4.1.49.	N	Y
STBC	Indicates whether STBC is used. 0 indicates no STBC (NSTS=NSS in the Data field). 1 indicates STBC is used (NSTS=2NSS in the Data field). This parameter is 0 for a CMMG OFDM MU PPDU.	Y	Y
RCPI	Is a measure of the received RF power measured over the preamble of a received frame. Refer to 20.3.10 for the definition of RCPI.	N	Y
TXOP_PS_NOT_ALLOWED	Indicates whether a CMMG AP allows non-AP CMMG STAs in TXOP power save mode to enter doze state during the TXOP. 0 indicates that the CMMG AP allows non-AP CMMG STAs to enter doze mode during a TXOP. 1 indicates that the CMMG AP does not allow non-AP CMMG STAs to enter doze mode during a TXOP.	Y	Y
PARTI AL_AI D	Provides an abbreviated indication of the intended recipient(s) of the PSDU (see 10.20). Integer: range from 0 to 511 if UPLINK_INDICATION is 1, and range from 0 to 63 if UPLINK_INDICATION is 0.	Y	Y
UPLINK_INDICATION	Set to 1 if the CMMG PPDU is addressed to AP. Set to 0 otherwise (see 10.20).	Y	Y
COLOR	If UPLINK_INDICATION is 0, set to a value of its choosing within the range from 0 to 7 and shall maintain that value for the duration of the existence of the BSS. Otherwise, not present (see 10.20).	Y	Y
CH_BANDWIDTH	Indicates the channel width of the transmitted PPDU: Enumerated type: — CBW540 for 540 MHz — CBW1080 for 1080 MHz	Y	Y
DUPLICATE_MODULATION	In TXVECTOR, indicates the PPDU transmitted with CMMG duplicate format. In RXVECTOR, indicates the estimated PPDU transmitted with CMMG duplicate format; — Present if CH_BANDWIDTH equals CBW1080 and the PPDU is transmitted with duplicate format. — Otherwise not present.	O	O
DYN_BANDWIDTH	In TXVECTOR, if present, indicates whether the transmitter is capable of Static or Dynamic bandwidth operation. In RXVECTOR, if valid, indicates whether the transmitter is capable of Static or Dynamic bandwidth operation. Enumerated type: — Static if the transmitter is capable of Static bandwidth operation. — Dynamic if the transmitter is capable of Dynamic bandwidth operation. NOTE—In the RXVECTOR, the validity of this parameter is determined by the MAC based on the contents of the received MPDU.	O	Y

Table 25-1—TXVECTOR and RXVECTOR parameters *(continued)*

Parameter	Value	TXVECTOR	RXVECTOR
BEAMFORMED	Set to 1 if a beamforming steering matrix is applied to the waveform in a CMMG OFDM mode transmission as described in 20.3.11.11.2. Set to 0 otherwise. NOTE—When BEAMFORMED is equal to 1, smoothing is not recommended.	Y	O
TIME_OF_DEPARTURE_REQUESTED	Enumerated type: — true indicates that the MAC entity requests that the PHY entity measure and report time of departure parameters corresponding to the time when the first frame energy is sent by the transmitting port. — false indicates that the MAC entity requests that the PHY entity neither measure nor report time of departure parameters.	O	N
RX_START_OF_FRAME_OFFSET	0 to 2^{32}–1. An estimate of the offset (in 10 nanosecond units) from the point in time at which the start of the preamble corresponding to the incoming frame arrived at the receive antenna port to the point in time at which this primitive is issued to the MAC.	N	Y
PACKET_TYPE	Enumerated type: — TRN-R-PACKET indicates either a packet whose data part is followed by one or more TRN-R subfields, or a packet that is requesting TRN-R subfields to be appended to a future response packet. — TRN-T-PACKET indicates a packet whose data part is followed by one or more TRN-T subfields. This field is reserved if TRN-LEN is 0.	Y	Y
BEAM_TRACKING_REQUEST	This parameter indicates whether beam tracking is requested. Enumerated type: — Beam tracking requested or Beam tracking not requested.	Y	Y
LAST_RSSI	In the TXVECTOR, LAST_RSSI indicates the received power level of the last packet with a valid PHY SIG that was received an SIFS period before transmission of the current packet; otherwise, it is 0 (see 10.3.2.3.3). In the RXVECTOR, LAST_RSSI indicates the value of the LAST_RSSI field from the PCLP header of the received packet. Valid values are integers in the range from 0 to 15: — Values of 2 to 14 represent power levels (–71+value×2) dBm. — A value of 15 represents power greater than or equal to –42 dBm. — A value of 1 represents power less than or equal to –68 dBm. — A value of 0 indicates that the previous packet was not received an SIFS period before the current transmission.	Y	Y
Turnaround	Set to 1 or 0 as specified in 10.3.2.3.3.	Y	Y

NOTE—In the “TXVECTOR” and “RXVECTOR” columns, the following apply:
Y = Present
N = Not present
O = Optional

25.3 Common parameters

25.3.1 Introduction

This subclause introduces some common parameters.

25.3.2 Common requirements

25.3.2.1 Introduction

This subclause describes the common requirements from all 3 modes: control, SC, and OFDM.

25.3.2.2 Transmit RF delay

The transmit RF delay is as defined in 17.3.8.6, and its value is implementation dependent.

25.3.2.3 Center frequency tolerance

25.3.2.3.1 General

The transmitter center frequency tolerance shall be ± 20 ppm maximum.

25.3.2.3.2 Center frequency convergence

The transmitter center frequency shall converge to within 1 ppm of its final value within 2.5 µs from the start of the packet.

25.3.2.3.3 Symbol clock tolerance

The symbol clock frequency tolerance shall be ± 20 ppm maximum.

The transmit center frequency and the symbol clock frequency shall be derived from the same reference oscillator.

25.3.2.3.4 Transmit rampup and rampdown

The transmit power-on ramp is defined as the time it takes for a transmitter to rise from less than 10% to greater than 90% of the average power to be transmitted in the frame.

The transmit power-on ramp shall be less than 30 ns.

The transmit power-down ramp is defined as the time it takes the transmitter to fall from greater than 90% to less than 10% of the maximum power to be transmitted in the frame.

The transmit power-down ramp shall be less than 30 ns.

25.3.2.3.5 Maximum input requirement

The receiver maximum input level is the maximum power level at the receive antenna(s) of the incoming signal, in dBm, present at the input of the receiver antenna for which the error rate criterion (defined in 25.3.2.3.6) is met. A compliant receiver shall have a receiver maximum input level at the receive antenna(s) of at least 10 microwatts/cm^2 for each of the modulation formats that the receiver supports.

25.3.2.3.6 Receive sensitivity

The packet error ratio (PER) shall be less than 10% for a PSDU length of 4096 octets with the rate-dependent input levels listed in Table 25-2.

Table 25-2—Receiver sensitivity

MCS Index	CBW 540 MHz	CBW 1080 MHz
1	–74	–71
2	–69	–66
3	–67	–64
4	–61	–58
5	–59	–56
6	–55	–52
7	–53	–50
8	–51	–48
9	–74	–71
10	–69	–66
11	–66	–63
12	–64	–61
13	–60	–57
14	–57	–54
15	–55	–52
16	–53	–50

25.3.3 Time-related parameters

Table 25-3 defines the timing-related parameters for CMMG format.

Table 25-3—Time-related parameters

Parameter	CBW 540 MHz	CBW 1080 MHz	Description
N_{SD}	168	336	Number of complex data numbers per OFDM symbol
N_{SP}	8	16	Number of pilot subcarriers per OFDM symbol
N_{DC}	3	3	Number of DC subcarriers per OFDM symbol
N_{ST}	179	355	Total number of subcarriers per OFDM symbol

Table 25-3—Time-related parameters *(continued)*

Parameter	CBW 540 MHz	CBW 1080 MHz	Description
N_{SR}	89	177	Highest data subcarrier index per OFDM symbol
F_S	660 MHz	1320 MHz	OFDM sample rate
T_S	1.515 ns = $1/F_S$	0.758 ns = $1/F_S$	OFDM sample time
F_C	440 MHz = 2/3 F_S	880 MHz = 2/3 F_S	SC chip rate
T_C	2.272 ns = $1/F_C$	1.136 ns = $1/F_C$	SC chip time
Δ_F	2.578125 MHz		Subcarrier frequency spacing
T_{DFT}	387.879 ns		IDFT/DFT period
T_{GI}	96.97 ns = $T_{DFT}/4$		Guard interval duration
T_{GIS}	48.485 ns = $T_{DFT}/8$		Short guard interval duration
T_{SYML}	484.8 = $T_{DFT} + T_{GI}$ = $1.25\,T_{DFT}$		Long GI symbol interval
T_{SYMS}	436.4 = $T_{DFT} + T_{GI}$ = $1.125\,T_{DFT}$		Short GI symbol interval
T_{SYM}	T_{SYML} or T_{SYMS} depending on the GI used (see Table 22-8)		Symbol interval
T_{seq}	581.8 ns = $256\,T_C$		ZCZ block duration
T_{CSTF}	8145.5 ns = $14\,T_{seq}$		Short training field duration for control mode
T_{STF}	5818 ns = $10\,T_{seq}$		Short training field duration *n* for SC/OFDM mode
T_{CEF}	2327.3 ns = $4\,T_{seq}$		Channel estimation field duration
T_{SIG}	2327.3 ns = $4\,T_{seq}$		SIGNAL field duration
T_{OSTF}	484.8 ns = $4\,T_{SYMS}$		Duration of each OSTF
T_{OCEF}	484.8 ns = $4\,T_{SYMS}$		Duration of each OCEF

Table 25-4 defines parameters used frequently in Clause 25.

Table 25-4—Frequently used parameters

Symbol	Explanation
N_{BL}	Number of the data blocks for SC transmission.
N_{CBPB}	Number of coded bits per block.
N_{CBPS}	For OFDM transmission: Number of coded bits per OFDM symbol. For SC transmission: Number of coded bits per constellation symbol.
N_{CBPSS}	Number of coded bits per symbol per spatial stream.
N_{DBPS}	Number of data bits per symbol.
N_{DSPB}	Number of data constellation symbols per block for SC transmission.

Table 25-4—Frequently used parameters *(continued)*

Symbol	Explanation
N_{UWPB}	Length of the UW in each block for SC transmission.
$N_{BLS} = N_{DSPB} + N_{UWPB}$	Number of the symbols in each block for SC transmission.
N_{BPSCS}	Number of coded bits per subcarrier per spatial stream.
N_{RX}	Number of receive chains.
N_{STS}	For pre-CMMG modulated fields, $N_{STS} = 1$ (see NOTE). For CMMG modulated fields, N_{STS} is the number of space-time streams.
N_{OCEF}	Number of OCEF symbols 25.6.7.
N_{SS}	Number of spatial streams.
N_{TX}	Number of transmit chains.
R	R is the coding rate.
NOTE—Pre-CMMG modulated fields refer to the STF, CEF, and CMMG SIG field, while CMMG modulated fields refer to the OCEF and Data field (see Figure 25-1, Figure 25-2, and Figure 25-3).	

25.3.4 Mathematical conventions in the signal description

25.3.4.1 Notation

$[\mathbf{Q}]_{m,n}$ indicates the element in row m and column n of matrix $\mathbf{Q}$.

25.3.4.2 Subcarrier indices in use

For a 540 MHz OFDM mode PPDU transmission, the 540 MHz is divided into 256 subcarriers. The signal is transmitted on subcarrier –89 to –2 and 2 to 89, with –1, 0, and 1 being the center (DC) subcarriers.

For a 1080 MHz OFDM mode PPDU transmission, the 1080 MHz is divided into 512 subcarriers. The signal is transmitted on subcarrier –177 to –2 and 2 to 177, with –1, 0, and 1 being the center (DC) subcarriers.

25.3.4.3 Transmitted signal

The transmitted signal is described in complex baseband signal notation. The actual transmitted signal is defined by the complex baseband signal in Equation (25-1).

$$r_{RF}^{i_{Tx}} = \mathrm{Re}\{ r_{PPDU}^{i_{Tx}}(t) \exp(j2\pi f_c t) \} \quad (25\text{-}1)$$

where

r_{PPDU} represents the complex baseband signal in transmit chain i_{Tx}

f_c represents the center frequency of the portion of the transmitted PPDU

The transmitted RF signal is derived by up-converting the complex baseband signal, which consists of several fields. The fields and timing boundaries for various fields are shown in Figure 25-1 to Figure 25-3.

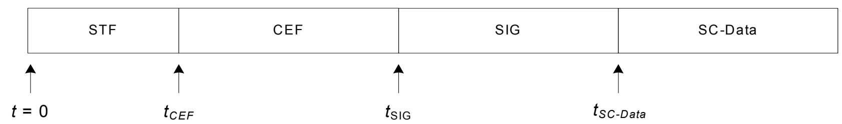


Figure 25-1—Packet structure for the SC mode PPDU with CBW 540 MHz

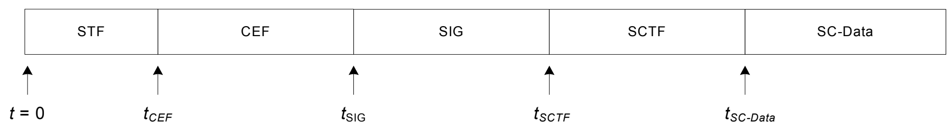


Figure 25-2—Packet structure for the SC mode PPDU with CBW 1080 MHz

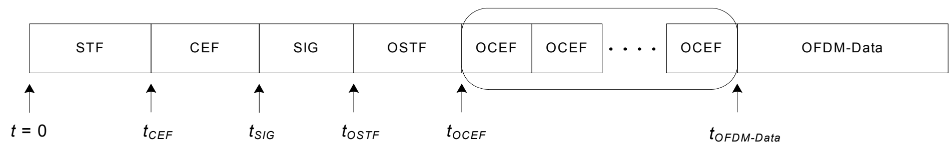


Figure 25-3—Packet structure for the OFDM mode PPDU

The time offset, t_{Field}, determines the starting time of the corresponding field.

For the SC mode transmission with 540 MHz,

$$r^{i_{Tx}}_{PPDU}(t) = r^{i_{Tx}}_{STF}(t) + r^{i_{Tx}}_{CEF}(t - t_{CEF}) + r^{i_{Tx}}_{SIG}(t - t_{SIG}) + r^{i_{Tx}}_{SC-Data}(t - t_{SC-Data}) \quad (25\text{-}2)$$

For the SC mode transmission with 1080 MHz,

$$r^{i_{Tx}}_{PPDU}(t) = r^{i_{Tx}}_{STF}(t) + r^{i_{Tx}}_{CEF}(t - t_{CEF}) + r^{i_{Tx}}_{SIG}(t - t_{SIG}) + r^{i_{Tx}}_{SCTF}(t - t_{SCTF}) + r^{i_{Tx}}_{SC-Data}(t - t_{SC-Data}) \quad (25\text{-}3)$$

For the OFDM mode transmission,

$$r^{i_{Tx}}_{PPDU}(t) = r^{i_{Tx}}_{STF}(t) + r^{i_{Tx}}_{CEF}(t - t_{CEF}) + r^{i_{Tx}}_{SIG}(t - t_{SIG}) + r^{i_{Tx}}_{MCTF}(t - t_{MCTF}) + r^{i_{Tx}}_{OFDM-Data}(t - t_{OFDM-Data}) \quad (25\text{-}4)$$

where

$t_{CEF} = T_{STF}$

$t_{SIG} = t_{CEF} + T_{CEF}$

$t_{SCEF} = t_{SIG} + T_{SIG}$

$T_{OSTF} = t_{SIG} + T_{SIG}$

$t_{OCEF} = t_{OSTF} + T_{OSTF}$

$t_{SC-Data} = t_{SCTF} + T_{SCTF}$

$t_{OFDM-Data} = t_{OCTF} + N_{OCEF}T_{OCEF}$

Each OFDM mode baseband waveform $r_{subfield}(nT_s)$, for the fields above, is defined via the inverse discrete Fourier transform (IDFT) as

$$r_{subfield}^{i_{Tx}}(t) = \frac{1}{\sqrt{N_{Tone}N_{STS}}} w_{T_{subfield}}(t) \sum_{k=-N_{SR}}^{N_{SR}} \sum_{m=0}^{N_{STS}-1} [Q_k]_{i_{Tx},m} \gamma_{k,CBW} X_{k,m} \exp((j2\pi k\Delta_F(t - T_{GI} - T_{CS}(m)))) \quad (25\text{-}5)$$

In Equation (25-5) the following notions are used:

N_{Tone}	is, for 540 MHz transmission, 176 and, for 1080 MHz transmission, 352
N_{STS}	is the number of the space time stream
T_{GI}	is the guard interval duration used for each OFDM symbol
Q_k	is the spatial mapping matrix with N_{Tx} rows and N_{STS} for the subcarrier k
$w_{T_{subfield}}$	is a windowing function. An example function, $w_{T_{subfield}}$, is given in 25.3.4.5
$\gamma_{k,CBW}$	is defined in 25.3.4.4
Δ_F	is the subcarrier frequency spacing given in Table 25-3
$T_{CS}(m)$	represents the cyclic shift per space-time stream, whose value is defined in Table 25-27
$X_{k,m}$	is the frequency-domain symbol in subcarrier k of space-time stream m. Some of the $X_{k,m}$ within $-N_{SR} \le k \le N_{SR}$ have a value of 0, such as the DC tones

The base band waveform for fields defined by time domain sequence or for single carrier transmission is

$$r_{Field}(nT_C) = x(n) \quad (25\text{-}6)$$

where $x(n)$ is the constellation point n.

Conversion from the sampled digital domain to the continuous time domain is beyond the scope of this document. Filtering for pulse shaping such as in GMSK is beyond the scope of this standard.

25.3.4.4 Definition of tone rotation for OFDM mode transmission

The function $\Upsilon_{k,CBW}$ is used to represent a rotation of the tones. $\Upsilon_{k,CBW}$ is determined by the TXVECTOR parameter CH_BANDWIDTH as defined in Table 25-5.

Table 25-5—CH_BANDWIDTH and $\Upsilon_{k,CBW}$

CH_BANDWIDTH	$\Upsilon_{k,CBW}$
CBW540	$\Upsilon_{k,540}$
CBW1080	$\Upsilon_{k,1080}$

For a 540 MHz OFDM mode PPDU transmission,

$$\Upsilon_{k,540} = 1 \quad (25\text{-}7)$$

For a 1080 MHz OFDM mode PPDU transmission,

$$\Upsilon_{k,1080} = \begin{cases} 1, & k < 0 \\ j, & k \ge 0 \end{cases} \quad (25\text{-}8)$$

25.3.4.5 The windowing function

The windowing function $w_{T_{Field}}(nT_S)$ is used to smooth the transition between adjacent fields in the packet where OFDM mode modulation is employed. No windowing is applied to preamble fields or to SC modulated fields. The windowing function is different from being equivalent to "1" only in the transition region.

An example of a windowing function is given by

$$w_T(t) = \begin{cases} \sin^2\left(\frac{\pi}{2}\left(\frac{1}{2} + \frac{t}{T_R}\right)\right), \frac{-T_R}{2} < t \le \frac{T_R}{2} \\ 1, \frac{T_R}{2} < t \le T - \frac{T_R}{2} \\ \sin^2\left(\frac{\pi}{2}\left(\frac{1}{2} - \frac{t}{T_R}\right)\right), T - \frac{T_R}{2} < t \le T + \frac{T_R}{2} \end{cases} \tag{25-9}$$

The transition region creates an overlap (with length T_R) between adjacent fields. The field wave form is extended cyclically to fill the part of the transition region in which it is undefined. If the transition region vanishes (i.e., T_R=0), the windowing function degenerates to a rectangular window. The choice of windowing function is implementation dependent, as long as transmit EVM and transmit mask requirements are met.

25.3.5 CMMG PHY preamble

25.3.5.1 General

The CMMG PHY preamble is the part of the PHY PPDU that is used for packet detection, AGC, frequency offset estimation, synchronization, indication of transmission mode (Control mode, SC mode, or OFDM mode), indication of transmission bandwidth (540 MHz or 1080 MHz), and channel estimation. The format of the preamble is common to both SC packets and OFDM packets and consists of a Short Training field followed by a Channel Estimation field. The content of the Short Training field is the same between SC and OFDM packets (see 25.3.5.2), but the content of the Channel Estimation field is not the same between such packets (see 25.3.5.3).

NOTE—For SC and OFDM MIMO mode transmission, different transmit antenna transmit a different preamble that is composed of one of the four ZCZ sequences with the order of $Z_{256}^1, Z_{256}^2, Z_{256}^3, Z_{256}^4$, such as for the case of one transmit antenna, the preamble sequence is composed of Z_{256}^1, for the case of two transmit antennas, the preamble sequences are composed of Z_{256}^1, Z_{256}^2, respectively.

25.3.5.2 CMMG Short Training field

25.3.5.2.1 STF of control mode

The Short Training field is composed of 50 repetitions of the sequence $Z(n)$ of length 32. The sequences $Z(n)$ is defined in 25.8.

The waveform for the STF is

$$r_{STF}(nT_C) = Z(n \bmod 32)\exp\left(j\pi\frac{n}{2}\right), n = 0, 1, \ldots, 50 \times 32 - 1 \tag{25-10}$$

where T_C is SC mode chip time of CBW 540 MHz.

25.3.5.2.2 STF of SC and OFDM mode

The Short Training fields of SC and OFDM modes share the same definition. The common Short Training field is composed of 17 repetitions of the sequence $Z(n)$ of length 32. The sequences $Z(n)$ is defined in 25.8.

The waveform for the Short Training field is

$$r_{STF}(nT_C) = Z(n \bmod 32)\exp\left(j\pi\frac{n}{2}\right), n = 0, 1, \ldots, 17 \times 32 - 1 \tag{25-11}$$

where T_C is SC mode chip time of CBW 540 MHz.

25.3.5.3 CMMG Channel Estimation field

25.3.5.3.1 CEF of control mode

The CEF of CMMG control mode is composed of four concatenated $Z(n)$ sequences where each sequence is multiplied by an individual sign assignment. As shown in Figure 25-4, the CEF of control mode is defined as $-Z(n), Z(n), -Z(n), -Z(n)$, where the sequence is defined in 25.8.

The waveform for the CEF is

$$r_{CEF}(nT_C) = \begin{cases} -Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 0, 1, \ldots, 256 - 1 \\ Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 256, \ldots, 256 \times 2 - 1 \\ -Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 256 \times 2, \ldots, 256 \times 3 - 1 \\ -Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 256 \times 3, \ldots, 256 \times 4 - 1 \end{cases} \tag{25-12}$$

where T_C is SC mode chip time of CBW 540 MHz. The control mode preamble is illustrated in Figure 25-4.

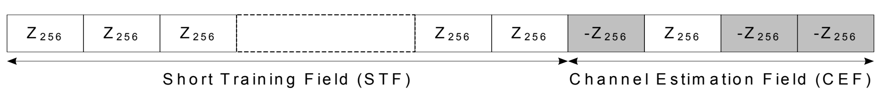


Figure 25-4—Control mode preamble

NOTE—All fields are transmitted with SC mode transmission. For 1080 MHz SC transmission, the STFs, the CEFs, and the SIG fields are transmitted with duplicated style.

25.3.5.3.2 CEF of SC mode

The CEF of SC mode is also composed of four concatenated $Z(n)$ sequences but is with different sign assignment patterns. As shown in Figure 25-5 and Figure 25-6, the CEF of SC 540 MHz PHY is defined as $[-Z(n), Z(n), Z(n), -Z(n)]$, and the CEF of SC 1080 MHz PHY is defined as $[-Z(n), -Z(n), Z(n), Z(n)]$, where the sequence $Z(n)$ is defined in 25.8.

The waveform for the CEF of SC 540 MHz mode is

$$r_{CEF}(nT_C) = \begin{cases} -Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 0, 1, \ldots, 256-1 \\ Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 256, \ldots, 256 \times 2-1 \\ Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 256 \times 2, \ldots, 256 \times 3-1 \\ -Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 256 \times 3, \ldots, 256 \times 4-1 \end{cases} \tag{25-13}$$

and the waveform for the CEF of SC 1080 MHz mode is

$$r_{CEF}(nT_C) = \begin{cases} -Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 0, 1, \ldots, 256-1 \\ -Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 256, \ldots, 256 \times 2-1 \\ Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 256 \times 2, \ldots, 256 \times 3-1 \\ Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 256 \times 3, \ldots, 256 \times 4-1 \end{cases} \tag{25-14}$$

where T_C is SC mode chip time of CBW 540 MHz.

The SC mode preambles are illustrated in Figure 25-5 and Figure 25-6.

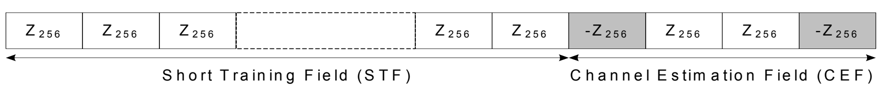


Figure 25-5—CMMG SC mode preamble for CBW 540 MHz

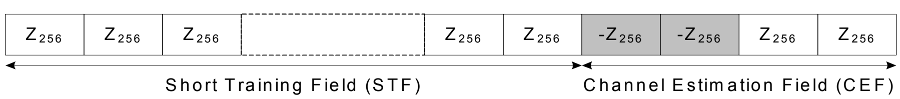


Figure 25-6—CMMG SC mode preamble for CBW 1080 MHz

NOTE—All fields are transmitted with SC mode transmission. For 1080 MHz SC mode transmission, the STFs, the CEFs, and the SIG fields are transmitted with duplicated style.

25.3.5.3.3 CEF of OFDM mode

The CEF of OFDM mode is also composed of four concatenated *Z(n)* sequences but is with different sign assignment patterns. As shown in Figure 25-7 and Figure 25-8, the CEF of OFDM 540 MHz PHY is defined as $[-Z(n), Z(n), Z(n), Z(n)]$, and the CEF of OFDM 1080 MHz PHY is defined as $[-Z(n), -Z(n), -Z(n), Z(n)]$, where the sequence *Z(n)* is defined in 25.8.

The waveform for the CEF of OFDM 540 MHz mode is

$$r_{CEF}(nT_C) = \begin{cases} -Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 0, 1, \ldots, 256-1 \\ Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 256, \ldots, 256\times 2-1 \\ Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 256\times 2, \ldots, 256\times 3-1 \\ Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 256\times 3, \ldots, 256\times 4-1 \end{cases} \tag{25-15}$$

and the waveform for the CEF of OFDM 1080 MHz mode is

$$r_{CEF}(nT_C) = \begin{cases} -Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 0, 1, \ldots, 256-1 \\ -Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 256, \ldots, 256\times 2-1 \\ -Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 256\times 2, \ldots, 256\times 3-1 \\ Z(n \bmod 256)\exp\left(j\pi\frac{n}{2}\right), n = 256\times 3, \ldots, 256\times 4-1 \end{cases} \tag{25-16}$$

where T_C is SC chip time of CBW 540 MHz.

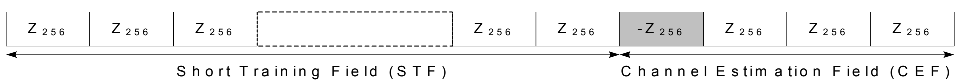


Figure 25-7—CMMG OFDM mode preamble for CBW 540 MHz

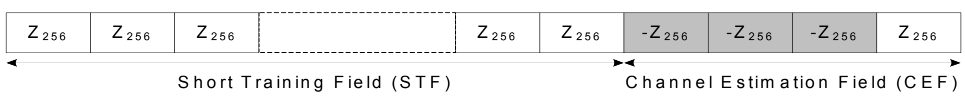


Figure 25-8—CMMG OFDM mode preamble for CBW 1080 MHz

NOTE—The STFs, the CEFs, and the SIG fields are transmitted with SC mode transmission. For 1080 MHz SC mode transmission, the STFs, the CEFs, and the SIG fields are transmitted with duplicated style.

25.3.6 CRC calculation

The value of cyclic redundancy check (CRC) field is the 1s complement of Equation (25-17).

$$CRC(D) = (M(D) \oplus I(D))D^K \bmod G(D) \tag{25-17}$$

where

$M(D) = m_0 D^{N-1} + m_1 D^{N-2} + \ldots + m_{N-1}$

N is the number of bits over which the CRC is generated

m_i is bit i of the input bit sequence

$I(D) = \sum_{i=N-K}^{N-1} D^i$ are initialized values that are added modulo 2 to the first K bits of the input bit sequence

K is the length of CRC sequence: $K = 16$ for CRC of the CMMG SIG, and $K = 8$ for the data field

$G(D) = D^{16} + D^{12} + D^5 + 1$ is the CRC generating polynomial of 8 bits

$crc(D) = x_0 D^{15} + x_1 D^{14} + \ldots + x_{14} D + x_{15}$

Figure 25-9 shows the operation of the CRC of 16 bits. First, the shift register is reset to all 1s. The bits are then passed through the XOR operation at the input. When the last bit has entered, the output is generated by shifting the bits out of the shift register, x_{15} first, through an inverter.

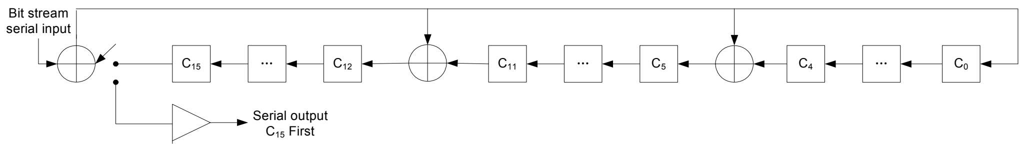


Figure 25-9—16-bit CRC calculation

$G(D) = D^8 + D^7 + D^4 + D^3 + D + 1$ is the CRC generating polynomial of 8 bits

$crc(D) = x_0 D^7 + x_1 D^6 + \ldots + x_6 D + x_7$

Figure 25-10 shows the operation of the CRC of 8 bits.

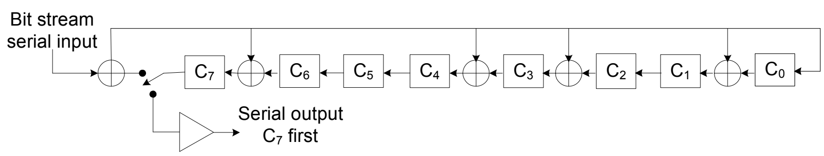


Figure 25-10—8-bit CRC calculation

25.3.7 Scrambler

The CMMG control mode SIG, CMMG SC/OFDM mode SIG, and the data fields following the scrambler initialization field (including data padding bits) shall be scrambled by XORing each bit in turn with a length 127 periodic sequence generated by the polynomial $S(x) = x^7 + x^4 + 1$. The octets of the PSDU and the pad bits shall be placed into a bit stream with bit 0 (LSB) of each octet first and bit 7 of each octet (MSB) last. The generation of the sequence and the XOR operation are defined in Figure 25-11.

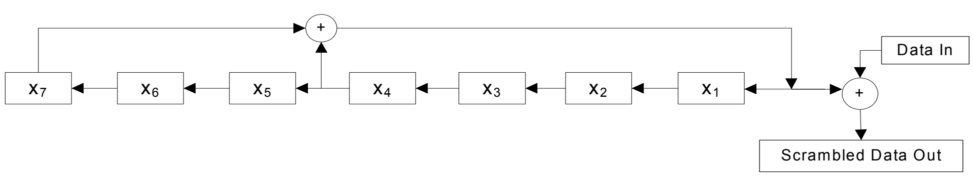


Figure 25-11—Scrambler

For each PPDU, the transmitter shall select a nonzero seed value for the scrambler (bits x_1 through x_7). The seed value should be selected in a pseudo random fashion. The seed value is sent in the Scrambler Initialization field of the PHY header. Each data bit in the data field of the PPDU is then XORed with the scrambler output (x_4 XOR x_7), and the scrambler content shifts once.

25.3.8 Common LDPC parity matrices

25.3.8.1 Introduction

Transmission/reception of LDPC with codeword length of 672 bits (expansion factor $z = 42$) is mandatory, and transmission/reception of LDPC with codeword length 2016 bits (expansion factor $z = 126$) is optional.

25.3.8.2 General

The structured LDPC code is defined by a parity check matrix $\mathbf{H}$ of size $(m \times z) \times (n \times z)$, which is determined by a base matrix $\overline{\mathbf{H}}$ of size $m \times n$, an expansion factor z, and a base permutation matrix $\mathbf{P}$ of size $z \times z$. The number of information bits is $k = (n-m) \times z$, the number of codeword bits is nz, then coding rate $r = k/(nz)$. If each element $\bar{h}_{ij}$ in the base matrix $\overline{\mathbf{H}}$ is replaced by zero subblock matrix of size $z \times z$ or the subblock matrix $\mathbf{P}^{h_{ij}}$, the parity check matrix $\mathbf{H}$ can be obtained.

The base matrix $\overline{\mathbf{H}}$ is defined as follows:

$$\overline{\mathbf{H}} = \begin{bmatrix} \bar{h}_{00} & \bar{h}_{01} & \cdots & \bar{h}_{0(n-1)} \\ \bar{h}_{10} & \bar{h}_{11} & \cdots & \bar{h}_{1(n-1)} \\ \cdots & \cdots & \cdots & \cdots \\ \bar{h}_{(m-1)0} & \bar{h}_{(m-1)1} & \cdots & \bar{h}_{(m-1)(n-1)} \end{bmatrix} \tag{25-18}$$

The parity check matrix $\mathbf{H}$ is defined as follows:

$$\mathbf{H} = \begin{bmatrix} \mathbf{P}^{\bar{h}_{00}} & \mathbf{P}^{\bar{h}_{01}} & \cdots & \mathbf{P}^{\bar{h}_{0(n-1)}} \\ \mathbf{P}^{\bar{h}_{10}} & \mathbf{P}^{\bar{h}_{11}} & \cdots & \mathbf{P}^{\bar{h}_{1(n-1)}} \\ \cdots & \cdots & \cdots & \cdots \\ \mathbf{P}^{\bar{h}_{(m-1)0}} & \mathbf{P}^{\bar{h}_{(m-1)1}} & \cdots & \mathbf{P}^{\bar{h}_{(m-1)(n-1)}} \end{bmatrix} \tag{25-19}$$

where, if $\bar{h}_{ij} = -1$, $\mathbf{P}^{h_{ij}}$ equals a zero matrix of size $z \times z$; otherwise, $\mathbf{P}^{h_{ij}}$ equals the base permutation matrix $\mathbf{P}$ to h_{ij} power. The base permutation matrix $\mathbf{P}$ of size $z \times z$ is defined as follows:

$$\mathbf{P} = \begin{bmatrix} 0 & 1 & 0 & \cdots & 0 \\ 0 & 0 & 1 & \cdots & 0 \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & 0 & \cdots & 1 \\ 1 & 0 & 0 & \cdots & 0 \end{bmatrix} \tag{25-20}$$

Table 25-6 defines the base matrix prototypes of the parity-check matrices for a codeword block length nz bits, with a subblock size z bits.

Table 25-6—Base matrix prototypes for codeword block length *nz* bits, subblock size is *z* bits

(a) Coding Rate=1/2															
-1	0	-1	0	-1	0	-1	0	0	-1	-1	-1	-1	-1	-1	-1
0	-1	-1	34	-1	12	-1	36	18	0	-1	-1	-1	-1	-1	-1
8	-1	0	-1	0	-1	0	-1	-1	13	0	-1	-1	-1	-1	-1
-1	16	40	-1	32	-1	22	-1	-1	-1	19	0	-1	-1	-1	-1
-1	20	-1	22	-1	2	-1	28	32	-1	-1	21	0	-1	-1	-1
30	-1	18	-1	-1	14	-1	30	-1	37	-1	-1	31	0	-1	-1
40	-1	12	-1	38	-1	6	-1	-1	-1	26	-1	-1	13	0	-1
-1	24	-1	20	10	-1	2	-1	-1	-1	-1	18	-1	-1	5	0
(b) Coding Rate=5/8															
-1	0	-1	0	0	0	0	0	0	-1	0	-1	-1	-1	-1	-1
0	-1	0	-1	32	-1	22	-1	18	0	19	0	-1	-1	-1	-1
8	16	40	34	-1	12	-1	36	32	-1	-1	21	0	-1	-1	-1
30	20	18	22	38	-1	6	-1	-1	13	-1	-1	31	0	-1	-1
-1	24	-1	20	-1	2	-1	28	16	37	-1	-1	-1	13	0	-1
40	-1	12	-1	10	14	2	30	-1	19	-1	-1	-1	-1	5	0
(c) Coding Rate=3/4															
0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-1
8	16	40	34	32	12	22	36	18	13	19	0	-1	0	-1	-1
30	20	18	22	38	2	6	28	32	37	26	21	31	-1	0	-1
40	24	12	20	10	14	2	30	16	19	34	18	-1	13	5	0
(d) Coding Rate=13/16															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1
30	20	18	22	38	2	6	28	32	37	26	21	34	-1	0	-1
40	24	12	20	10	14	2	30	16	19	34	18	8	13	5	0

25.3.9 CMMG SIG

25.3.9.1 General

The CMMG SIG field carries information required to interpret PPDUs. The preamble and the CMMG SIG fields are all transmitted using modulation. The structure of the CMMG SIG field is shown in Figure 25-12.

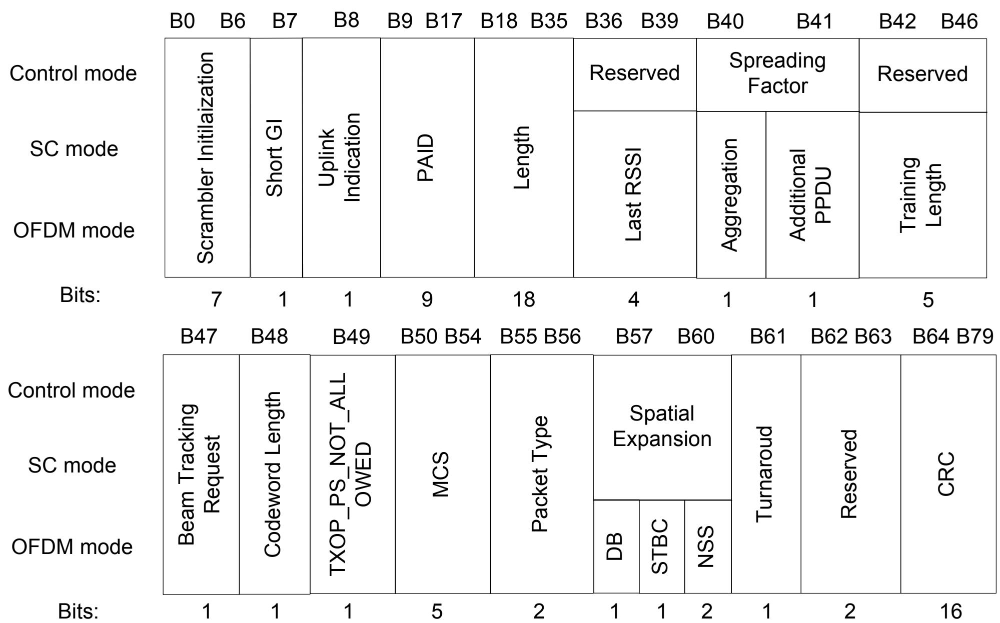


Figure 25-12—CMMG SIG structure

The CMMG SIG field contains the fields listed in Table 25-7. The mapping of the fields is also described in Table 25-7.

Table 25-7—Fields in the CMMG SIG field

Bit	Fields	Number of bits	Description
B0–B6	Scrambler Initialization	7	The initial scrambler state.
B7	Short GI	1	Set to 0 if short guard interval is not used in the Data field. Set to 1 if short guard interval is used in the Data field.
B8	Uplink Indication	1	Set to the value of the TXVECTOR parameter UPLINK_INDICATION.
B9–B17	PAID	9	If Uplink Indication is not present or set to 1, set to the value of the TXVECTOR parameter PARTIAL_AID. PARTIAL_AID provides an abbreviated indication of the intended recipient(s) of the PSDU (see 10.20). If Uplink Indication is equal to 0, B9–B11 are set to the value of the TXVECTOR parameter COLOR, and B12–B17 are set to the value of the TXVECTOR parameter PARTIAL_AID.

Table 25-7—Fields in the CMMG SIG field *(continued)*

Bit	Fields	Number of bits	Description
B18–B35	Length	18	Number of data octets in the PSDU, Range from 0 to 262 143
B36–B39	Last RSSI	4	For SC/OFDM mode: Contains a copy of the parameter LAST_RSSI from the TXVECTOR. When set to 0, this field is reserved and ignored by the receiver. The value is an unsigned integer: — Values of 2 to 14 represent power levels (–71+value×2) dBm. — A value of 15 represents a power greater than or equal to –42 dBm. — A value of 1 represents a power less than or equal to –68 dBm. Value of 0 indicates that the previous packet was not received an SIFS period before the current transmission. For control mode: Reserved.
B40–B41	Spreading Factor/ Aggregation/Additional PPDU	2	For control mode: — Set to 0: spreading by 13 — Set to 1: spreading by 7 — Set to 2: spreading by 4 — Set to 3: no spreading For SC/OFDM mode: Aggregation: — Set to 1 indicate that the PPDU in the data portion of the packet contains an A-MPDU; otherwise, set to 0. Additional PPDU: — Contains a copy of the parameter ADD-PPDU from the TXVECTOR. A value of 1 indicates that this PPDU is immediately followed by another PPDU with no IFS or preamble on the subsequent PPDU. — A value of 0 indicates that no additional PPDU follows this PPDU.
B42–B46	Training Length	5	For SC/OFDM mode: Corresponds to the TXVECTOR parameter TRNLEN. If the Beam Tracking Request field is 0, the Training Length field indicates the length of the training field. The use of this field is defined in 20.10.2.2.3. A value of 0 indicates that no training field is present in this PPDU. If the Beam Tracking Request field is 1 and the Packet Type field is 10, the Training Length field indicates the length of the training field. If the Packet Type field is 11, the Training Length field indicates the length of the training field requested for receive training. For control mode: Reserved.
B47	Beam Tracking Request	1	Corresponds to the TXVECTOR parameter BEAM_TRACKING_REQUEST. Set to 1 to indicate the need for beam tracking (10.38.7); otherwise, set to 0. The Beam Tracking Request field is reserved when the Training Length field is 0.

Table 25-7—Fields in the CMMG SIG field *(continued)*

Bit	Fields	Number of bits	Description
B48	Codeword Length	1	Set to 0 indicate that the codeword length is 672. Set to 1 indicate that the codeword length is 2016.
B49	TXOP_PS_NOT_AL-LOWED	1	Set to 0 by CMMG AP if it allows non-AP CMMG STAs in TXOP power save mode to enter doze state during a TXOP. Set to 1 otherwise. The bit is reserved and set to 1 in CMMG PPDUs transmitted by a non-AP CMMG STA.
B50–B54	MCS	5	Index into the modulation and coding scheme table.
B55–B56	Packet Type	2	When the Training Length field is nonzero, corresponds to the TXVECTOR parameter PACKET-TYPE. — Packet Type = 11 indicates either a packet whose data part is followed by one or more TRN-R subfields, or a packet that is requesting TRN-R subfields to be appended to a future response packet. — Packet Type = 10 indicates a packet whose data part is followed by one or more TRN-T subfields. When the Training Length field is zero and Packet Type = 01, indicates that PPDU is a sounding PPDU. This field is reserved when the Training Length field is zero and Packet Type = 00.
B57–B60	Spatial Expansion	4	For control/SC mode: Index into the corresponding spatial expansion method defined in Table 25-15.
	DB	1	For OFDM mode: If the PPDU is transmitted on 1080 MHz channel: Set DB to 1 for allowing dynamic bandwidth. Set to 0 for not allowing dynamic bandwidth. Otherwise set to 0 (Reserved). For control and SC mode: Reserved.
	STBC	1	For OFDM mode: Set to 1 if space time block coding is used; otherwise, set to 0.
	NSS	2	For OFDM mode: Set to 0 for 1 spatial stream. Set to 1 for 2 spatial streams. Set to 2 for 3 spatial streams. Set to 3 for 4 spatial streams.
B61	Turnaround	1	As defined in Table 25-1.
B62–B63	Reserved	2	Reserved.
B64–B79	CRC	16	CMMG SIG check sequence. Definition of this field calculation is in 25.3.6.
NOTE—A value of 0 in the CMMG Length field indicates a PPDU that does not include a data field, i.e., NDP. NDP transmissions are used for sounding purposes only (see 10.34.2). The packet ends after the last CMMG OCEF or the CMMG SIG.			

All the numeric fields are encoded in unsigned binary, least significant bit first.

Reserved bits are set to 0 by the transmitter and shall be ignored by the receiver.

25.3.9.2 Encoding of SIG

The scrambled SIG sequence consists of 80 bits, shown as $x = (x_0, x_1, x_2, \ldots, x_{79})$ and encoded with LDPC of rate-1/2 and length 672, as follows:

a) The scrambled SIG sequence is padded with 4 0s bits to create 84 bits. The 84-bit sequence include two contiguous subsequences with length of 42 bits, shown as $[[0, 0, 0, 0, x_0, \ldots, x_{37}], [x_{38}, \ldots, x_{79}]]$, and the two subsequences are repeated once, respectively, to obtain 168 bits, such as $\mathbf{a}' = [[0]_{1\times 4}, x_0, \ldots, x_{37}, [0]_{1\times 4}, x_0, \ldots, x_{37}, x_{38}, \ldots, x_{79}, x_{38}, \ldots, x_{79}]$. Then, the repeated data sequence is padded with 168 zero bits to create 336 bits.

b) Then, using rate-1/2 LDPC base matrix and setting $\bar{h}_{26} = -1$, the 336-bit sequence is added with parity bits $[p_0, \ldots, p_{335}]$ to create LDPC codeword, shown as $\mathbf{c} = [[0]_{1\times 168}, \mathbf{a}', [p_0, \ldots, p_{335}]]$, such that $\mathbf{H} \times \mathbf{c}^T = 0$, where $\mathbf{H}$ is revised LDPC parity check matrix.

c) The basic code is $\mathbf{c}' = [x_0, x_1, \ldots, x_{79}, p_0, p_1, \ldots, p_{335}]$. Using rate-matching to obtain transmitting sequence of 1024 bits: $S = [\mathbf{c}', \mathbf{c}', \mathbf{c}'(0, \ldots, 191)]$.

25.3.10 Duplication transmission on a 1080 MHz channel

The STFs, the CEFs, and the SIG fields that are transmitted using SC modulation are specified at the SC chip rate F_C equal to 440 MHz. For transmission on the 1080 MHz channel, the signal is resampled with a 2 rate change, applied appreciate phase rotation for each 540 MHz subband, and then summed to form the transmitted signal.

Let $r(nT_C) = r_{STF}(nT_C) + r_{CEF}(nT_C - t_{CEF}) + r_{SIG}(nT_C - t_{SIG})$, where T_C is the SC chip time duration for 540 MHz channel bandwidth and r_{CEF} is described in 25.3.5.

Then

$$r^{(1)}\left(n\frac{T_C}{2}\right) = \begin{cases} r\left(n\frac{T_C}{2}\right), n = 0, 2, 4, \ldots \\ 0, otherwise \end{cases} \tag{25-21}$$

$$r^{(2)}\left(n\frac{T_C}{2}\right) = \sum_{k=0}^{K-1} r^{(1)}\left((n-k)\frac{T_C}{2}\right)h_{Filt}(k), n = 0, 1, 2, \ldots \tag{25-22}$$

$$\bar{r}\left(n\frac{T_C}{2}\right) = r^{(2)}\left(\left(n+\frac{K-1}{2}\right)\frac{T_C}{2}\right), n = 0, 1, 2, \ldots \tag{25-23}$$

where K is the length of the filter defined in at chip rate 880 MHz whose definition is out of scope of this standard. The transmitted signal is given as

$$\bar{r}\left(n\frac{T_C}{2}\right) = \bar{r}\left(n\frac{T_C}{2}\right)\cdot\frac{1}{\sqrt{2}}e^{-j\pi T_C n\frac{B}{2}} + \bar{r}\left(n\frac{T_C}{2}\right)\cdot\frac{1}{\sqrt{2}}e^{j\pi T_C n\frac{B}{2}} \tag{25-24}$$

where B = 540 MHz.

25.3.11 h_{Filt} definition

The filter h_{Filt} is defined by the following coefficients (from h_0 to h_{70}):

[1,–6,–5,3,8,0,–8,–4,6,8,–4,–13, –2,16,14,–9,–23,–4,23,15, –20,–27,20,57,4,–99, –102,70,247,144,–264, –558,–175,991,2327,2917,2327,991,–175,–558,–264,144,247,70,–102, –99,4,57,20,–27,–20, 15,23,–4, –23,–9,14,16,–2,–13,–4,8,6,–4,–8,0,8,3,–5,–6,1].

Normalized to have a norm of $\sqrt{3}$ so that $h_{Filt}(k) = \dfrac{\sqrt{3}h_k}{\sqrt{\sum_{l=0}^{70} |h_l|^2}}$.

25.3.12 Encoding of Data field

The scrambled Data field is encoded with LDPC codeword length of *n* bits, information length of *k* bits, and expansion factor of *z* as follows:

a) $L_{DPCW} = k - 8$ is the maximal number of data bits in each LDPC codeword. The number of LDPC codeword is calculated as $N_{CW} = \lceil Length \times 8 / L_{DPCW} \rceil$.

b) The number of data bits in the i^{th} LDPC codeword is

$$L_i = \begin{cases} L_{DPCW1}, i = 0, 1, \ldots, N_{CW1} - 1 \\ L_{DPCW1} - 1, i = N_{CW1}, N_{CW1} + 1, \ldots, N_{CW} - 1 \end{cases}$$

where

$L_{DPCW1} = \lceil Length \times 8 / N_{CW} \rceil$

$N_{CW1} = \mathrm{mod}((Length \times 8), (L_{DPCW1} - 1))$

$\lceil x \rceil$ is smallest integer that is larger than or equal to real number x.

c) The data field is broken into N_{CW} blocks of data word $\mathbf{b}_i$, $i = 0, 1, \ldots, N_{CW} - 1$. Each data word is added with 8-bit CRC sequence, see 25.3.6, then padded with $f_i = k - L_i - 8$ zero bits to create *k* bits, such as $\mathbf{b'}_i = (0, \ldots, 0, \mathbf{b}_i, crc_0^i, \ldots, crc_7^i)$.

d) For each data word, $n - k$ parity bits are added to create the LDPC codeword $\mathbf{d}_i = (\mathbf{b'}_i, p_0^i, p_1^i, \ldots, p_{(n-k-1)}^i)$, such that $\mathbf{H} \times \mathbf{d}_i^T = \mathbf{0}$.

e) Packet encoding: The j^{th} bit set that is composed of all the j^{th} bits of N_{CW} LDPC codeword is encoded with 1-bit parity check to create a parity bit T_j, $j = 0, 1, \ldots, n-1$. All the parity bits T_j ($j = 0, 1, \ldots, n-1$) are combined into a parity data word $\mathbf{d}_{N_{CW}}$ with length of *n* bits. That is, $\mathbf{d}_{N_{CW}} = \mathbf{d}_0 \oplus \mathbf{d}_1 \oplus \cdots \oplus \mathbf{d}_{(N_{CW}-1)}$.

f) Bits selection parameter: the punctured-bit index set of i^{th} codeword that are not belong to padding bits are $\mathbf{S}_i$ ($i = 0, 1, \ldots, N_{CW} - 1$), and the punctured-bit index set of parity data word $\mathbf{d}_{N_{CW}}$ is $\bar{\mathbf{S}}_{N_{CW}}$. The intersection of any two different sets of $\bar{\mathbf{S}}_i$ ($i = 0, 1, \ldots, N_{CW}$) is empty set. The length of $\bar{\mathbf{S}}_i$ is $e_i (i = 0, \ldots, N_{CW})$, such as: (where $n' = n - f_0$).

   1) if $N_{CW} = 1$: $e_0 = 0$, $e_1 = n'$;

   2) if $1 < N_{CW} \le 15$: $e_i = z$, $i = 0, 1, \ldots, N_{CW} - 1$, $e_{N_{CW}} = n' - \sum_{i=0}^{N_{CW}-1} e_i$;

   3) if $N_{CW} > 15$: $e_i = \begin{cases} a+1, i = 0, 1, \ldots, g-1 \\ a, i = g, g+1, \ldots, N_{CW} \end{cases}$, where, $a = \lfloor n'/(N_{CW}+1) \rfloor$, $g = n' - a \times (N_{CW}+1)$.

g) Bits selection: the first element of $\bar{\mathbf{S}}_i$ is equal to the last element of $\bar{\mathbf{S}}_{(i-1)}$ plus 1, such as, $\bar{\mathbf{S}}_i = [f_0 + \sum_{j=0}^{i-1} e_j, f_0 + \sum_{j=0}^{i-1} e_j + 1, \ldots, f_0 + \sum_{j=0}^{i} e_j - 1]$, where, f_0 is the length of padding bits for the 0^{th} codeword. Remove the zero padding bits and the punctured bits from $\mathbf{d}_i$ to obtain codeword $\mathbf{c}_i$, where $i = 0, 1, \ldots, N_{CW} - 1$. The punctured-bit index set of parity data word $\mathbf{d}_{N_{CW}}$ is $\bar{\mathbf{S}}_{N_{CW}} = \left[f_0 + \sum_{j=0}^{N_{CW}-1} e_j, f_0 + \sum_{j=0}^{N_{CW}-1} e_j + 1, \ldots, f_0 + \sum_{j=0}^{N_{CW}} e_j - 1 \right]$. Remove the padding-bit-generated bits and the punctured bits from $\mathbf{d}_{N_{CW}}$ to obtain $\mathbf{c}_{N_{CW}}$, where the padding-bit-generated bits are totally generated from the zero padding bits.

Example of data field encoding:

The data field contains $Length = 512$ bytes. The parameter of LDPC: $n = 672$, $k = 336$, $R = 1/2$, $z = 42$.

a) $L_{DPCW} = k - 8 = 328$, the number of LDPC codeword: $N_{CW} = \lceil Length \times 8 / L_{DPCW} \rceil = 13$;

b) $L_{DPCW1} = \lceil Length \times 8 / N_{CW} \rceil = 316$, $N_{CW1} = \mathrm{mod}((Length \times 8), (L_{DPCW1} - 1)) = 1$,

$$L_i = \begin{cases} 316, i = 0 \\ 315, i = 1, 2, \ldots, 12 \end{cases};$$

that is, the number of data bits in the *0*th LDPC codeword is 316, and the $1 \sim 12\mathrm{th}$ LDPC codeword is 315.

c) The data field is broken into $N_{CW} = 13$ blocks of data word. Each data word is added with 8 bits *CRC* sequence, see 25.3.6. Then padded with zero bits: the *0*th data word is padded with 12 bits and the $1 \sim 12\mathrm{th}$ data word are padded with 13 bits.

d) All the data words are encoded to obtain LDPC codeword $\mathbf{d}_i = (\mathbf{b'}_i, p_0^i, p_1^i, \ldots, p_{(n-k-1)}^i)$, $i = 0, 1, \ldots, 12$.

e) Packet encoding: Encoded with 1-bit parity check to create $\mathbf{d}_{13}$, length of 672 bits.

f) Bits selection parameter: because of $(N_{CW} = 13) \leq 15$, $e_i = 42, i = 0, 1, \ldots, 12$, and $n' = n - f_0 = 672 - 12 = 660$, $e_{13} = 660 - \sum_{i=0}^{12} e_i = 114$.

g) Bits selection: Remove the zero padding bits $[0, 1, \ldots, 11]$ and the punctured bits $\bar{\mathbf{S}}_0 = [12, 13, \ldots, 53]$ from $\mathbf{d}_0$ to obtain codeword $\mathbf{c}_0$ with length of 618 bits; Remove the zero padding bits $[0, 1, \ldots, 12]$ and the punctured bits $\bar{\mathbf{S}}_1 = [54, 55, \ldots, 95]$ from $\mathbf{d}_1$ to obtain codeword $\mathbf{c}_1$ with length of 617 bits; the same operating to obtain $\mathbf{c}_2, \ldots, \mathbf{c}_{12}$. Remove the padding-bit-generated bits $[0, 1, \ldots, 11]$ and the punctured bits $\bar{\mathbf{S}}_{13} = [558, 559, \ldots, 671]$ from $\mathbf{d}_{13}$ to obtain codeword $\mathbf{c}_{13}$ with length of 546 bits.

25.3.13 Received channel power indicator (RCPI) measurement

The RCPI is a measure of the received RF power in the selected channel. This parameter shall be measured by the PHY of the received RF power in the channel measured over the data portion of the received frame. RCPI shall be a monotonically increasing, logarithmic function of the received power level defined in dBm. The allowed values for the Received RCPI parameter shall be an 8 bit value in the range from 0 to 220, with indicated values rounded to the nearest 0.5 dB as follows:

— 0: Power < –110 dBm
— 1: Power = –109.5 dBm
— 2: Power = –109.0 dBm

And so on up to:

— 220: Power > 0 dBm
— 221–254: reserved
— 255: Measurement not available

where RCPI = int{(Power in dBm +110) × 2} for 0 dBm > Power > –110 dBm.

RCPI shall equal the received RF power with an accuracy of ± 5 dB (95% confidence interval) within the specified dynamic range of the receiver. The received RF power shall be determined assuming a receiver noise equivalent bandwidth equal to the channel width multiplied by 1.1. The relative error between RF power measurements made within a 1 second interval should be less than ± 1 dB.

25.4 CMMG control mode

25.4.1 Introduction

Transmission and reception of the CMMG control mode PPDUs are mandatory. The CMMG control mode uses the same chip rate as the CMMG SC mode. The CMMG control mode is transmitted when the TXVECTOR indicates MCS 0. The modulation and coding scheme for the CMMG control mode is shown in Table 25-8.

Table 25-8—Modulation and coding scheme for the CMMG control mode

MCS index	Modulation	Code rate	Data rate
0	π/2-BPSK	1/2	25.38 Mb/s for SF 13, 47.14 Mb/s for SF 11, 82.5 Mb/s for SF 4, and 330 Mb/s for no spreading

25.4.2 PPDU format

The CMMG control mode frame is composed of CMMG control mode STF, CMMG control mode CEF, CMMG control mode SIG, CMMG control mode Data field, and possibly AGC and TRN-R/T subfields. This is shown in Figure 25-13.

Figure 25-13—CMMG control mode PPDU format

25.4.3 CMMG preamble transmission

In CMMG control mode preamble is transmitted using SC transmission (see 25.3.5).

25.4.4 CMMG control mode SIG transmission

25.4.4.1 General

The CMMG control mode SIG and data are modulated by π/2-BPSK and are spread by Barker sequences.

25.4.4.2 Generation of CRC bits

The CRC sequence is calculated over bits 0–63 and uses CRC 16-CCITT as described in 25.3.6.

25.4.4.3 Scrambler

The operation of the scrambler is defined in 25.3.7. Bits x_1, x_2, x_3, x_4, x_5, x_6, x_7 of the scrambler shift register are initialized using the bits in the scrambler initialization bits from the SIG. The SIG is scrambled starting from bit 7.

25.4.4.4 Encoding

See 25.3.9.2.

25.4.4.5 Modulation

The CMMG control mode SIG is modulated with π/2-BPSK modulation, the input bit stream is mapped according to the following equation $\tilde{s}_k = 2 \cdot c_k - 1$. Each output symbol is then rotated according to the following equation: $s_k = \tilde{s}_k \cdot e^{(j\pi k)/2}$.

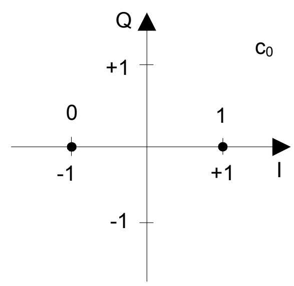


Figure 25-14—Constellation bit encoding for BPSK

25.4.4.6 Spreading

The constellation points are spread using the Barker sequence Barker(L) defined as follows in Table 25-9, where L is the spreading length.

Table 25-9—The Barker(*L*) sequences

Length L	Barker(L) sequences
4	+1,+1, −1,+1
7	+1, +1, +1, −1, −1,+1, −1
13	+1, +1, +1, +1, +1, −1, −1, +1, +1, −1, +1, −1, +1

The waveform for the modulated and spread data field is

$$r_{DATA}(nT_C) = \left(\mathrm{Barker}(n \bmod L)d\left(\left\lfloor \frac{n}{L} \right\rfloor\right)\right) \times \exp\left(j\pi\frac{n}{2}\right), n = 0, 1, 2, \ldots \quad (25\text{-}25)$$

where $d(k)$ is the modulated constellation point k and T_C is the SC chip time.

For CMMG control mode SIG, the spreading factor is always Barker(13).

25.4.5 CMMG control mode Data field

25.4.5.1 General

The Data field consists of the payload data of the PSDU. The PSDU is scrambled, encoded, modulated, and spread as described in the following subclauses.

25.4.5.2 Scrambler

The operation of the scrambler is defined in 25.3.7. The scrambling of the data field continues the scrambling of the CMMG control mode SIG with no reset.

25.4.5.3 Encoder

Use the LDPC of rate-1/2 and length 672. See 25.3.12.

25.4.5.4 Modulation

See 25.4.4.5.

25.4.5.5 Spreading

Spreading factor of CMMG control mode data field is indicated in CMMG control mode SIG. See 25.4.4.6.

25.4.6 CMMG control mode performance requirements

25.4.6.1 Transmit requirements

25.4.6.1.1 Introduction

Transmitter performance requirements of the control mode are defined in 25.4.6.1.2.

25.4.6.1.2 Transmit EVM

The transmit EVM accuracy test shall be performed by instrumentation capable of converting the transmitted signal into a stream of complex samples, with sufficient accuracy in terms of I/Q arm amplitude and phase balance, dc offsets, phase noise, etc. The instrumentation shall perform carrier lock, symbol timing recovery, and amplitude adjustment while making the measurements. The instrumentation shall incorporate a rake receiver or equalizer to reduce error resulting from multipath. If used, the equalizer shall be trained using information in the preamble (STF/CEF). For CMMG control mode EVM, the signal is first de-spread using the spreading Barker sequence, the EVM is then calculated on the resulting symbols according to the formula below:

$$EVM = 20\log_{10}\left(\sqrt{\frac{1}{N_S P_{avg}}\sum_{i=1}^{N_S}[(I_i - I_i^*)^2 + (Q_i - Q_i^*)^2]}\right) \tag{25-26}$$

where N_S is the number of samples to be measured and N_S shall be 1000, P_{avg} is the average power of the constellation, (I_i,Q_i) is the complex coordinates of the measured symbol i, (I_i^*, Q_i^*) is the complex coordinates of the ideal constellation point for the measured symbol i.

The test equipment should use a root-raised cosine filter with roll-off factor of 0.25 for the pulse shaping filter when conducting EVM measurement.

The transmit pulse shaping used is left to the implementer.

The relative constellation error (EVM) shall not exceed an MCS dependent value according to Table 25-10.

Table 25-10—EVM requirement for control mode

MCS index	Description	EVM value [dB]
0	Control mode modulation	–6

25.4.6.2 Receive requirements

25.4.6.2.1 Introduction

Subclause 25.4.6.2.2 describes the performance requirement from the CMMG control mode receiver.

25.4.6.2.2 CCA

The start of a valid CMMG control mode transmission at a receive level greater than the minimum sensitivity for CMMG control mode (–78 dBm) shall cause CCA to indicate busy with a probability > 90% within 3 µs.

25.5 CMMG SC mode

25.5.1 Introduction

Transmission and reception of CMMG SC mode PPDUs transmitted by CMMG SC mode style are mandatory for MCSs 1 to 3. Transmission and reception of CMMG SC mode PPDUs transmitted by CMMG SC MIMO mode may be supported.

25.5.2 Transmitter block diagram

Figure 25-15 shows the transmit process for the CMMG SC mode SIG transmission. The actual structure of the transmitter is implementation dependent.

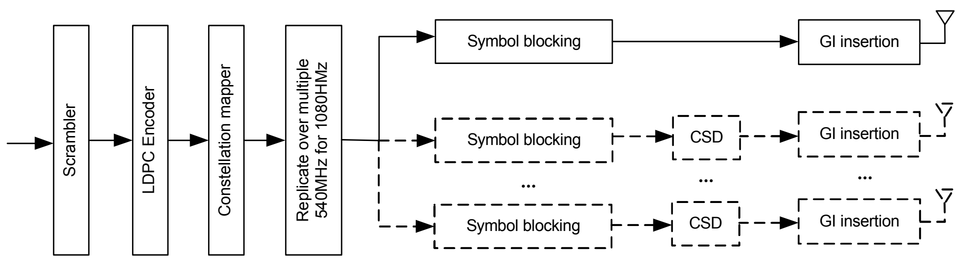


Figure 25-15—Transmitter block diagram for CMMG SC mode SIG field

Figure 25-16 shows the transmit block used to generate the data fields of 540 MHz and 1080 MHz using SC mode transmission.

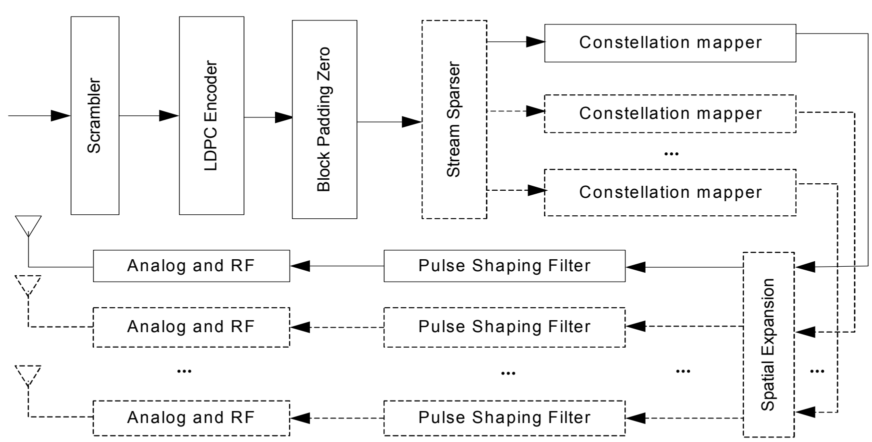


Figure 25-16—Transmitter block diagram for data fields of CMMG SC mode PPDUs

NOTE—The operations denoted by the dotted line arrows and dotted line boxes in the above two figures are optional and are applied for SC MIMO mode transmission.

25.5.3 Overview of the PPDU encoding process

25.5.3.1 General

This subclause provides an overview of the CMMG SC mode PPDU encoding process.

25.5.3.2 Construction of CMMG SC mode SIG

The construction of the CMMG SC mode SIG field proceeds as follows:

a) Obtain the parameters from TXVECTOR. Add the reserved bits, append the calculated CRC. The calculation of the CRC of the CMMG SC mode SIG is described in 25.3.6.
b) Scrambler: Scramble the CMMG SC mode SIG bits. The scrambler is described in 25.3.7.
c) LDPC encoder: The scrambled bits are encoded using the LDPC code as described in 25.5.5.4.2.
d) Constellation mapper: BPSK modulate the coded bits as described in 25.5.5.4.3 to form the transmitted symbol blocks of CMMG SC mode SIG.
e) Duplication and phase rotation: Apply the appropriate phase rotations for each 540 MHz subchannel as 25.5.5.4.4.
f) Symbol blocking: Divide the encoded SIG field into symbol block of length 256.
g) CSD: Apply CSD for each transmit chain as described in 25.5.5.4.5. This is need only for the CMMG SC mode MIMO mechanism.
h) GI insertion: Prepend a GI for each symbol block of length 256.
i) Pulse filter, Analog, and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit.

NOTE—Conversion from the sampled digital domain to the continuous time domain is beyond the scope of this document. Filtering for pulse shaping such as in GMSK is beyond the scope of this standard.

25.5.3.3 Construction of CMMG SC mode PPDUs

The construction of the data field in a CMMG SC mode PPDU LDPC encoding proceeds as follows:

a) Scrambler: Scramble the PHY padded data.
b) LDPC encoder: The scrambled bits are encoded using the LDPC code as described in 25.3.12.
c) Blocking Padding Zero: Append the PHY pad bits to the PSDU as described in 25.5.6.4.
d) Stream parser: The output of the LDPC encoder is rearranged into blocks as described in 25.5.6.5.
e) Constellation mapper: Map to π/2-BPSK, π/2-QPSK, π/2-16-QAM, or π/2-64-QAM constellation points as described in 25.5.6.6.
f) Spatial Expansion: Apply the spatial expansion mechanism according to the combination of the number of the spatial streams and the number of the transmit antennas as described in 25.5.6.7.
g) Pulse filter, Analog, and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit.

25.5.4 CMMG SC mode PPDU format

A CMMG SC mode PPDU frame is composed of the CMMG SC mode STF, the CMMG SC mode CEF, the CMMG SC mode SIG field, the optional CMMG SC mode SCTF, the SC data block, and the optional training fields, which is illustrated in Figure 25-17 where the SCTF fields is transmitted for 1080 MHz channel bandwidth.

STF	CEF	SIG	SCTF	BLK	...	BLK	AGC subfields	TRN-R/T subfields

Figure 25-17—Format of CMMG SC mode PPDU

NOTE—The SCTF is only transmitted for 1080 MHz channel bandwidth and is composed of a ZCZ sequence of length 512. For MIMO transmission, different transmit antenna transmit a different preamble that is composed of one the four ZCZ sequences with the order of $Z_{512}^1, Z_{512}^2, Z_{512}^3, Z_{512}^4$, such as for the case of one transmit antenna, the preamble sequence is composed of Z_{512}^1, for the case of two transmit antennas, the preamble sequences are composed of Z_{512}^1, Z_{512}^2, respectively.

25.5.5 CMMG SC mode SIG transmission

25.5.5.1 SIG field

The CMMG SC mode SIG field carries information required to interpret PPDUs. The preamble and the CMMG SC mode SIG fields all are transmitted with SC mode modulation.

25.5.5.2 Generation of the CRC bits of SIG

The calculation of the CRC of the CMMG SC mode SIG is described in 25.3.6.

25.5.5.3 Scrambler

The operation of the scrambler is defined in 25.3.7. Bits x_1, x_2, x_3, x_4, x_5, x_6, x_7 of the scrambler shift register are initialized using the bits in the scrambler initialization bits from the SIG. The CMMG SC mode SIG is scrambled starting from bit 7.

25.5.5.4 Encoding and modulations

25.5.5.4.1 General

The modulation and coding scheme defines the modulation and code rate that is used in the PPDU. The modulation and coding schemes are defined in 25.5.6.6.

25.5.5.4.2 Encoding

See 25.3.9.2.

25.5.5.4.3 Modulation

See 25.4.4.5.

25.5.5.4.4 Duplication

If the channel bandwidth is 1080 MHz, the modulated SIG symbols are duplicated as described in 25.3.10.

25.5.5.4.5 Symbol blocking, CSD, and GI insertion

The modulated CMMG SC mode SIG symbols are divided into four symbols blocks of length 256. For each block, the cyclic shift values for the CMMG SC mode SIG field of the PPDU for transmit chain i_{TX} out of a total of N_{TX} are defined in Table 25-11.

Table 25-11—Cyclic shift values for the CMMG SIG field

$T_{CS}^{i_{TX}}$ **values for the CMMG-SIG field**				
Total number of transmit chains (N_{TX})	Cyclic shift for transmit chain i_{TX} (in units of ns)			
	1	2	3	4
1	0	—	—	—
2	0	$-128\,T_C$	—	—
3	0	$-85\,T_C$	$-170\,T_C$	—
4	0	$-64\,T_C$	$-128\,T_C$	$-192\,T_C$

After the CSD operations, each group of 256 symbols is prepended by the last 64 symbols that form the cyclic prefix.

25.5.6 Data field transmission

25.5.6.1 General

The subclause describes the transmission of the SC data field.

25.5.6.2 Scrambler

The operation of the scrambler is defined in 25.3.7. The scrambling of the Data field continues the scrambling of the CMMG SC mode SIG with no reset for CMMG SC mode transmission.

25.5.6.3 Encoding

See 25.3.12.

25.5.6.4 Symbol block padding zeros

The number of symbol blocks, N_{BL}, is calculated as follows:

$$N_{BL} = m_{SE}\left\lceil \frac{Length \times 8 + (8 + L_{CHECK}) \times N_{CW}}{m_{SE} N_{CBPB}} \right\rceil \tag{25-27}$$

where L_{CHECK} is the number of LDPC parity bits, m_{SE} values are listed in Table 25-12, and N_{CBPB} values are shown in Table 25-13.

The number of padding zeros is given by

$$N_{BPAD} = N_{BL} N_{CBPB} - (Length \times 8 + (8 + L_{CHECK}) \times N_{CW}) \tag{25-28}$$

Table 25-12—Values of m_{SE}

N_{SS}	N_{TXT}	m_{SE}
1	1	1
	2	2
	3	3
	4	4
2	2	2
	3	4
	4	4
3	3	3
	4	6
4	4	4

Table 25-13—Values of N_{CBPB}

Symbol mapping	N_{CBPB} (540 MHz)		N_{CBPB} (1080 MHz)	
	Long GI	Short GI	Long GI	Short GI
π/2-BPSK	192	224	384	448
π/2-QPSK	384	448	768	896
π/2-16-QAM	768	896	1536	1792
π/2-64-QAM	1152	1344	2304	2688

The PSDU is concatenated with N_{BPAD} 0s. They are scrambled using the continuation of the scrambler sequence that scrambled the PSDU.

25.5.6.5 Stream parser

After coding and puncturing, the data bit streams at the output of the FEC encoder are processed in groups of N_{CBPB}. Each of these groups is rearranged into N_{SS} blocks of N_{CBPSS} bits.

The number of bits assigned to a single axis (real or imaginary) of a constellation point in a spatial stream is denoted by Equation (25-29).

$$s = \max\left\{1, \frac{N_{CBPS}}{2}\right\} \tag{25-29}$$

Consecutive blocks of *s* bits are assigned to different spatial streams in a round robin fashion.

Bit *i* at the output of encoder is assigned to input bit *k* of spatial stream where

$$i = (i_{SS} - 1) \cdot s + N_{SS} \cdot s \cdot \left\lfloor \frac{k}{s} \right\rfloor + k \mod s \tag{25-30}$$

where $i_{SS} = 1, 2, \ldots, N_{SS}$, $i = 0, 1, \ldots, N_{CBPB} - 1$, $k = 0, 1, \ldots, N_{CBPSS} - 1$.

25.5.6.6 Constellation mapping

The modulation and coding scheme (MCS) field specifies the modulation and code rate used in the PPDU.

A CMMG STA shall support all equal modulation (EQM) rates for one spatial stream (MCSs 1 to 3). MCSs 4 to 8 are optional.

The coded and padded bit stream is converted into a stream of complex constellation points according to the modulation specified in the MCS table.

In π/2-BPSK modulation, the input bit stream is mapped according to the following equation: $\tilde{s}_k = 2 \cdot c_k - 1$, where c_k is the k^{th} input coded (or scrambled pad) bit. Each output symbol is then rotated according to the following equation: $s_k = \tilde{s}_k \cdot e^{(j\pi k)/2}$.

NOTE—With appropriate choice of transmit filtering, π/2-BPSK is equivalent to a precoded pulse-shaped MSK (e.g., GMSK). The precoder is simply $b_{out,k} = b_{in,k} \oplus b_{in,k-1}$, where $b_{in,k}$ is the scrambled input stream, $b_{in,-1}$ is 0, and $b_{out,k}$ is the input to the (G)MSK modulator.

In π/2-QPSK modulation, the input bit stream is mapped according to the following equation: $\tilde{s}(k) = \frac{1}{\sqrt{2}}((2c_{2k}-1)+j(2c_{2k+1}-1))\exp\left(-j\frac{\pi}{4}\right)$, where k is the output symbol index, k=0,1,…. Each output symbol is then rotated according to the following equation: $s_k = \tilde{s}_k \cdot e^{(j\pi k)/2}$.

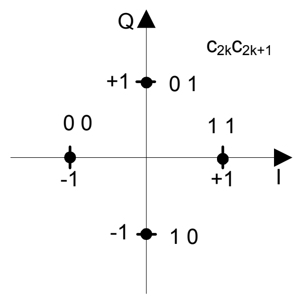


Figure 25-18—QPSK constellation bit encoding

In π/2-16-QAM modulation, the input bit stream is mapped according to the following equation:

$$\tilde{s}_k = \frac{1}{\sqrt{10}}\{(4c_{4k}-2)-(2c_{4k}-1)(2c_{4k+1}-1)+j(4c_{4k+2}-2)-j(2c_{4k+2}-1)(2c_{4k+3}-1)\} \tag{25-31}$$

where k is the output symbol index, $k = 0, 1, \ldots$. Each output symbol is then rotated according to the following equation: $s_k = \tilde{s}_k \cdot e^{(j\pi k)/2}$.

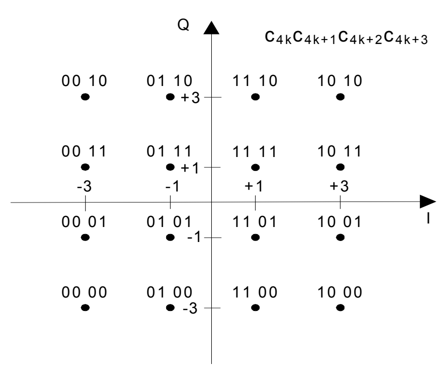


Figure 25-19—16-QAM constellation bit encoding

In π/2-64-QAM modulation, the input bit stream is mapped according to the following equation:

$$\begin{aligned}\tilde{s}_k = {} & \frac{1}{\sqrt{42}}((8c_{6k}-4)-(2c_{6k}-1)(4c_{6k+1}-2)+(2c_{6k}-1)(2c_{6k+1}-1)(2c_{6k+2}-1)) \\ & +j\frac{1}{\sqrt{42}}((8c_{6k+3}-4)-(2c_{6k+3}-1)(4c_{6k+4}-2)+(2c_{6k+3}-1)(2c_{6+4}-1)(2c_{6k+5}-1))\end{aligned} \tag{25-32}$$

where k is the output symbol index, $k = 0, 1, \ldots$. Each output symbol is then rotated according to the following equation: $s_k = \tilde{s}_k \cdot e^{(j\pi k)/2}$.

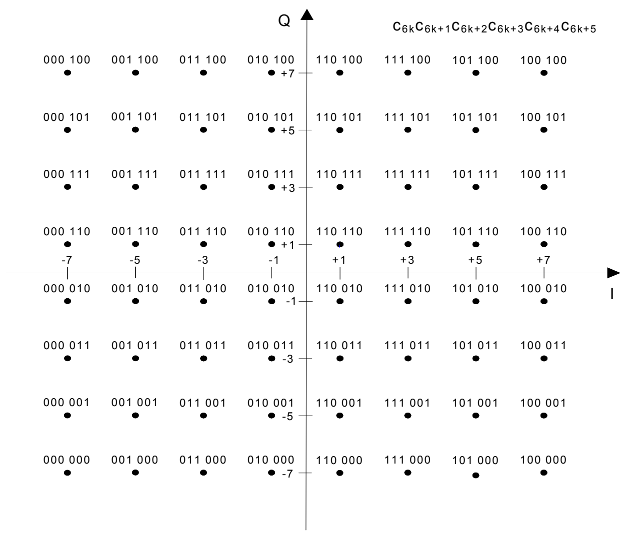


Figure 25-20—64-QAM constellation bit encoding

25.5.6.7 Spatial expansion

Each spatial stream is divided into many subblocks that each subblock includes N_{DSPB} constellation symbols. Values of N_{DSPB} and N_{UWPB} are shown in Table 25-14.

Table 25-14—Values of N_{DSPB} and N_{UWPB}

	N_{CBPB} (CBW 540 MHz)		N_{CBPB} (CBW 1080 MHz)	
	Long GI	**Short GI**	**Long GI**	**Short GI**
N_{DSPB}	192	224	384	448
N_{UWPB}	64	32	128	64

The spatial stream of complex numbers, $\mathbf{d}_{i,n}$, $i = 1, \ldots, N_{SS}$, $n = 0, 1, \ldots, N_{BL}-1$, is the input to the spatial expansion modular, which produces as output the stream of complex numbers $\mathbf{x}_{i_{TXT},n}$, $i_{TXT} = 1, \ldots, N_{TXT}$. The relation between the spatial streams and the output streams is given in Table 25-15 where $\mathbf{x}_{i_{TXT},n} = (\tilde{\mathbf{x}}_{i_{TXT},n})^T$, $\tilde{\mathbf{d}}_{i,n} = [\mathbf{d}_{i,n}, \mathbf{0}_{1\times N_{UWPB}}]^T$, $\tilde{\mathbf{u}}_{i_{TXT}} = \left[\mathbf{0}_{1\times N_{DSPB}}, Z_{N_{UWPB}}^{i_{TXT}}\right]^T$, and $\mathbf{Q}_{N_{BLS}}$ is defined as

$$\mathbf{Q}_{N_{BLS}} = \begin{bmatrix}\mathbf{Q}_1 & \mathbf{Q}_2 \\ \mathbf{Q}_3 & \mathbf{Q}_4\end{bmatrix} \tag{25-33}$$

where $\mathbf{Q}_2 = \mathbf{0}_{N_{DSPB} \times N_{UWPB}}$, $\mathbf{Q}_3 = \mathbf{0}_{N_{UWPB} \times N_{DSPB}}$, and

$$\mathbf{Q}_1 = \begin{bmatrix} 0 & 0 & 0 & \dots & 0 & 0 & 1 \\ 0 & 0 & 0 & \dots & 0 & 1 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & 1 & 0 & \dots & 0 & 0 & 0 \\ 1 & 0 & 0 & \dots & 0 & 0 & 0 \end{bmatrix}_{N_{DSPB} \times N_{DSPB}}, \mathbf{Q}_4 = \begin{bmatrix} 0 & 0 & 0 & \dots & 0 & 0 & 1 \\ 0 & 0 & 0 & \dots & 0 & 1 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & 1 & 0 & \dots & 0 & 0 & 0 \\ 1 & 0 & 0 & \dots & 0 & 0 & 0 \end{bmatrix}_{N_{UWPB} \times N_{UWPB}} \tag{25-34}$$

The starting index for the first symbol for π/2 rotation is 0. If the Additional PPDU field within the SIG field is equal to 0, the same ZCZ sequence guard interval is prepended to the first block transmitted. If the Additional PPDU field within the SIG field is equal to 1, the same ZCZ sequence guard interval is prepended to the first block transmitted. See Figure 25-21.

UW	Data Symbols	UW	Data Symbols	UW	Data Symbols	UW

Figure 25-21—Block transmission

Table 25-15—Constellation mapper output to spatial mapper input

$Index$	N_{SS}	N_{TXT}	i_{TXT}	$\tilde{\mathbf{x}}_{i_{TXT}, 2^a m}$	$\tilde{\mathbf{x}}_{i_{TXT}, 2^a m+1}$	$\tilde{\mathbf{x}}_{i_{TXT}, 2^a m+2}$	$\tilde{\mathbf{x}}_{i_{TXT}, 2^a m+3}$
1	1	1	1	$\tilde{\mathbf{d}}_{1, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\tilde{\mathbf{d}}_{1, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
2		2	1	$\tilde{\mathbf{d}}_{1, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$-\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
			2	$\tilde{\mathbf{d}}_{1, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
3		3	1	$\tilde{\mathbf{d}}_{1, 3m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 3m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 3m+2} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{0}$
			2	$-\tilde{\mathbf{d}}_{1, 3m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 3m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{0}$	$-\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 3m+2} + \tilde{\mathbf{u}}_{i_{TXT}}$
			3	$-\tilde{\mathbf{d}}_{1, 3m+2} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{0}$	$\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 3m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 3m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$
4		4	1	$\tilde{\mathbf{d}}_{1, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$-\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	$-\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 2^a m+2} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\tilde{\mathbf{d}}_{1, 2^a m+3} + \tilde{\mathbf{u}}_{i_{TXT}}$
			2	$\tilde{\mathbf{d}}_{1, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$-\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 2^a m+3} + \tilde{\mathbf{u}}_{i_{TXT}}$	$-\tilde{\mathbf{d}}_{1, 2^a m+2} + \tilde{\mathbf{u}}_{i_{TXT}}$
			3	$\tilde{\mathbf{d}}_{1, 2^a m+2} + \tilde{\mathbf{u}}_{i_{TXT}}$	$-\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 2^a m+3} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$-\tilde{\mathbf{d}}_{1, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$
			4	$\tilde{\mathbf{d}}_{1, 2^a m+3} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 2^a m+2} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\tilde{\mathbf{d}}_{1, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$
5	2	2	1	$\tilde{\mathbf{d}}_{1, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\tilde{\mathbf{d}}_{1, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
			2	$\tilde{\mathbf{d}}_{2, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\tilde{\mathbf{d}}_{2, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
6		3	1	$\tilde{\mathbf{d}}_{1, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$-\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
			2	$\tilde{\mathbf{d}}_{1, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
			3	$\tilde{\mathbf{d}}_{2, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{2, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
7		4	1	$\tilde{\mathbf{d}}_{1, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$-\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
			2	$\tilde{\mathbf{d}}_{1, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{1, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
			3	$\tilde{\mathbf{d}}_{2, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$-\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{2, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
			4	$\tilde{\mathbf{d}}_{2, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{Q}_{N_{BLS}}\tilde{\mathbf{d}}^{*}_{2, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—

Table 25-15—Constellation mapper output to spatial mapper input *(continued)*

$Index$	N_{SS}	N_{TXT}	i_{TXT}	$\tilde{\mathbf{x}}_{i_{TXT}, 2^a m}$	$\tilde{\mathbf{x}}_{i_{TXT}, 2^a m+1}$	$\tilde{\mathbf{x}}_{i_{TXT}, 2^a m+2}$	$\tilde{\mathbf{x}}_{i_{TXT}, 2^a m+3}$
8	3	3	1	$\tilde{\mathbf{d}}_{1, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\tilde{\mathbf{d}}_{1, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
			2	$\tilde{\mathbf{d}}_{2, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\tilde{\mathbf{d}}_{2, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
			3	$\tilde{\mathbf{d}}_{3, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{d}_{3, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
9		4	1	$\tilde{\mathbf{d}}_{1, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$-\mathbf{Q}_{N_{BLS}} \tilde{\mathbf{d}}^*_{1, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
			2	$\tilde{\mathbf{d}}_{1, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{Q}_{N_{BLS}} \tilde{\mathbf{d}}^*_{1, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
			3	$\tilde{\mathbf{d}}_{2, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{Q}_{N_{BLS}} \tilde{\mathbf{d}}_{2, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
			4	$\tilde{\mathbf{d}}_{3, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\mathbf{Q}_{N_{BLS}} \tilde{\mathbf{d}}_{3, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
10	4	4	1	$\tilde{\mathbf{d}}_{1, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\tilde{\mathbf{d}}_{1, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
			2	$\tilde{\mathbf{d}}_{2, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\tilde{\mathbf{d}}_{2, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
			3	$\tilde{\mathbf{d}}_{3, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\tilde{\mathbf{d}}_{3, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—
			4	$\tilde{\mathbf{d}}_{4, 2^a m} + \tilde{\mathbf{u}}_{i_{TXT}}$	$\tilde{\mathbf{d}}_{4, 2^a m+1} + \tilde{\mathbf{u}}_{i_{TXT}}$	—	—

NOTE 1—$a = 2$, for $N_{SS} = 1$ and $N_{TXT} = 4$; otherwise, $a = 1$.
NOTE 2—* indicates conjugate operation.

25.5.6.8 Duplication transmission

When the TXVECTOR parameter DUPLICATE_MODULATION is present, the transmitted PPDU is a duplicate. The modulated data symbols are duplicated as described in 25.3.10.

25.5.7 Performance requirements

25.5.7.1 Transmit requirements

25.5.7.1.1 Introduction

Transmitter performance requirements of the SC mode are defined in 25.5.7.1.2.

25.5.7.1.2 Transmit EVM

The transmit EVM accuracy test shall be performed by instrumentation capable of converting the transmitted signal into a stream of complex samples, with sufficient accuracy in terms of I/Q arm amplitude and phase balance, DC offsets, phase noise, etc.

The instrumentation shall perform carrier lock, symbol timing recovery, amplitude adjustment, and equalization while making the measurements. The equalizer shall be trained using information in the CMMG SC mode preamble (STF/CEF). For the CMMG SC mode EVM, measuring samples at the sample rate, the measured symbols should not contain the first and the last hundred symbols of a given packet (ramp up/down). The EVM is calculated according to the formula below:

$$EVM = 20\log_{10}\left(\sqrt{\left(\frac{1}{N_s P_{avg}} \sum_{i=1}^{N_S} \left[(I_i - I_i^* - I_0)^2 + (Q_i - Q_i^* - Q_0)^2\right]\right)}\right) \tag{25-35}$$

where

N_s is the number of samples to be measured and N_s should be 1000
P_{avg} is the average power of the constellation
(I_i, Q_i) is the complex coordinates of the measured symbol i
(I_i^*, Q_i^*) is the complex coordinates of the ideal constellation point for the measured symbol i
(I_0, Q_0) is the complex DC term chosen to reduce EVM

The test equipment should use a root-raised cosine filter with roll-off factor of 0.25 for the pulse shaping filter when conducting EVM measurement.

The transmit pulse shaping used is left to the implementer.

The relative constellation error (EVM) shall not exceed an MCS dependent value according to Table 25-16.

Table 25-16—EVM requirements for SC mode

CMMG MCS indexes	Modulation	Coding rate	EVM value (dB)
1	π/2-BPSK	1/2	–7
2	π/2-QPSK	1/2	–11
3	π/2-QPSK	3/4	–13
4	π/2-16-QAM	1/2	–19
5	π/2-16-QAM	3/4	–21
6	π/2-64-QAM	5/8	–25
7	π/2-64-QAM	3/4	–26
8	π/2-64-QAM	13/16	–28

25.5.7.1.3 Time of Departure accuracy

The Time of Departure accuracy test evaluates TIME_OF_DEPARTURE against aTxPHYTxStartRMS and aTxPHYTxStartRMS against TIME_OF_DEPARTURE_ACCURACY_TEST_THRESH as defined in Annex P with the following test parameters:

— MULTICHANNEL_SAMPLING_RATE is 440×10^6 sample/s for 540 MHz channel and 880 × 106 sample/s for 1080 MHz channel
— FIRST_TRANSITION_FIELD is Short Training field
— SECOND_TRANSITION_FIELD is Channel Estimation field
— TRAINING_FIELD is Channel Estimation field
— TIME_OF_DEPARTURE_ACCURACY_TEST_THRESH is 80 ns

NOTE—The indicated windowing applies to the time of departure accuracy test equipment, and not the transmitter or receiver.

25.5.7.2 Receive requirements

25.5.7.2.1 Introduction

This subclause describes the receiver requirements of the CMMG SC mode.

25.5.7.2.2 CCA

The start of a valid CMMG SC mode transmission at a receive level greater than the minimum sensitivity for MCS 0 (–74 dBm for 540 MHz, –71 dBm for 1080 MHz) shall cause CCA to indicate busy with a probability > 90% within 1 μs. The receiver shall hold the carrier sense signal busy for any signal 20 dB above the minimum sensitivity for MCS 0.

25.6 CMMG OFDM mode

25.6.1 Introduction

Transmission and reception of OFDM mode PPDUs are optional.

25.6.2 CMMG OFDM mode PPDU format

A CMMG OFDM mode OFDM PPDU frame is composed of the CMMG OFDM mode STFs, the CMMG OFDM mode CEF, the CMMG OFDM mode SIG field, the CMMG OFDM mode Short Training Field (OSTF), the CMMG OFDM mode Channel Estimation Field (OCEF), CMMG OFDM mode symbols, and the optional training fields, as shown in Figure 25-22.

STF	CEF	SIG	OSTF	OCEF	Sym	...	Sym	AGC subfields	TRN-R/T subfields

Figure 25-22—Format of the CMMG OFDM mode PPDU

25.6.3 Transmission block diagram

Figure 25-23 shows the transmit process for the CMMG OFDM mode SIG transmission. The actual structure of the transmitter is implementation dependent.

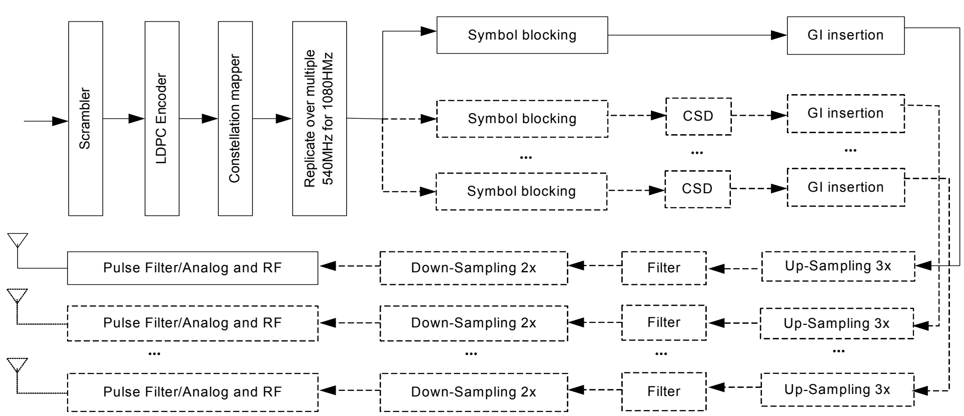


Figure 25-23—Transmitter block diagram for CMMG OFDM mode SIG fields

Figure 25-24 shows the transmitter blocks used to generate the Data field of OFDM mode PPDU with LDPC encoding.

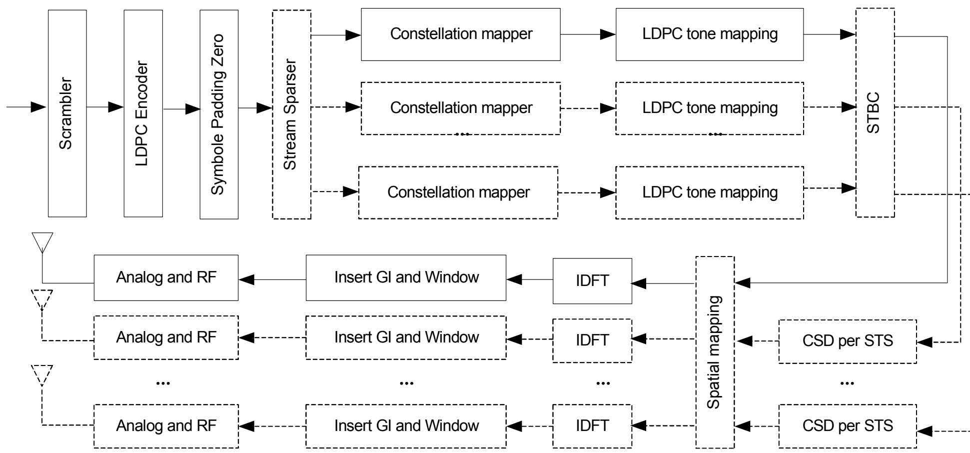


Figure 25-24—Transmitter block diagram for the data field of CMMG OFDM mode

NOTE—The operation denoted by the dotted line arrows and dotted line boxes in the above two figures are optional and are applied for OFDM MIMO mode transmission.

25.6.4 Overview of CMMG OFDM mode PPDU encoding process

25.6.4.1 General

This subclause provides an overview of the CMMG OFDM mode PPDU encoding process.

25.6.4.2 Construction of CMMG OFDM mode SIG

The construction of the CMMG OFDM mode SIG field proceeds as follows:

a) Obtain the parameters from TXVECTOR. Add the reserved bits, append the calculated CRC. The calculation of the CRC of the CMMG OFDM mode SIG is described in 25.3.6.
b) Scrambler: Scramble the CMMG OFDM mode SIG bits. The Scrambler is described in 25.3.7.
c) LDPC encoder: The scrambled bits are encoded using the LDPC code as described in 25.5.5.4.2.
d) Constellation mapper: BPSK modulate the coded bits as described in 25.5.5.4.3 to form the transmitted symbol blocks of CMMG PHY SIG.
e) Duplication and phase rotation: Apply the appropriate phase rotations for each 540 MHz subchannel as 25.5.5.4.4.
f) CSD: Apply CSD for each transmit chain as described in 25.5.5.4.5. This is need only for the CMMG OFDM MIMO mode mechanism.
g) Symbol blocking and GI insertion: Prepend a GI and generate the transmission symbol block.
h) Upsampling, filtering, and downsampling: Sample rate change in CMMG OFDM mode transmission as described in 25.6.5.4. This is only needed for the CMMG OFDM mode mechanism.
i) Pulse filter, Analog, and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit.

NOTE—Conversion from the sampled digital domain to the continuous time domain is beyond the scope of this document. Filtering for pulse shaping such as in GMSK is beyond the scope of this standard.

25.6.4.3 Construction of CMMG OFDM mode PPDU

The construction of the Data field in an OFDM mode PPDU with LDPC encoding proceeds as follows:

a) Scrambler: Scramble the PHY padded data. The scrambler is described in 25.3.7.
b) LDPC encoder: The scrambled bits are encoded using the LDPC code with the APEP_LENGTH in the TXVECTOR as described in 25.6.8.3.
c) Stream parser: The output of the LDPC encoder is rearranged into blocks as described in 25.6.8.5.
d) Constellation mapper: Map to BPSK, QPSK, 16-QAM, or 64-QAM constellation points as described in 25.6.8.6.
e) LDPC tone mapper: The LDPC tone mapping shall be performed on all LDPC encoded streams as described in 25.6.8.7.
f) OFDM symbol padding zeros: Append the CMMG OFDM mode pad bits to the PSDU as described in 25.6.8.4.
g) STBC: Apply STBC as described in 25.6.8.8.
h) Pilot insertion: Insert pilots following the steps described in 25.6.8.9.
i) CSD: Apply CSD for each space-time stream as described in 25.6.8.10.
j) Spatial mapping: Apply the **Q** matrix as described in 25.6.8.11.
k) Phase rotation: Apply the appropriate phase rotations for each 540 MHz subchannel. As described in 25.3.4.4.
l) IDFT: Compute the inverse discrete Fourier transform.
m) Insert GI and apply windowing: Prepend a GI and apply windowing.
n) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit.

25.6.4.4 Construction of OSTF

The OSTF is defined in 25.6.6 and is constructed as follows:

a) Sequence generation: Generate the OSTF in the frequency-domain over the bandwidth indicated by CH_BANDWIDTH as described in 25.6.6.
b) Phase rotation: Apply appropriate phase rotation for each 540 MHz subchannel as described in 25.3.4.3 and 25.3.4.4.
c) CSD: Apply CSD for each space-time stream and frequency segment as described in 25.6.8.10.
d) Spatial mapping: Apply the **Q** matrix as described in 25.6.8.11.
e) IDFT: Compute the inverse discrete Fourier transform.
f) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 25.3.4.3.
g) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 25.3.4.3 and 25.6.6 for details.

25.6.4.5 Construction of OCEF

The OCEF is defined in 25.6.7 and constructed as follows:

a) Sequence generation: Generate the OCEF sequence in the frequency-domain over the bandwidth indicated by CH_BANDWIDTH as described in 25.6.7.
b) Phase rotation: Apply appropriate phase rotation for each 540 MHz subchannel as described in 25.3.4.3 and 25.3.4.4.

c) Matrix mapping: Apply the matrix to the OCEF sequence and apply the matrix to the pilot tones as described in 25.6.7.

d) CSD: Apply CSD for each space-time stream and frequency segment as described in 25.6.8.10.

e) Spatial mapping: Apply the **Q** matrix as described in 25.6.8.11.

f) IDFT: Compute the inverse discrete Fourier transform.

g) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 25.3.4.3.

h) Analog and RF: Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 25.3.4.3 and 25.6.7 for details.

25.6.5 CMMG OFDM mode SIG fields

25.6.5.1 SIG fields

See 25.5.5.1 to 25.5.5.4.2.

25.6.5.2 Modulation

See 25.4.4.5.

25.6.5.3 Duplication

If the channel bandwidth is 1080 MHz, the modulated SIG symbols are duplicated as described in 25.3.10.

25.6.5.4 Symbol blocking, CSD, and GI insertion

See 25.5.5.4.5.

25.6.5.5 Sample rate change

If the channel bandwidth is 540 MHz, the preamble sequence and the CMMG OFDM mode SIG fields defined in the above subclauses are specified at the SC chip rate (T_C). For transmission in the OFDM (nominal) sample rate, the signal is resampled with a 3/2 rate change. The resampling is done by upsampling by a factor of 3, filtering by the filter h_{Filt} defined in 25.3.11, and downsampling by a factor of 2 (see equation below). To define the transmission of the preamble when the packet is an OFDM packet, the preamble waveform is defined below.

Let $r(nT_C) = r_{STF}(nT_C) + r_{CEF}(nT_C - t_{ce}) + r_{SIG}(nT_C - t_{SIG})$, then

$$r\left(n\frac{T_s}{2}\right) = \begin{cases} r\left(n\frac{T_c}{3}\right), n = 0, 3, 6, \ldots \\ 0, otherwise \end{cases} \tag{25-36}$$

$$\tilde{r}\left(n\frac{T_s}{2}\right) = \sum_{k=0}^{K-1} r\left((n-k)\cdot\frac{T_s}{2}\right)h_{Filt}(k), n = 0, 1, \ldots \tag{25-37}$$

$$r(nT_s) = \tilde{r}\left(2n\frac{T_s}{2} - \frac{K-1}{2}\frac{T_s}{2}\right), n = 0, 1, \ldots \tag{25-38}$$

where K is the length of the filter defined in 25.3.11, $\tilde{r}(n = 0)$ for $n < 0$.

If the channel bandwidth is 1080 MHz, the modulated SIG symbols are transmitted using duplication style as described in 25.3.10.

25.6.6 OSTF definition

The main purpose of the OFDM Short Training Field (OSTF) is to improve automatic gain control estimation in a MIMO transmission. The duration of the OSTF is $T_{OFDM\text{-}STF}$ regardless of the Short GI field setting in CMMG OFDM SIG.

For a 540 MHz transmission, the frequency domain sequence is given by Equation (25-39).

$$OSTF_{-89,\,89} = \{0, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{b}, \mathbf{a}, \mathbf{b}, \mathbf{b}, \mathbf{b}, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{a}, \mathbf{b}, \mathbf{b}, \mathbf{a}, \mathbf{b}, \mathbf{a}, \mathbf{a}, 0, 0, 0, 0, \mathbf{b}, \mathbf{b}, \mathbf{b}, \mathbf{b}, \mathbf{a}, \mathbf{b}, \mathbf{b}, \mathbf{b}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{a}, \mathbf{b}, \mathbf{a}, \mathbf{a}, 0, 0\} \tag{25-39}$$

where $\mathbf{a} = [1, 0, 0,0]$ and $\mathbf{b} = [-1, 0, 0,0]$.

For a 1080 MHz transmission, the frequency domain sequence is given by Equation (25-40).

$$OSTF_{-177,\,177} = \frac{1+j}{\sqrt{2}}\{0, \mathbf{b}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{b}, \mathbf{b}, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{b}, \mathbf{b}, \mathbf{b}, \mathbf{a}, \mathbf{b}, \mathbf{a}, \mathbf{b}, \mathbf{b}, \mathbf{b}, \mathbf{a}, \mathbf{b}, \mathbf{b}, \mathbf{a}, \mathbf{b}, \mathbf{a}, \mathbf{b}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{b}, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{a}, \mathbf{b}, \mathbf{0}, \mathbf{0}, \mathbf{0}, \mathbf{0}, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{b}, \mathbf{b}, \mathbf{b}, \mathbf{b}, \mathbf{b}, \mathbf{b}, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{b}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{a}, \mathbf{b}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{a}, \mathbf{b}, \mathbf{b}, -1, 0\} \tag{25-40}$$

where $\mathbf{a} = [1, 0, 0,0]$ and $\mathbf{b} = [-1, 0, 0,0]$.

The time domain representation of the signal of transmit chain i_{TXT} shall be as specified in Equation (25-41).

$$r_{OSTF}^{i_{TX}}(t) = \frac{w_{T_{OCEF}}(t)}{\sqrt{N_{Tone}N_{STS}}} \sum_{k=-N_{SR}}^{N_{SR}} \sum_{m=1}^{N_{STS}} [Q_k]_{i_{TX},m} \Upsilon_{k,CBW} OSTF_k \exp(j2\pi\Delta_F(t - T_{CS}(m))) \tag{25-41}$$

where

N_{Tone} is, for 540 MHz transmission, 176, and, for 1080 MHz transmission, 352

T_{CS} is given in Table 25-27

Q_k is defined in 25.6.8.13

$\Upsilon_{k,CBW}$ is defined in 25.3.4.4

25.6.7 OCEF definition

The OCEF provides a means for the receiver to estimate the MIMO channel between the set of constellation mapper outputs (or, if STBC is applied, the STBC encoder outputs) and the receive chains. The transmitter provides training for N_{STS} space-time streams (spatial mapper inputs) used for the transmission of the PSDU(s). For each tone, the MIMO channel that can be estimated is a $N_{RX} \times N_{STS}$ matrix. A frame transmission has a preamble that contains OCEF symbols, where the data tones of each OCEF symbol are multiplied by entries belonging to a matrix $\mathbf{P}_{OCEF}$, to enable channel estimation at the receiver. The pilot tones of each OCEF symbol are multiplied by the entries of a matrix $\mathbf{R}_{OCEF}$ defined in the following text. The multiplication of the pilot tones in the OCEF symbol by the $\mathbf{R}_{OCEF}$ matrix instead of the $\mathbf{P}_{OCEF}$ matrix allows receivers to track phase and frequency offset during MIMO channel estimation using the OCEF. The number of OCEF symbols, N_{OCEF}, is a function of the number of space-time streams N_{STS} as shown in Table 25-17. As a result the OCEF consists of one, two, or four symbols.

Table 25-17—Number of OCEFs required for different numbers of space-time streams

N_{STS}	N_{OCEF}
1	1
2	2
3	4
4	4

In a 540 MHz transmission, let $OCEF_{left}$ and $OCEF_{right}$ be the sequences defined in Equation (25-42) and Equation (25-43), respectively.

$$\begin{aligned} OCEF_{left} = \{ & 1, -1, -1, 1, 1, -1, -1, 1, 1, -1, 1, 1, 1, 1, 1, 1, 1, 1, -1, -1, 1, -1, 1, 1, 1, \\ & -1, 1, 1, -1, 1, -1, -1, 1, 1, -1, -1, 1, -1, 1, 1, 1, 1, 1, 1, 1, -1, -1, 1, 1, 1, \\ & -1, 1, 1, -1, 1, -1, 1, -1, -1, -1, 1, -1, -1, -1, -1, 1, 1, -1, -1, -1, -1, -1, \\ & -1, 1, -1, -1, -1, 1, 1, 1, 1, -1, -1, 1, 1, -1, 1, 1 \} \end{aligned} \tag{25-42}$$

$$\begin{aligned} OCEF_{right} = \{ & -1, 1, -1, 1, 1, -1, 1, -1, -1, -1, 1, 1, 1, 1, 1, -1, -1, -1, 1, 1, 1, 1, -1, -1, \\ & -1, -1, -1, -1, -1, 1, -1, 1, -1, 1, 1, 1, -1, -1, -1, -1, 1, 1, -1, -1, -1, 1, \\ & 1, -1, 1, 1, -1, 1, 1, 1, 1, -1, 1, -1, -1, -1, 1, -1, 1, -1, 1, -1, 1, -1, 1, 1, \\ & 1, 1, -1, 1, -1, 1, -1, -1, 1, 1, 1, -1, 1, 1, -1, -1, -1, 1 \} \end{aligned} \tag{25-43}$$

In a 540 MHz transmission, the OCEF sequence transmitted is given by Equation (25-44).

$$OCEF_{-89, 89} = \{OCEF_{left}, 0, 0, 0, OCEF_{right}\} \tag{25-44}$$

In a 1080 MHz transmission, let $OCEF_{left}$ and $OCEF_{right}$ be the sequences defined in Equation (25-45) and Equation (25-46), respectively.

$$\begin{aligned} OCEF_{left} = \{ & 1, -1, 1, -1, -1, -1, -1, -1, 1, 1, -1, -1, 1, 1, 1, 1, 1, -1, -1, -1, -1, 1, \\ & -1, 1, -1, 1, 1, 1, 1, -1, 1, 1, -1, -1, 1, 1, 1, -1, 1, 1, -1, -1, 1, -1, -1, -1, \\ & 1, -1, 1, 1, -1, 1, 1, 1, -1, -1, 1, -1, -1, -1, -1, -1, 1, 1, -1, -1, -1, -1, \\ & -1, 1, -1, 1, 1, 1, -1, -1, -1, -1, 1, 1, 1, -1, 1, 1, 1, 1, -1, -1, 1, 1, -1, 1, 1, \\ & 1, 1, 1, -1, -1, -1, 1, -1, 1, 1, -1, 1, 1, -1, 1, 1, -1, 1, -1, 1, 1, 1, 1, -1, 1, \\ & 1, -1, 1, -1, 1, 1, 1, 1, 1, 1, -1, -1, 1, -1, -1, -1, 1, -1, 1, 1, -1, 1, 1, 1, -1, \\ & -1, 1, -1, 1, 1, 1, 1, -1, 1, 1, 1, -1, 1, 1, 1, 1, -1, 1, -1, -1, -1, 1, -1, 1, 1, 1, \\ & -1, -1, -1, -1, -1, -1, 1 \} \end{aligned} \tag{25-45}$$

$$\begin{aligned} OCEF_{right} = \{&-1, 1, -1, -1, 1, 1, 1, -1, 1, -1, 1, 1, 1, 1, -1, -1, 1, 1, -1, 1, 1, -1, -1, -1, \\ &1, 1, 1, -1, -1, 1, -1, -1, -1, 1, -1, 1, -1, 1, -1, 1, 1, 1, -1, 1, -1, -1, -1, \\ &-1, 1, 1, -1, 1, -1, 1, 1, 1, -1, 1, 1, 1, 1, -1, -1, -1, -1, 1, 1, 1, 1, 1, -1, 1, \\ &-1, 1, 1, -1, 1, -1, -1, 1, -1, -1, -1, -1, 1, 1, 1, 1, -1, 1, 1, 1, 1, 1, -1, 1, \\ &1, -1, -1, -1, 1, -1, -1, -1, 1, -1, 1, 1, 1, 1, -1, -1, -1, 1, 1, -1, 1, -1, 1, \\ &-1, 1, -1, -1, -1, -1, -1, -1, 1, -1, -1, -1, 1, -1, 1, 1, 1, 1, -1, -1, -1, \\ &1, 1, 1, -1, -1, -1, 1, -1, -1, -1, -1, 1, -1, 1, -1, 1, 1, 1, 1, 1, 1, -1, 1, -1, \\ &1, -1, 1, 1, 1, -1, 1, -1, 1, -1, 1, 1\} \end{aligned} \tag{25-46}$$

In a 1080 MHz transmission, the OCEF sequence transmitted is given by Equation (25-47).

$$OCEF_{-177, 177} = \{OCEF_{left}, 0, 0, 0, OCEF_{right}\} \tag{25-47}$$

The generation of the time domain OCEF symbols per frequency segment is shown in Figure 25-25 where A_{OCEF} is given in Equation (25-48).

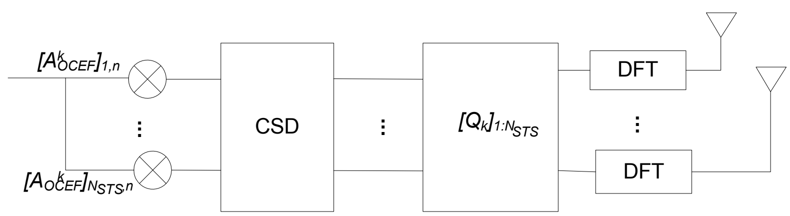


Figure 25-25—Generation of OCEF symbols per frequency segment

$$A^k_{OCEF} = \begin{cases} R_{OCEF}, k \in K_{Pilot} \\ P_{OCEF}, otherwise \end{cases} \tag{25-48}$$

where K_{Pilot} is the set of subcarrier indices for the pilot tones.

For a 540 MHz transmission, $K_{Pilot} = \{\pm 11, \pm 33, \pm 55, \pm 77\}$.

For a 1080 MHz transmission, $K_{Pilot} = \{\pm 11, \pm 33, \pm 55, \pm 77, \pm 99, \pm 121, \pm 143, \pm 165\}$.

R_{OCEF} is a $N_{OCEF} \times N_{OCEF}$ matrix whose elements are defined in Equation (25-49).

$$[R_{OCEF}]_{m, n} = [P_{OCEF}]_{1, n}, 1 \le m, n \le N_{OCEF} \tag{25-49}$$

$$P_{OCEF} = \begin{bmatrix} 1 & -1 & 1 & 1 \\ 1 & 1 & -1 & 1 \\ 1 & 1 & 1 & -1 \\ -1 & 1 & 1 & 1 \end{bmatrix} \tag{25-50}$$

The time domain representation of the waveform transmitted on transmit chain i_{TX} shall be as described by Equation (25-51).

$$r_{OCEF}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Tone}N_{STS}}} \sum_{n=0}^{N_{OCEF}-1} w_{T_{OCEF}}(t - nT_{OCEF}) \sum_{k=-N_{SR}}^{N_{SR}} \sum_{m=1}^{N_{STS}} \begin{pmatrix} [Q_k]_{i_{TX},m} [A_{OCEF}^k]_{m,n+1} \Upsilon_{k,CBW} OCEF_k \\ \cdot \exp(j2\pi\Delta_F(t - nT_{OCEF} - T_{GI} - T_{CS}(m))) \end{pmatrix} \quad (25\text{-}51)$$

where

N_{Tone} is, for 540 MHz transmission, 176, and, for 1080 MHz transmission, 352

T_{CS} is given in Table 25-27

Q_k is defined in 25.6.8.13

$\gamma_{k,CBW}$ is defined in 25.3.4.4

T_{OCEF} is the duration of each OCEF symbol

A_{OCEF} is defined in Equation (25-49)

25.6.8 Data fields

25.6.8.1 General

The LDPC encoding process is composed of several steps including determining the number of padding bits, padding with zeros, and the coding of every word.

25.6.8.2 Scrambler

The operation of the scrambler is defined in 25.3.7. The scrambling of the Data field continues the scrambling of the CMMG OFDM mode SIG with no reset for OFDM transmission.

25.6.8.3 Encoding

See 25.3.12.

25.6.8.4 OFDM symbol padding zeros

The number of symbol blocks, N_{SYM}, is calculated as

$$N_{SYM} = \left\lceil \frac{Length \times 8 + (8 + L_{CHECK}) \times N_{CW}}{R \cdot lcm\{m_{STBC}N_{CBPS}, L_{CW}\}} \right\rceil \cdot \frac{lcm\{m_{STBC}N_{CBPS}, L_{CW}\}}{N_{CBPS}} \quad (25\text{-}52)$$

where

L_{CHECK} is the number of LDPC parity bits

$lcm\{a, b\}$ denotes the least common multiple of a and b

L_{CW} denotes the LDPC code word length

$Length$ is the length of the PSDU defined in the CMMG SIG field

R is the code rate

N_{CBPS} is the number of code bits per symbol as defined in the MCS table

$m_{STBC} = 2$ if STBC is used; else $m_{STBC} = 1$

$$N_{SPAD} = R \times N_{SYM} \times N_{CBPS} - (Length \times 8 + (8 + L_{CHECK}) \times N_{CW}) \quad (25\text{-}53)$$

The PSDU is concatenated with N_{SPAD} zeros. They are scrambled using the continuation of the scrambler sequence that scrambled the PSDU.

25.6.8.5 Stream parser

After coding and puncturing, the data bit streams at the output of the FEC encoder are processed in groups of N_{CBPS}. Each of these groups is rearranged into N_{ss} blocks of N_{CBPSS} bits.

The number of bits assigned to a single axis (real or imaginary) of a constellation point in a spatial stream is denoted by Equation (25-54).

$$s = \max\left\{1, \frac{N_{BPSCS}}{2}\right\} \tag{25-54}$$

Consecutive blocks of s bits are assigned to different spatial streams in a round robin fashion.

Bit i at the output of encoder is assigned to input bit k of spatial stream where

$$i = (i_{SS} - 1) \cdot s + N_{ss} \cdot s \cdot \left\lfloor \frac{k}{s} \right\rfloor + k \mod s \tag{25-55}$$

where $i_{SS} = 1, 2, \ldots, N_{SS}$, $i = 0, 1, \ldots, N_{CBPS} - 1$, $k = 0, 1, \ldots, N_{CBPSS} - 1$.

25.6.8.6 Subcarrier modulation mapping

The OFDM subcarriers shall be modulated by using BPSK, QPSK, 16-QAM, or 64-QAM, depending on the RATE requested. The encoded and interleaved binary serial input data shall be divided into groups of (1, 2, 4, or 6) bits and converted into complex numbers representing BPSK, QPSK, 16-QAM, or 64-QAM constellation points. The conversion shall be performed according to Gray-coded constellation mappings, illustrated in Figure 25-26, with the input bit, B_0 being the earliest in the stream. The output values, d, are formed by multiplying the resulting (I+jQ) value by a normalization factor K_{MOD}, as described in Equation (25-56).

$$d = (I + jQ) \times K_{MOD} \tag{25-56}$$

The normalization factor, K_{MOD}, depends on the base modulation mode, as prescribed in Table 25-18. Note that the modulation type can be different from the start to the end of the transmission, as the signal changes from SIGNAL to DATA, as shown in Figure 25-26 to Figure 25-20. The purpose of the normalization factor is to achieve the same average power for all mappings. In practical implementations, an approximate value of the normalization factor may be used, as long as the device conforms with the modulation accuracy requirements described in 25.6.9.1.2.

Table 25-18—Modulation-dependent normalization factor

Modulation	K_{MOD}
BPSK	1
QPSK	$1/\sqrt{2}$
16-QAM	$1/\sqrt{10}$
64-QAM	$1/\sqrt{42}$

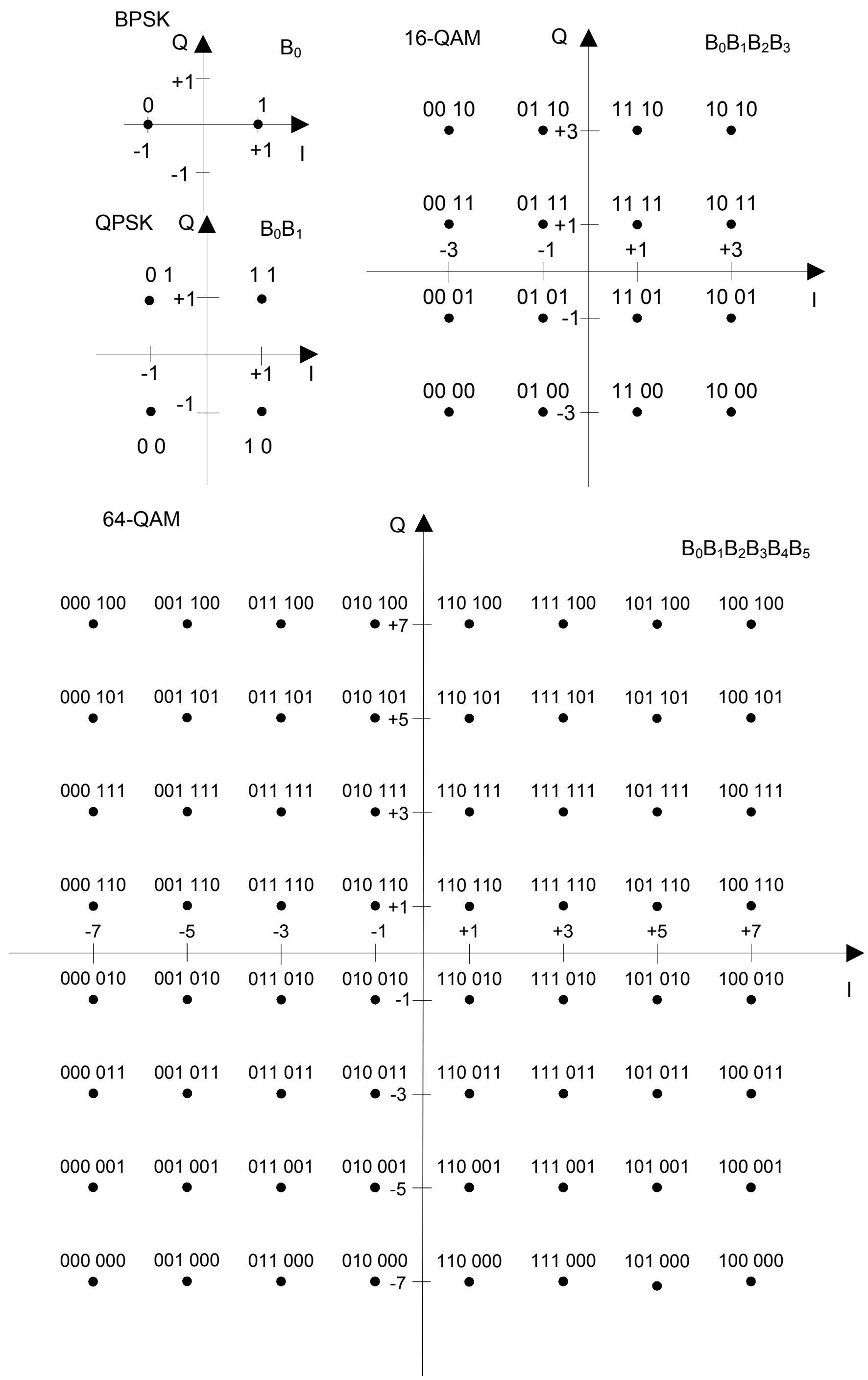


Figure 25-26—BPSK, QPSK, 16-QAM, and 64-QAM constellation bit encoding

For BPSK, B_0 determines the I value, as illustrated in Table 25-19. For QPSK, B_0 determines the I value, and B_1 determines the Q value, as illustrated in Table 25-20. For 16-QAM, B_0 and B_1 determine the I value, and B_2 and B_3 determine the Q value, as illustrated in Table 25-21. For 64-QAM, B_0, B_1, and B_2 determine the I value, and B_3, B_4, and B_5 determine the Q value, as illustrated in Table 25-22.

Table 25-19—BPSK encoding table

Input bit (B_0)	I-out	Q-out
0	–1	0
1	1	0

Table 25-20—QPSK encoding table

Input bit (B_0)	I-out	Input bit (B_1)	Q-out
0	–1	0	–1
1	1	1	1

Table 25-21—16-QAM encoding table

Input bits (B_0B_1)	I-out	Input bits (B_2B_3)	Q-out
00	–3	00	–3
01	–1	01	–1
11	1	11	1
10	3	10	3

Table 25-22—64-QAM encoding table

Input bits ($B_0B_1B_2$)	I-out	Input bits ($B_3B_4B_5$)	Q-out
000	–7	000	–7
001	–5	001	–5
011	–3	011	–3
010	–1	010	–1
110	1	110	1
111	3	111	3
101	5	101	5
100	7	100	7

25.6.8.7 Tone mapping

The LDPC tone mapping shall be performed on all LDPC encoded streams using an LDPC tone-mapping distance parameter, D_{TM}. D_{TM} is constant for each bandwidth, and its value for different bandwidths is given in Table 25-23.

Table 25-23—Value of tone mapping parameter

Parameter	CBW 540 MHz	CBW 1080 MHz
D_{TM}	6	12

LDPC tone mapping for LDPC-coded streams is done by permuting the stream of complex numbers generated by the constellation mappers to obtain

$$d''_{t(k), i, n} = d'_{k, i, n} \tag{25-57}$$

where $i = 1, 2, \ldots, N_{SS}$, and

$$t(k) = D_{TM}\left(k \bmod \frac{N_{SD}}{D_{TM}}\right) + \left\lfloor \frac{kD_{TM}}{N_{SD}} \right\rfloor \tag{25-58}$$

The two consecutively generated complex constellation numbers are transmitted on two data tones that are separated by at least $D_{TM} - 1$ from other data tones.

25.6.8.8 Space-time block coding

This subclause defines a set of optional robust transmission techniques that are applicable only when using STBC coding for OFDM mode PPDUs. In this case, N_{SS} spatial streams are mapped to N_{STS} space-time streams. These techniques are based on STBC. When the STBC field in the CMMG SIG is 1, a symbol operation shall occur between the constellation mapper and the spatial mapper as defined in this subclause.

If STBC is applied, the stream of complex numbers $d_{k, i, n}$, $k = 0, 1, \ldots, N_{SD} - 1$, $i = 1, 2, \ldots, N_{SS}$, $n = 0, 1, \ldots, N_{SYM-1}$, is the input to the STBC encoder, which produces as output the stream of complex numbers $\tilde{d}_{k, i_{STS}, n}$, $k = 0, 1, \ldots, N_{SD} - 1$, $i_{STS} = 1, 2, \ldots, N_{STS}$, $n = 0, 1, \ldots, N_{SYM-1}$. For given values of k and i, STBC processing operates on the complex modulation symbols in sequential pairs of OFDM symbols so that the values of $\tilde{d}_{k, 2i-1, 2m}$ and $\tilde{d}_{k, 2i, 2m}$ depend on $\tilde{d}_{k, 2i, 2m}$ and $d_{k, i, 2m+1}$. Also, $\tilde{d}_{k, 2i-1, 2m+1}$ and $\tilde{d}_{k, 2i, 2m+1}$ depend on $d_{k, i, 2m}$ and $d_{k, i, 2m+1}$. This is defined in Table 25-24.

Table 25-24—Constellation mapper output to spatial mapper input for STBC

N_{STS}	N_{SS}	i_{STS}	$\tilde{d}_{k, i_{STS}, 2m}$	$\tilde{d}_{k, i_{STS}, 2m+1}$
2	1	1	$d_{k, 1, 2m}$	$d_{k, 1, 2m+1}$
		2	$-d^*_{k, 1, 2m+1}$	$d^*_{k, 1, 2m}$
4	2	1	$d_{k, 1, 2m}$	$d_{k, 1, 2m+1}$
		2	$-d^*_{k, 1, 2m+1}$	$d^*_{k, 1, 2m}$
		3	$d_{k, 2, 2m}$	$d_{k, 2, 2m+1}$
		4	$-d^*_{k, 2, 2m+1}$	$d^*_{k, 2, 2m}$

If STBC is not applied, $d_{k,i,n} = \tilde{d}_{k,i,r}$ and $N_{STS} = N_{SS}$.

NOTE—When STBC is applied, an odd number of space-time streams is not allowed, and $N_{STS} = 2N_{SS}$.

25.6.8.9 Pilot subcarriers

For a 540 MHz transmission, eight pilot tones shall be inserted in subcarriers $\{\pm 77, \pm 55, \pm 33, \pm 11\}$. The pilot mapping P_n^k for subcarrier k for symbol n shall be as specified in Equation (25-59).

$$\begin{aligned} P_n^{k \in \{-77, -55, -33, -11, 11, 33, 55, 77\}} &= \{\Psi_{n \bmod 8}, \Psi_{(n+1) \bmod 8}, \ldots, \Psi_{(n+7) \bmod 8}\} \\ P_n^{k \notin \{-77, -55, -33, -11, 11, 33, 55, 77\}} &= 0 \end{aligned} \tag{25-59}$$

where Ψ_m is defined in Table 25-25

Table 25-25—Pilot values for CBW 540 MHz transmission

Ψ_0	Ψ_1	Ψ_2	Ψ_3	Ψ_4	Ψ_5	Ψ_6	Ψ_7
1	1	1	–1	–1	1	1	1

For a 1080 MHz transmission, 16 pilot tones shall be inserted in subcarriers –165, –143, –121, –99, –77, –55, –33, –11, 11, 33, 55, 77, 99, 121, 143, 165. The pilot mapping P_n^k for subcarrier k for symbol n shall be as specified in Equation (25-60).

$$\begin{aligned} P_n^{k \in \{-165, -143, -121, -99, -77, -55, -33, -11, 11, 33, 55, 77, 99, 121, 143, 165\}} &= \{\Psi_{n \bmod 16}, \Psi_{(n+1) \bmod 16}, \ldots, \Psi_{(n+15) \bmod 16}\} \\ P_n^{k \notin \{-165, -143, -121, -99, -77, -55, -33, -11, 11, 33, 55, 77, 99, 121, 143, 165\}} &= 0 \end{aligned} \tag{25-60}$$

where Ψ_m is defined in Table 25-26.

Table 25-26—Pilot values for CBW 1080 MHz transmission

Ψ_0	Ψ_1	Ψ_2	Ψ_3	Ψ_4	Ψ_5	Ψ_6	Ψ_7	Ψ_8	Ψ_9	Ψ_{10}	Ψ_{11}	Ψ_{12}	Ψ_{13}	Ψ_{14}	Ψ_{15}
–1	1	–1	1	1	–1	–1	–1	–1	–1	1	1	1	–1	1	1

25.6.8.10 Cyclic shift diversity (CSD) for OFDM mode data fields transmission

The cyclic shift values defined in this subclause apply to the data fields of the PPDU. Cyclic shifts are applied eliminate unintended beamforming when correlated signals are transmitted in multiple space-time streams $T_{CS}(n)$. The cyclic shift value for the data fields for space-time stream n out of N_{STS} total space-time streams is shown in Table 25-27.

Table 25-27—Cyclic shift values for the data fields of an OFDM mode PPDU

$T_{CS}(n)$ **values for the data field of a PPDU**				
N_{STS}	Cyclic shift for space-time stream n (ns)			
	1	2	3	4
1	0	—	—	—
2	0	$-128\,T_s$	—	—
3	0	$-170\,T_s$	$-85\,T_S$	—
4	0	$-128\,T_S$	$-64\,T_S$	$-192\,T_S$

25.6.8.11 OFDM modulation

The time domain waveform of the Data field of a CMMG OFDM mode PPDU from transmit chain, shall be as defined in Equation (25-61).

$$r_{Data}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Tone}N_{STS,\,total}}}\sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \sum_{k=-N_{SR}}^{N_{SR}}\sum_{m=1}^{N_{STT}} [Q_K]_{i_{TX},m}\Upsilon_{k,\,CBW}(\tilde{D}_{k,\,m,\,n,\,CBW} + p_nP_n^k)\exp(j2\pi k\Delta_F(t - nT_{SYM} - T_{GI} - T_{CS}m)) \tag{25-61}$$

where

- p_n is defined in 17.3.5.10 (OFDM modulation)
- N_{Tone} is, for 540 MHz transmission, 176 and, for 1080 MHz transmission, 352
- $\tilde{D}_{k,\,m,\,n,\,CBW}$ is the transmitted constellation on subcarrier k, space-time stream m, and Data field OFDM symbol n and is defined in Equation (25-62) through Equation (25-64)
- T_{GI} is the (short) guard interval duration and is given in Table 25-3
- $T_{CS}(n)$ is given in 25.6.8.10
- P_n^k is defined in 25.6.8.9
- $\Upsilon_{k,\,CBW}$ is defined in 25.3.4.4
- T_{GI} is the guard interval duration

For a 540 MHz transmission,

$$\tilde{D}_{k,\,m,\,n,\,540} = \begin{cases} 0, k = 0, \pm1, \pm11, \pm33, \pm55, \pm77 \\ \tilde{d}_{M_{540}^r(k),\,m,\,n}, otherwise \end{cases} \tag{25-62}$$

and $M_{540}^r(k)$ is defined as

$$M^r_{540}(k) = \begin{cases} k+89, -89 \le k \le -78 \\ k+88, -76 \le k \le -56 \\ k+87, -54 \le k \le -34 \\ k+86, -32 \le k \le -12 \\ k+85, -10 \le k \le -2 \\ k+82, 2 \le k \le 10 \\ k+81, 12 \le k \le 32 \\ k+80, 34 \le k \le 54 \\ k+79, 56 \le k \le 76 \\ k+78, 78 \le k \le 89 \end{cases} \tag{25-63}$$

For a 1080 MHz transmission,

$$\tilde{D}_{k,m,n,1080} = \begin{cases} 0, k = 0, \pm1, \pm11, \pm33, \pm55, \pm77, \pm99, \pm121, \pm143, \pm165 \\ \tilde{d}_{M^r_{1080}(k),m,n}, otherwise \end{cases} \tag{25-64}$$

and $M^r_{1080}(k)$ is defined as

$$M^r_{1080}(k) = \begin{cases} k+177, -177 \le k \le -166 \\ k+176, -164 \le k \le -144 \\ k+174, -142 \le k \le -122 \\ k+173, -120 \le k \le -100 \\ k+172, -98 \le k \le -78 \\ k+171, -76 \le k \le -56 \\ k+170, -54 \le k \le -34 \\ k+169, -32 \le k \le -12 \\ k+168, -10 \le k \le -2 \\ k+165, 2 \le k \le 10 \\ k+164, 12 \le k \le 32 \\ k+163, 34 \le k \le 54 \\ k+162, 56 \le k \le 76 \\ k+161, 78 \le k \le 98 \\ k+160, 100 \le k \le 120 \\ k+159, 122 \le k \le 142 \\ k+158, 144 \le k \le 164 \\ k+157, 166 \le k \le 177 \end{cases} \tag{25-65}$$

$\mathbf{Q}_k$ is a spatial mapping/steering matrix with N_{TX} rows and columns N_{STS} for subcarrier k. $\mathbf{Q}_k$ may be frequency dependent. Refer to the examples of listed in 19.3.11.11.2 for examples of that could be used for OFDM mode PPDU. Note that implementations are not restricted to the spatial mapping matrix examples listed in 19.3.11.11.2.

25.6.8.12 Duplication transmission

When the TXVECTOR parameter DUPLICATE_MODULATION is present, the transmitted PPDU is a duplicate. For 1080 MHz, the Data field shall be as defined by

$$r_{Data}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Tone}N_{STS,\,total}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \tag{25-66}$$

$$\sum_{k=-89}^{89} \sum_{m=1}^{N_{STS}} (\tilde{D}_{k,m,n} + p_n P_n^k)([Q_{k-88}]_{i_{TX,m}} \Upsilon_{k,CBW} \exp(j2\pi(k-88)\Delta_F(t - nT_{SYM} - T_{GI} - T_{CS}(m)))$$

$$+ j[Q_{k-88}]_{i_{TX,m}} \Upsilon_{k,CBW} \exp(j2\pi(k+88)\Delta_F(t - nT_{SYM} - T_{GI} - T_{CS}(m))))$$

where

p_n	is defined in 17.3.5.10 (OFDM modulation)
N_{Tone}	is 352
$\tilde{D}_{k,m,n}$	is the transmitted constellation on subcarrier k, space-time stream m, and Data field OFDM symbol n and is defined in Equation (25-62) through Equation (25-64)
T_{GI}	is the (short) guard interval duration and is given in Table 25-3
$T_{CS}(n)$	is given in 25.6.8.10
P_n^k	is defined in 25.6.8.9
$\Upsilon_{k,CBW}$	is defined in 25.3.4.4
T_{GI}	is the guard interval duration

25.6.8.13 Beamforming

25.6.8.13.1 General

CMMG OFDM MIMO mode beamforming is used by a STA with multiple antennas (the beamformer) to steer signals using knowledge of the channel to improve throughput. With CMMG OFDM MIMO mode beamforming, all space-time streams in the transmitted signal are intended for reception at a single STA.

For CMMG OFDM MIMO mode beamforming, the steering matrix $\mathbf{Q}_k$ can be determined from the effective channel $\mathbf{H}_{eff,\,k}$, or the beamforming feedback matrix, $\mathbf{V}_k$, that is sent back to the beamformer by the beamformee using compressed beamforming feedback matrix format as defined in 25.6.8.13.2. The feedback report format is described in 9.6.30.2.

25.6.8.13.2 Compressed Beamforming feedback matrix

Upon receipt of a NDP sounding PPDU, the beamformee shall remove the space-time stream CSD in Table 25-27 from the measured channel before computing a set of matrices for feedback to the beamformer. The beamforming feedback matrix $\mathbf{V}_k$, found by the beamformee for subcarrier k shall be compressed in the form of angles using the method described in 20.3.12.3.6. The angles, $\phi(k)$ and $\psi(k)$, are quantized according to Table 9-76e.

The beamformee shall generate the beamforming feedback matrices with the number of rows (N_r) equal to the N_{STS} of the NDP.

After receiving the angle information, $\phi(k)$ and $\psi(k)$, the beamformer reconstructs $\mathbf{V}_k$ using Equation (19-79). For CMMG OFDM MIMO mode beamforming, the beamformer can use this $\mathbf{V}_k$ matrix to determine the steering matrix $\mathbf{Q}_k$. The method used by the beamformer to calculate the steering matrix $\mathbf{Q}_k$ is implementation specific.

The beamformee decides the tone grouping value to be used in the beamforming feedback matrix $\mathbf{V}$. A beamformer shall support all tone grouping values and codebook information values.

25.6.8.14 CMMG preamble format for sounding PPDU

25.6.8.14.1 General

The MIMO channel measurement takes place in every PPDU as a result of transmitting the OCEFs as part of the PHY preamble. The number of OCEFs transmitted shall be determined by the number of space time streams transmitted. The use of the same spatial transformation enables the computation of the spatial equalization at the receiver.

When the number of space-time streams, N_{STS}, is less than the number of transmit antennas, or less than $min(N_{TX},N_{RX})$, sending only N_{STS} OCEFs does not allow the receiver to recover a full characterization of the MIMO channel, even though the resulting MIMO channel measurement is sufficient for receiving the Data field of the CMMG PPDU.

However, there are several cases where it is desirable to obtain as full a characterization of the channel as possible, thus requiring the transmission of a sufficient number of OCEFs to sound the full dimensionality of the channel, which is in some cases N_{STS} and in other cases $min(N_{TX},N_{RX})$. These cases of MIMO channel measurement are referred to as MIMO channel sounding. A sounding packet may be used to sound available channel dimensions. A sounding PPDU is identified by setting the Not Sounding field in the CMMG SIG to 0. A sounding PPDU may have any allowed number of OCEFs satisfying $N_{OCEFs} \geq N_{STS}$ as shown in Table 25-17.

25.6.8.14.2 Sounding with an NDP

A STA may sound the channel using a NDP (indicated by zero in the Length field in the CMMGSIG field) with the Not Sounding field set to 0. The number of OCEFs is the number implied by the $2^{STBC} N_{ss}$, which shall indicate spatial time streams. The last OCEF of an NDP shall not be followed by a Data field as shown in Figure 25-27.

STF	CEF	SIG	OSTF	OCEF

Figure 25-27—CMMG NDP format

It is optional for a STA to process an NDP.

25.6.8.14.3 Sounding PPDU for channel quality assessment

In response to the reception of an MRQ, sent by STA A to STA B, the responding STA B returns to the requesting STA A an MCS selection that STA B determines to be a suitable MCS for STA A to use in subsequent transmissions to STA B. In determining the MCS, STA B performs a channel quality assessment, which entails using whatever information STA B has about the channel, such as an estimate of the MIMO channel derived from the sounding PPDU that carries the MRQ. To enable this calculation, the MRQ is sent in conjunction with a sounding PPDU.

The STA sending the MRQ (STA A) determines how many OCEFs to send and whether to use an NDP or not, based on the Transmit Beamforming Capabilities field, number of space-time streams used in the PPDU carrying the MRQ, the number of transmit chains it is using (N_{TX}), whether the transmit and receive STAs support STBC, and in some cases, the number of receive chains at the responding STA (N_{RX}).

The maximum number of available space-time streams is set by the number of transmit and receive chains and the STBC capabilities of the transmitter and receiver, as is shown in Table 25-28. While the number of receive chains at a STA is not communicated in a capabilities indicator, the maximum number of space-time streams supported may be inferred from the STBC capabilities of the receiving STA. When the number of receive chains is known at the transmitter, the number of OCEFs sent to obtain a full channel quality assessment is determined according to the maximum number of space-time streams indicated in Table 25-28. The number of OCEFs to use in conjunction with the indicated number of space-time streams is determined according to Table 25-17.

Table 25-28—Maximum available space-time streams

N_{TX}	N_{RX}	$N_{STS, max}$ **without STBC**	$N_{STS, max}$ **with STBC**
1	1	1	N/A
2	1	1	2
4	1	1	2
4	2	2	4

The sounding PPDU may have nonidentity spatial mapping matrix $\mathbf{Q}_k$. For different receiving STAs, $\mathbf{Q}_k$ may vary.

25.6.9 Performance requirements

25.6.9.1 Transmit requirements

25.6.9.1.1 Introduction

This subclause describes the performance requirement from the OFDM mode transmitter.

25.6.9.1.2 Transmit EVM

The transmit EVM accuracy test shall be performed by instrumentation capable of converting the transmitted signal into a stream of complex samples, with sufficient accuracy in terms of I/Q arm amplitude and phase balance, DC offsets, phase noise, etc.

The sampled signal shall be processed in a manner similar to an actual receiver, according to the following steps, or an equivalent procedure:

a) Start of frame shall be detected.
b) Transition from short sequences to channel estimation sequences shall be detected, and fine timing (with one sample resolution) shall be established.
c) Frequency offsets shall be estimated and corrected.
d) The frame shall be de-rotated according to estimated frequency offset.
e) The complex channel response coefficients shall be estimated for each of the subcarriers using information contained in the preamble (STF/CEF and/or OCEF).
f) For each of the OFDM symbols: transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, derotate the subcarrier values according to estimated phase, and divide each subcarrier value with a complex estimated channel response coefficient.
g) For each data-carrying subcarrier, compute the Euclidean distance to the ideal location for the symbol, or pilot.
h) Compute the RMS average of all errors in a packet. It is given by

$$EVM = 20\log_{10}\left(\frac{1}{N_f}\sum_{i=1}^{N_f}\sqrt{\frac{\sum_{j=1}^{N_{SYM}}\left\{\sum_{k\in K}[(I(i,j,k)-I^*(i,j,k))^2+(Q(i,j,k)-Q^*(i,j,k))^2]\right\}}{(N_{ST}-N_{DC})N_{SYM}P_0}}\right) \tag{25-67}$$

where

N_f is the number of frames
i is the frame index
k is the carrier index
K is the set of pilot and data subcarriers $\{1,2, \ldots, (N_{SR}-1), (N_{SR}+N_{DC}), (N_{SR}+N_{DC}+1), \ldots, N_{ST}\}$
j is the symbol index
N_{SYM} is the number of symbols
N_{ST} is the total number of subcarriers
I^*,Q^* is the ideal constellation point for I and Q, respectively
P_0 is the average power of the constellation (I^*,Q^*) computed over the i^{th} frame

The measurements shall occur on the OFDM symbols and shall not occur on the other kinds of symbols. The measurement shall be performed on at least 10 frames with 16 symbols at least in each of them. Random data shall be used.

The EVM RMS error shall not exceed an MCS dependent value as found in Table 25-29.

Table 25-29—EVM requirements for OFDM

MCS index	Modulation	Coding rate	EVM value (dB)
9	BPSK	1/2	–7
10	QPSK	1/2	–11
11	QPSK	3/4	–13
12	16-QAM	1/2	–15
13	16-QAM	3/4	–19
14	64-QAM	5/8	–22
15	64-QAM	3/4	–24
16	64-QAM	13/16	–26

25.6.9.2 TX flatness

25.6.9.2.1 TX flatness for 540 MHz channel

When using the OFDM mode and only while transmitting OFDM symbols, the average energy of the OFDM symbols constellations in each of the subcarriers with indices –70 to –2 and +2 to +70 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the subcarriers with indices –71 to –89 and +70 to +89 shall deviate no more than +2/–4 dB from the average energy of subcarriers with indices –71 to –89 and +70 to +89.

25.6.9.2.2 TX flatness for 1080 MHz channel

When using the OFDM mode and only while transmitting OFDM symbols, the average energy of the OFDM symbols constellations in each of the subcarriers with indices –146 to –2 and +2 to +145 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the subcarriers with indices –147 to –177 and +147 to +177 shall deviate no more than +2/–4 dB from the average energy of subcarriers with indices –177 to –2 and +2 to +177.

25.6.9.2.3 Time of Departure accuracy

The Time of Departure accuracy test evaluates TIME_OF_DEPARTURE against aTxPHYTxStartRMS and aTxPHYTxStartRMS against TIME_OF_DEPARTURE_ACCURACY_TEST_THRESH as defined in Annex P with the following test parameters:

— MULTICHANNEL_SAMPLING_RATE is 660×10^6 sample/s for 540 MHz and 1320 for 1080 MHz.
— FIRST_TRANSITION_FIELD is Short Training field.
— SECOND_TRANSITION_FIELD is Channel Estimation field.
— TRAINING_FIELD is Channel Estimation field.
— TIME_OF_DEPARTURE_ACCURACY_TEST_THRESH is 80 ns.

NOTE—The indicated windowing applies to the time of departure accuracy test equipment, and not the transmitter or receiver.

25.6.9.3 Receive requirements

25.6.9.3.1 Introduction

Subclause 25.6.9.3.2 describes the performance requirement for an OFDM mode receiver.

25.6.9.3.2 CCA

The start of a valid CMMG OFDM mode or CMMG SC mode transmission at a receive level greater than the minimum sensitivity for MCS 0 (–74 dBm for 540 MHz, –71 dBm for 1080 MHz) shall cause CCA to indicate busy with a probability > 90% within 1 μs.

25.7 Analog beamforming PHY frame format

25.7.1 TX sector sweep

The packets sent during TX sector sweep are control mode packets as defined in 25.4.

25.7.2 Beam refinement

25.7.2.1 General

Beam refinement is a process where a STA can improve its antenna configuration (or antenna weight vectors) both for transmission and reception. If the SLS beamforming training did not include an RSS, as in the case where both devices have more than one transmit sector per antenna, beam refinement can serve as the first receive antenna configuration training. The procedure of beam refinement is described in 10.38.6.4

(BRP phase execution). In the beam refinement procedure, BRP packets are used to train the receiver and transmitter antenna. There are two types of BRP packets: BRP-RX packets and BRP-TX packets.

— BRP-RX packets are packets that have TRN-R training sequences appended to them. These packets enable receiver antenna weight vector training.
— BRP-TX packets are packets that have TRN-T training sequences appended to them. The transmitting STA may change antenna configuration at the beginning of each sequence. The receiving STA performs measurements on these sequences and sends feedback to the STA that transmits the BRP-TX packet.

25.7.2.2 BRP packet structure

Each BRP packet is composed of an STF, a CEF, and a data field followed by a training field containing an AGC training field and a receiver training field.

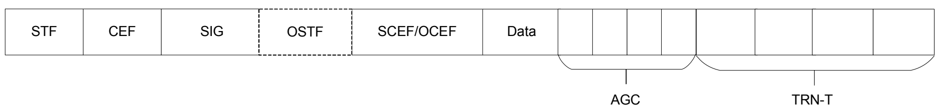


Figure 25-28—BRP packet structure

25.7.2.3 BRP packet SIG fields

A value of 0x0 in the Packet Type field indicates a BRP-RX packet (TRN-R field is present).

A value of 0x1 in the Packet Type field indicates a BRP-TX packet (TRN-T field is present).

A value of N in the Training Length field indicates that the AGC has 4N subfields and that the TRN- R/T field has 5N subfields.

The value N in the Training Length field of a BRP-RX packet is equal to the value of the L-RX field requested by the intended receiver of the BRP-RX packet at a previously received BRP Request field (see 9.5.4).

25.7.2.4 Beam refinement AGC field

The beam refinement AGC fields are composed of $4N$ repetitions of the sequence $[Z_{64}^1\ Z_{64}^1\ Z_{64}^1\ Z_{64}^1\ Z_{64}^1]$ when the packet is transmitted using the control mode in bandwidth 540 MHz, $[Z_{64}^2\ Z_{64}^2\ Z_{64}^2\ Z_{64}^2\ Z_{64}^2]$ when the packet is transmitted using the SC mode in bandwidth 540 MHz, $[Z_{64}^3\ Z_{64}^3\ Z_{64}^3\ Z_{64}^3\ Z_{64}^3]$ when the packet is transmitted using the OFDM mode in bandwidth 540 MHz, $[Z_{128}^1\ Z_{128}^1\ Z_{128}^1\ Z_{128}^1\ Z_{128}^1]$ when the packet is transmitted using the control mode in bandwidth 1080 MHz, $[Z_{128}^2\ Z_{128}^2\ Z_{128}^2\ Z_{128}^2\ Z_{128}^2]$ when the packet is transmitted using the SC mode in bandwidth 1080 MHz, and $[Z_{128}^3\ Z_{128}^3\ Z_{128}^3\ Z_{128}^3\ Z_{128}^3]$ when the packet is transmitted using the OFDM mode in bandwidth 1080 MHz. The sequences Z_{64}^1, Z_{64}^2, Z_{64}^3, Z_{128}^1, Z_{128}^2, and Z_{128}^3 are defined in 25.8. The sequences are transmitted using rotated π/2-QPSK modulation. Any transmit signal transients that occur due to this TX AWV configuration change shall completely settle by the end of the first Z_{64}^1, Z_{64}^2, or Z_{64}^3 subsequence in bandwidth 540 MHz and Z_{128}^1, Z_{128}^2, or Z_{128}^3 subsequence in bandwidth 1080 MHz.

In a BRP-TX packet, the transmitter may change the TX AWV configuration at the beginning of each AGC subfield. The set of AWVs used for the AGC subfields should be the same as that used for the TRN-T subfields. In a BRP-RX packet, the transmitter shall use the same TX AWV as in the preamble and data fields of the packet.

25.7.2.5 Beam refinement TRN-R field

The TRN-R fields enable receiver AWV training. The TRN-R fields have the form shown in Figure 25-29.

CEF	R_1	R_2	R_3	R_4	CEF	R_5	R_6	R_7	R_8	…

Figure 25-29—TRN-R field definition

Each subfield CEF matches the Channel Estimation field defined in 25.3.5. The $4N$ subfields R_1 through R_{4N} each consist of the sequence $[Z_{256}^1\ Z_{256}^3\ Z_{256}^1\ Z_{256}^2\ Z_{256}^4\ Z_{256}^2]$ in bandwidth 540 MHz and $[Z_{512}^1\ Z_{512}^3\ Z_{512}^1\ Z_{512}^2\ Z_{512}^4\ Z_{512}^2]$ in bandwidth 1080 MHz. The sequences Z_{256}^1, Z_{256}^2, Z_{256}^3, and Z_{256}^4 are defined in Table 25-33, and Z_{512}^1, Z_{512}^2, Z_{512}^3, and Z_{512}^4 are defined in Table 25-34, in 25.8. The sequences are transmitted using rotated π/2-QPSK modulation.

25.7.2.6 Beam refinement TRN-T field

The TRN-T field enables transmitter AWV training. The TRN-T fields have the form shown in Figure 25-30.

CEF	T_1	T_2	T_3	T_4	CEF	T_5	T_6	T_7	T_8	…

Figure 25-30—TRN-T field definition

Each subfield CEF matches the Channel Estimation field defined in 25.3.5. The $4N$ subfields T_1 through T_{4N} each consist of the sequence $[Z_{256}^1\ Z_{256}^3\ Z_{256}^1\ Z_{256}^2\ Z_{256}^4\ Z_{256}^2]$ in bandwidth 540 MHz and $[Z_{512}^1\ Z_{512}^3\ Z_{512}^1\ Z_{512}^2\ Z_{512}^4\ Z_{512}^2]$ in bandwidth 1080 MHz. The sequences Z_{256}^1, Z_{256}^2, Z_{256}^3, and Z_{256}^4 are defined in Table 25-33, and Z_{512}^1, Z_{512}^2, Z_{512}^3, and Z_{512}^4 are defined in Table 25-34, in 25.8. The sequences are transmitted using rotated π/2-QPSK modulation. When transmitting the CEF subfield, the transmitter shall use the same AWV as in the preamble and data fields of the packet. Any transmit signal transients that occur due to TX AWV configuration changes between subfields shall settle by the end of the first 64 samples of the subfield.

25.7.2.7 Channel measurement

The good autocorrelation properties of the ZCZ sequences enable reconstructing part of the impulse response of the channel between the transmitter and the receiver. The receiver should find the tap with largest amplitude in the channel during the CEF of the BRP-RX. It selects thereafter the set of taps that is measured around the tap with the largest amplitude, according to the value of dot11ChanMeasFBCKNtaps. It can select a contiguous set of taps or select a noncontiguous set of taps and include the tap delays subfield as part of the subfield measurement. It then measures the phase and amplitude of the corresponding channel taps in each of the TRN-T field repetition (except for those using the CEF AWV configuration). The beam refinement feedback subfield k–1 is the relative amplitude and phase of this tap in the k'th repetition compared to this tap in the first TRN-T subfield.

25.7.2.8 BRP resampling in an OFDM mode packet

The BRP AGC field, the CEF, and Tn/Rn field are specified at the SC chip rate (T_c). When appended to an OFDM packet, the signal is resampled as defined in 25.3.10.

25.8 ZCZ sequence

The following ZCZ sequences set is used in the STF, the CEF, the SCTF, and the Unique Word (UW). These are 5 ZCZ sequences sets, namely, $Z_{32}^i, Z_{64}^i, Z_{128}^i$, Z_{256}^i, and Z_{512}^i, with $i = 1, 2, 3, 4$ where the subscript denotes the length of the sequences and the superscript denotes the index of the ZCZ sequence. The sets are generated using the following recursive procedure, illustrated as in Figure 25-31.

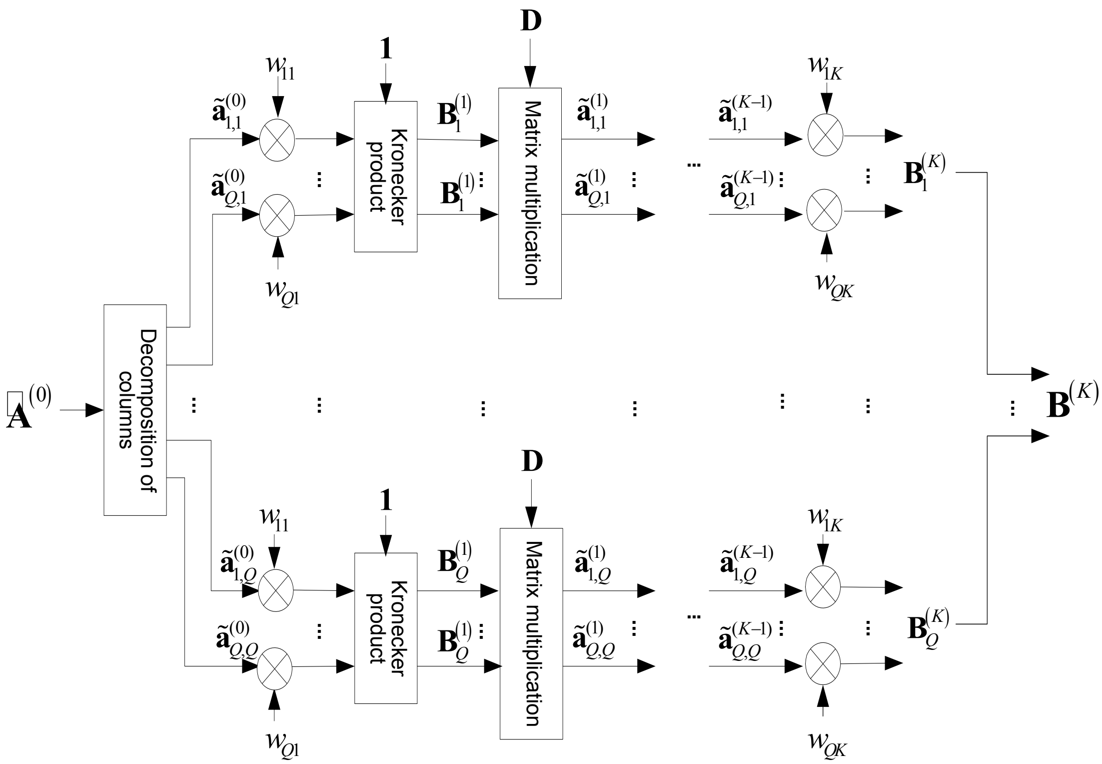


Figure 25-31—Generation of ZCZ sequences set

$\tilde{\mathbf{A}}^{(0)}$, $\mathbf{B}^{(k)}$, and $\tilde{\mathbf{A}}^{(k)}$ used in Figure 25-31 are defined as follows, respectively.

$$\tilde{\mathbf{A}}^{(0)} = \begin{bmatrix} \tilde{\mathbf{a}}_{1,1}^{(0)} & \cdots & \tilde{\mathbf{a}}_{1,Q}^{(0)} \\ \cdot & \cdot & \cdot \\ \tilde{\mathbf{a}}_{Q,1}^{(0)} & \cdots & \tilde{\mathbf{a}}_{Q,Q}^{(0)} \end{bmatrix} \tag{25-68}$$

$$\mathbf{B}^{(k)} = \begin{bmatrix} w_{1,k}\mathbf{I}_{Q^{k-1}L} & \mathbf{0}_{Q^{k-1}L} & \cdots & \mathbf{0}_{Q^{k-1}L} \\ \mathbf{0}_{Q^{k-1}L} & w_{2,k}\mathbf{I}_{Q^{k-1}L} & \cdots & \mathbf{0}_{Q^{k-1}L} \\ \cdot & \cdot & \cdot & \cdot \\ \mathbf{0}_{Q^{k-1}L} & \mathbf{0}_{Q^{k-1}L} & \cdots & w_{Q,k}\mathbf{I}_{Q^{k-1}L} \end{bmatrix} \tilde{\mathbf{A}}^{(k-1)}, \tilde{\mathbf{A}}^{(k)} = \mathbf{D}(\mathbf{1} \otimes \mathbf{B}^{(k)}) \tag{25-69}$$

where

$\tilde{\mathbf{a}}_{i,j}^{(0)}, i = 1, \ldots, Q, j = 1, \ldots, Q$	denotes the initial sequence
Q	is the number of ZCZ sequences
$\mathbf{I}_{Q^{k-1}L}$	denotes the identity matrix of size $Q^{k-1}L \times Q^{k-1}L$

L	denotes the length of the initial sequence
$\mathbf{0}_{Q^{k-1}L}$	denotes all zero matrix of size $Q^{k-1}L \times Q^{k-1}L$
$w_{i,j}, i = 1, \ldots, Q, j = 1, \ldots, K$	are elements of the coefficient matrix $\mathbf{W}$ of size $Q \times K$
K	is the number of the iterations
$\mathbf{D} = Diag(f_{1,1}\mathbf{I}_{Q^{k-1}L}, \ldots, f_{1,Q}\mathbf{I}_{Q^{k-1}L}, \ldots, f_{Q,1}\mathbf{I}_{Q^{k-1}L}, \ldots, f_{Q,Q}\mathbf{I}_{Q^{k-1}L})$	with $Diag(\upsilon)$ denoting the diagonal matrix with diagonal element υ
$f_{i,j}, i = 1, \ldots, Q, j = 1, \ldots, Q$	are elements of the Discrete Fourier Transform (DFT) matrix $\mathbf{F}_Q$ of size $Q \times Q$
$\mathbf{1}$	denotes all 1 column vector
$\otimes$	denotes Kronecker product

Note that $M = \{e^{(j2\pi\theta)/Q}\}_{\theta=0}^{Q-1}$, the elements of $\tilde{\mathbf{A}}^{(0)}$ belongs to M, and $w_{i,k} \in M, i = 1, \ldots, Q$.

When $\tilde{\mathbf{A}}^{(0)}$, $\mathbf{F}_4$, and $\mathbf{W}$ are given by Equation (25-70), the generated ZCZ sequence set Z_{32}^i is listed in Table 25-30 where 0,1,2, and 3 denote +1,+*j*,–1,–*j*.

$$\tilde{\mathbf{A}}^{(0)} = \begin{bmatrix} (-1,-1)^T & (-1,1)^T & (-1,-1)^T & (-1,1)^T \\ (-1,-1)^T & (-1,1)^T & (1,1)^T & (1,-1)^T \\ (-1,1)^T & (-1,-1)^T & (-1,1)^T & (-1,-1)^T \\ (-1,1)^T & (-1,-1)^T & (1,-1)^T & (1,1)^T \end{bmatrix}, \mathbf{F}_4 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & j & -1 & -j \\ 1 & -1 & 1 & -1 \\ 1 & -j & -1 & j \end{bmatrix}, \mathbf{W} = \begin{bmatrix} 1 \\ -j \\ -1 \\ 1 \end{bmatrix} \tag{25-70}$$

When $\tilde{\mathbf{A}}^{(0)}$, $\mathbf{F}_4$, and $\mathbf{W}$ are given by Equation (25-71), the generated ZCZ sequence set Z_{64}^i is listed in Table 25-31 where 0,1,2, and 3 denote +1,+*j*,–1,–*j*.

$$\tilde{\mathbf{A}}^{(0)} = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & j & -1 & -j \\ 1 & -1 & 1 & -1 \\ 1 & -j & -1 & j \end{bmatrix}, \mathbf{F}_4 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & j & -1 & -j \\ 1 & -1 & 1 & -1 \\ 1 & -j & -1 & j \end{bmatrix}, \mathbf{W} = \begin{bmatrix} -j & -1 \\ -1 & j \\ j & -j \\ -1 & -j \end{bmatrix} \tag{25-71}$$

When $\tilde{\mathbf{A}}^{(0)}$, $\mathbf{F}_4$, and $\mathbf{W}$ are given by Equation (25-72), the generated ZCZ sequence set Z_{128}^i is listed in Table 25-32 where 0,1,2, and 3 denote +1,+*j*,–1,–*j*.

$$\tilde{\mathbf{A}}^{(0)} = \begin{bmatrix} (-1,-1)^T & (-1,1)^T & (-1,-1)^T & (-1,1)^T \\ (-1,-1)^T & (-1,1)^T & (1,1)^T & (1,-1)^T \\ (-1,1)^T & (-1,-1)^T & (-1,1)^T & (-1,-1)^T \\ (-1,1)^T & (-1,-1)^T & (1,-1)^T & (1,1)^T \end{bmatrix}, \mathbf{F}_4 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & j & -1 & -j \\ 1 & -1 & 1 & -1 \\ 1 & -j & -1 & j \end{bmatrix}, \mathbf{W} = \begin{bmatrix} j & j \\ 1 & -j \\ -j & -j \\ -j & j \end{bmatrix} \tag{25-72}$$

When $\tilde{\mathbf{A}}^{(0)}$, $\mathbf{F}_4$, and $\mathbf{W}$ are given by Equation (25-73), the generated ZCZ sequence set Z_{256}^i is listed in Table 25-33 where 0,1,2, and 3 denote +1,+*j*,–1,–*j*.

$$\tilde{\mathbf{A}}^{(0)} = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & j & -1 & -j \\ 1 & -1 & 1 & -1 \\ 1 & -j & -1 & j \end{bmatrix}, \mathbf{F}_4 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & j & -1 & -j \\ 1 & -1 & 1 & -1 \\ 1 & -j & -1 & j \end{bmatrix}, \mathbf{W} = \begin{bmatrix} 1 & -1 & -j & -j \\ -1 & j & -j & -j \\ -j & -1 & -j & 1 \\ j & -j & -1 & j \end{bmatrix} \tag{25-73}$$

When $\tilde{\mathbf{A}}^{(0)}$, $\mathbf{F}_4$, and $\mathbf{W}$ are given by Equation (25-74), the generated ZCZ sequence set Z^i_{512} Z^i_{512} is listed in Table 25-34 where 0,1,2, and 3 denote +1,+*j*,–1,–*j*, respectively.

$$\tilde{\mathbf{A}}^{(0)} = \begin{bmatrix} (-1,-1)^T & (-1,1)^T & (-1,-1)^T & (-1,1)^T \\ (-1,-1)^T & (-1,1)^T & (1,1)^T & (1,-1)^T \\ (-1,1)^T & (-1,-1)^T & (-1,1)^T & (-1,-1)^T \\ (-1,1)^T & (-1,-1)^T & (1,-1)^T & (1,1)^T \end{bmatrix}, \mathbf{F}_4 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & j & -1 & -j \\ 1 & -1 & 1 & -1 \\ 1 & -j & -1 & j \end{bmatrix}, \mathbf{W} = \begin{bmatrix} 1 & -j & -j & -j \\ j & -j & j & -j \\ j & j & -j & -1 \\ -j & -j & 1 & -j \end{bmatrix} \quad (25\text{-}74)$$

Note that the sequence sets in the tables below are normative, and the description above is informative.

Table 25-30—The sequence set Z^i_{32}, i=1,2,3,4

	The sequence set Z^i_{32}, $i = 1, 2, 3, 4$ to be transmitted from left to right, up to down
Z^1_{32}	22110220222220132233020222002031
Z^2_{32}	20130022202022112031000020022233
Z^3_{32}	22330202220020312211022022222013
Z^4_{32}	20310000200222332013002220202211

Table 25-31—The sequence set Z^i_{64}, i=1,2,3,4

	The sequence set Z^i_{64}, $i = 1, 2, 3, 4$ to be transmitted from left to right, up to down
Z^1_{64}	2101000223031311210111130121020021012220230331332101333101212022
Z^2_{64}	2220012120221030222012320200032322202303202232122220301002002101
Z^3_{64}	2303020021011113230313110323000223032022210133312303313303232220
Z^4_{64}	2022032322201232202210300002012120222101222030102022321200022303

Table 25-32—The sequence set Z^i_{128}, i=1,2,3,4

	The sequence set Z^i_{128}, $i = 1, 2, 3, 4$ to be transmitted from left to right, up to down
Z^1_{128}	0011202022222013221102200022021300112020111113020033200211331320 0011202000000231221102202200203100112020333331200033200233113102
Z^2_{128}	0213222220202211201300220220001102132222131311000231220013311122 0213222202020033201300222002223302132222313133220231220031133300
Z^3_{128}	0033200222002031223302020000023100332002113313200011202011111302 0033200200222021322330202222220130033200233113102001120203333120
Z^4_{128}	0231220020022233203100000202003302312200133111220213222213131100 0231220002200011203100002020221102312200311333000213222231313322

Table 25-33—The sequence set Z^i_{256}, i=1,2,3,4

	The sequence set Z^i_{256} , $i = 1, 2, 3, 4$ to be transmitted from left to right, up to down
Z^1_{256}	13020310110023301302102133221223130221321100011202312132221123301 1302031011002330201321320033233031200310332223303120102111001223 1302031011002330312032031100300113022132110001122013031000330112 1302031011002330023103102211011231200310332223301302320333223001
Z^2_{256}	1021003312232013102111003001130210212211122302310310221123302013 1021003312232013213222110112201332030033300120133203110012231302 1021003312232013320333221223312010212211122302312132003301120231 1021003312232013031000332330023132030033300120131021332230013120
Z^3_{256}	1100011213022132110012233120102111002330130203100033233020132132 1100011213022132221123300231213233220112312021323322122313021021 1100011213022132332230011302320311002330130203102211011202310310 1100011213022132003301122013031033220112312021321100300131203203
Z^4_{256}	1223023110212211122313023203110012232013102100330112201321322211 1223023110212211233020130310221130010231320322113001130210211100 1223023110212211300131201021332212232013102100332330023103100033 1223023110212211011202312132003330010231320322111223312032033322

Table 25-34—The sequence set Z^i_{512}, i=1,2,3,4

	The sequence set Z^i_{512} , $i = 1, 2, 3, 4$ to be transmitted from left to right, up to down
Z^1_{512}	0011133100223120221131310000310222333113331120132211313111110213 0011133122001302221131312222132011222002002231201100202022221320 0011133100223120221131310000310233000220002231203322020222221320 2233311300223120003313130000310200111331331120130033131311110213 0011133100223120221131310000310200111331113302310033131333332031 0011133122001302221131312222132033000220220013023322020200003102 0011133100223120221131310000310211222002220013021100202000003102 2233311300223120003313130000310222333113113302312211313133332031
Z^2_{512}	0213113302203322201333330202330020313311311322112013333313130011 0213113320021100201333332020112213202200022033221302222220201122 0213113302203322201333330202330031020022022033223120000020201122 2031331102203322023111110202330002131133311322110231111113130011 0213113302203322201333330202330002131133133100330231111131312233 0213113320021100201333332020112231020022200211003120000002023300 0213113302203322201333330202330013202200200211001302222202023300 2031331102203322023111110202330020313311133100332013333331312233
Z^3_{512}	0033131300003102223331130022312022113131333320312233311311330231 0033131322221320223331132200130211002020000031021122200222001302 0033131300003102223331130022312033220202000031023300022022001302 2211313100003102001113310022312000331313333320310011133111330231 0033131300003102223331130022312000331313111102130011133133112013 0033131322221320223331132200130233220202222213203300022000223120 0033131300003102223331130022312011002020222213201122200200223120 2211313100003102001113310022312022113131111102132233311333112013
Z^4_{512}	0231111102023300203133110220332220133333131223320313311133100033 0231111120201122203133112002110013022222020233001320220020021100 0231111102023300203133110220332231200000020233003102002220021100 2013333302023300021311330220332202311111313122330213113313310033 0231111102023300203133110220332202311111313001102131133311322111 0231111120201122203133112002110031200000202011223102002202203322 0231111102023300203133110220332213022222020112213202200022033222 2013333302023300021311330220332220133333131300112031331131132211

25.9 Regulatory requirements

Wireless LANs (WLANs) implemented in accordance with this standard are subject to equipment certification and operating requirements established by regional and national regulatory administrations. The PHY specification establishes minimum technical requirements for interoperability, based upon established regulations at the time this standard was issued. These regulations are subject to revision or may be superseded.

25.10 Channelization

A CMMG channel is specified by the two PLME MIB fields specified in Table 25-35.

Table 25-35—Fields to specify CMMG channels

Field	Meaning
dot11CMMGCurrentChannelWidth	Channel width. Possible values represent 540 MHz and 1080 MHz channels.
dot11CMMGCurrentChannelCenterFrequencyIndex	For a 540 MHz or 1080 MHz channel, denotes the channel center frequency.

Given dot11CMMGCurrentChannelCenterFrequencyIndex, the center frequency is given by Equation (25-75) for 540 MHz channel.

$$f(n)[GHz] = \begin{cases} 42.66 + 0.54(n-1),\ 1 \le n \le 8 \\ 47.52 + 0.54(n-9),\ n = 9, 10 \end{cases} \tag{25-75}$$

where n denotes the channel index decided by dot11CMMGCurrentChannelCenterFrequencyIndex.

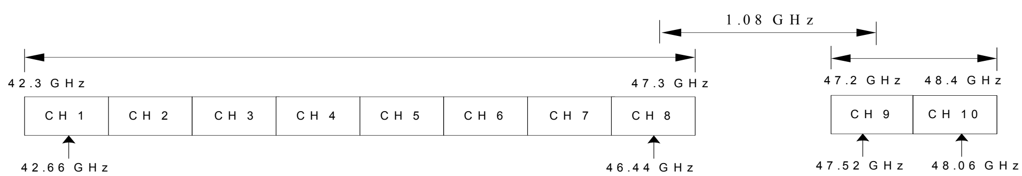


Figure 25-32—Channelization for CBW 540 MHz

Given dot11CMMGCurrentChannelCenterFrequencyIndex, the center frequency is given by Equation (25-76) for 1080 MHz channel.

$$f(n)[GHz] = \begin{cases} 42.93 + 1.08(n-11),\ 11 \le n \le 14 \\ 47.79,\ n = 15 \end{cases} \tag{25-76}$$

where n denotes the channel index decided by dot11CMMGCurrentChannelCenterFrequencyIndex.

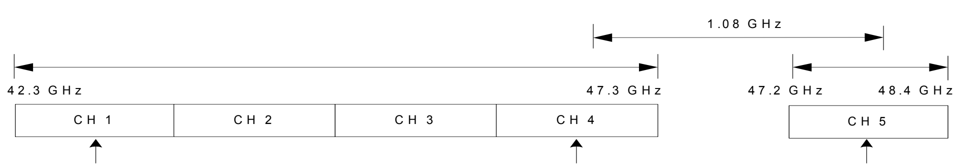


Figure 25-33—Channelization for CBW 1080 MHz

25.11 Transmit spectrum mask

For a 540 MHz or 1080 MHz mask PPDU, the interim transmit spectral mask shall have a 0 dBr (dB relative to the maximum spectral density of the signal) bandwidth of 470 MHz or 940 MHz, –17 dBr at 330 MHz or 660 MHz frequency offset, –22 dBr at 1350 MHz or 2670 MHz frequency offset, and –30 dBr at 1530 MHz or 3060 MHz frequency offset and above. The interim transmit spectral mask for frequency offsets in between 235 MHz or 470 MHz and 330 MHz or 660 MHz, in between 330 MHz or 660 MHz and 1350 MHz or 2700 MHz, and in between 1350 MHz or 2700 MHz and 1530 MHz or 3060 MHz shall be linearly interpolated in dB domain from the requirements for 235 MHz, 330 MHz, 1350 MHz, and 1530 MHz frequency offsets. The transmit spectrum shall not exceed the maximum of the interim transmit spectral mask.

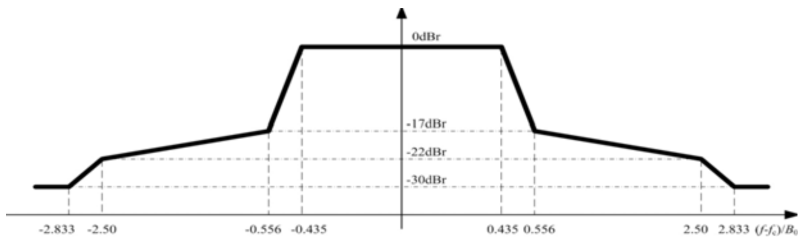


Figure 25-34—Example transmit spectral mask for a PPDU

25.12 PHY transmit procedure

25.12.1 PHY transmit procedure for a CMMG SC mode transmission

The PHY transmit procedure for a CMMG SC mode transmission is shown in Figure 25-35. In order to transmit data, a PHY-TXSTART.request primitive shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME, as specified in 25.14. Other transmit parameters, such as MCS and transmit power, are set via the PHY-SAP with the PHYTXSTART.request (TXVECTOR) primitive, as described in Table 25-1.

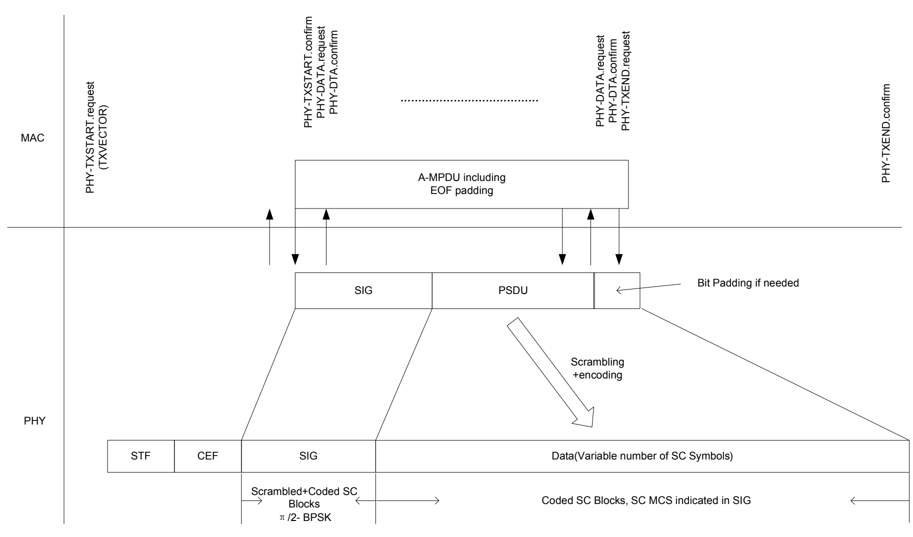


Figure 25-35—PHY transmit procedure for a CMMG SC mode transmission

The PHY shall then issue a PHY-TXSTART.request primitive, and transmission of the PHY preamble shall start, based on the parameters passed in the PHY-TXSTART.request primitive. The PHY shall calculate the length of the packet according the MCS and the length specified in the PHY-TXSTART.request primitive, adding padding bits if necessary.

The PHY continues with the scrambling, encoding, and transmission of the CMMG-SIG-A according to the PHY-TXSTART.req(TXVECTOR) parameters. The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The data are encoded as described in 25.5.6.3. The encoded data are then modulated as described in 25.5.6.6, depending on the MCS requested in the PHY_TXSTART.req. Transmission can be prematurely terminated by the MAC through the PHY-TXEND.request primitive. PHY-TXSTART shall be disabled by receiving a PHY-TXEND.request primitive.

Transmission of the PSDU is completed with the transmission of the last bits of the (encoded) PSDU. The packet transmission shall be completed, and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request primitive is acknowledged with a PHY-TXEND.confirm primitive from the PHY. In an SC transmission, normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number of blocks symbols indicated by N_{SYM} (see 25.5.6.4).

25.12.2 PHY transmit procedure for a CMMG OFDM mode transmission

The PHY transmit procedure for a CMMG OFDM transmission is shown in Figure 25-36. In order to transmit data, a PHY-TXSTART.request primitive shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME, as specified in 25.14. Other transmit parameters, such as MCS and transmit power, are set via the PHY-SAP with the PHYTXSTART.request(TXVECTOR) primitive, as described in Table 25-1.

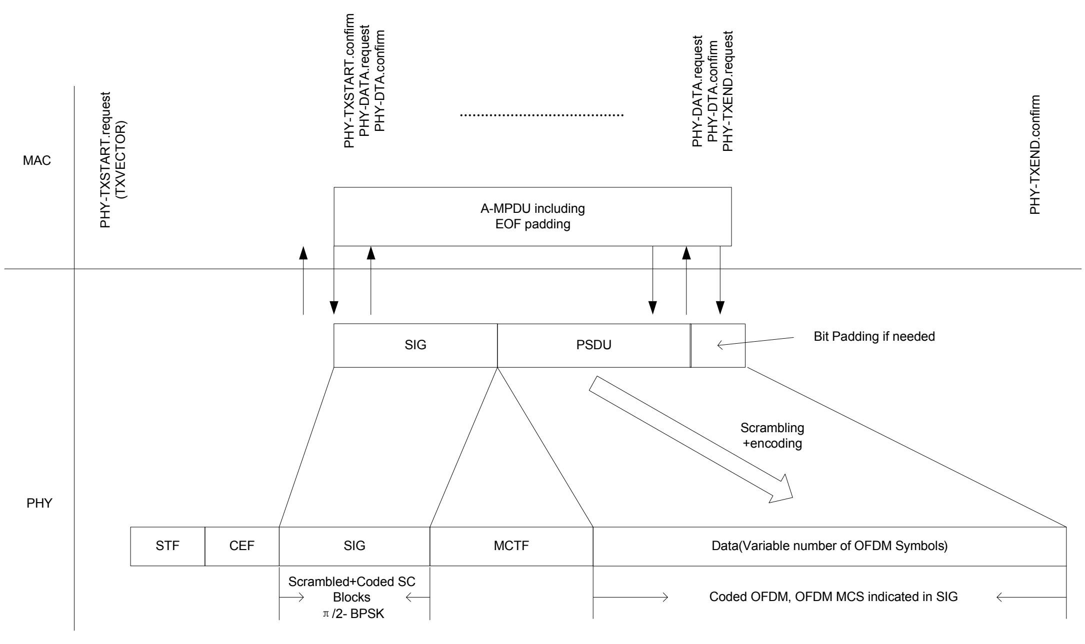


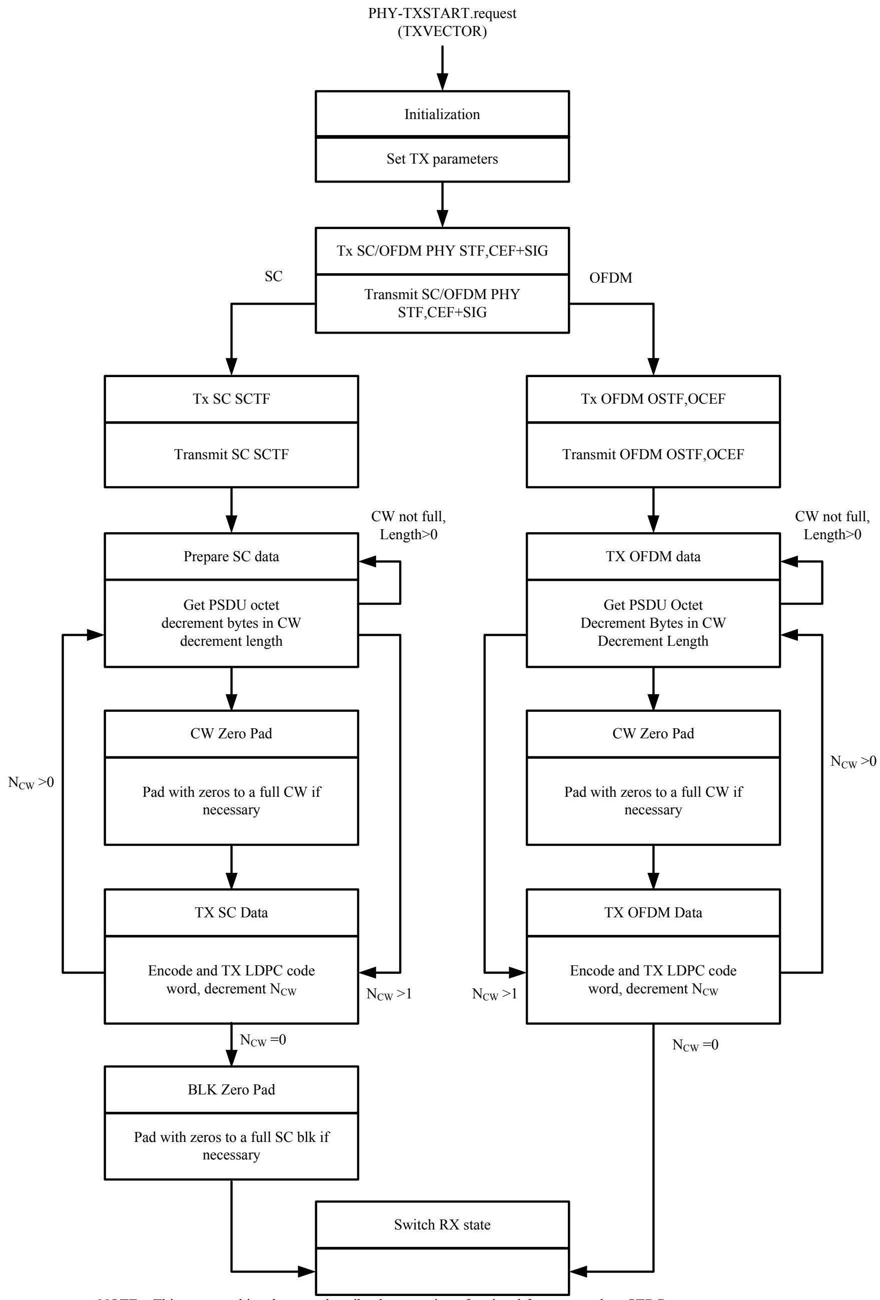
Figure 25-36—PHY transmit procedure for a CMMG OFDM mode transmission

The PHY shall then issue a PHY-TXSTART.request primitive, and transmission of the PHY preamble shall start, based on the parameters passed in the PHY-TXSTART.request primitive. The PHY shall calculate the length of the packet according the MCS and the length specified in the PHY-TXSTART.request primitive, adding padding bits if necessary.

The PHY continues with the scrambling, encoding, and transmission of the CMMG SIG according to the PHY-TXSTART.request(TXVECTOR) parameters. The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The data are scrambled and encoded as described in 25.6.8.2 and 25.6.8.3, respectively. The encoded data are then modulated as described in 25.6.8.6, depending on the MCS requested in the PHY-TXSTART.req. Transmission can be prematurely terminated by the MAC through the PHY-TXEND.request primitive. PHY-TXSTART shall be disabled by receiving a PHY-TXEND.request primitive.

Transmission of the PSDU is completed with the transmission of the last bits of the (encoded) PSDU. The packet transmission shall be completed, and the PHY entity shall enter the receive state (i.e., PHYTX-START shall be disabled). Each PHY-TXEND.request primitive is acknowledged with a PHY-TXEND.confirm primitive from the PHY. In an OFDM transmission, normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number of OFDM symbols indicated by N_{SYM} (see 25.6.8.4).

A typical state machine implementation of the transmit PHY for an OFDM mode transmission is provided in Figure 25-37. This state machine does not describe the operation of optional features, such as STBC.



NOTE—This state machine does not describe the operation of optional features, such as STBC.

Figure 25-37—Typical Tx state machine

25.13 Receive procedure

25.13.1 SC mode receive procedure

A typical PHY receive procedure is shown in Figure 25-38 for a CMMG SC mode transmission.

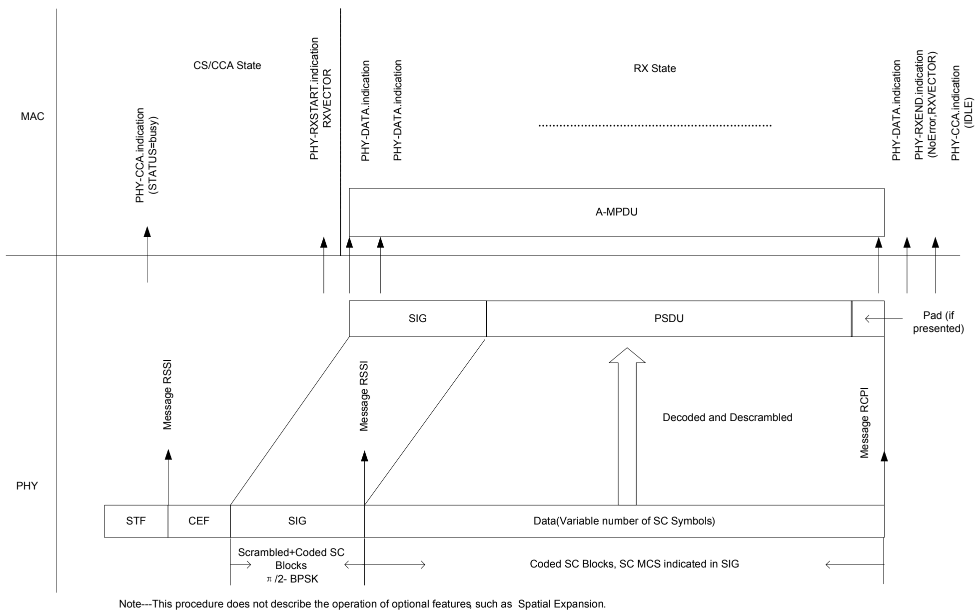


Figure 25-38—PHY receive procedure for a CMMG SC mode transmission

Upon receiving the transmitted PHY preamble overlapping the primary 540 MHz channel, the PHY measures a receive signal strength. This activity is indicated by the PHY to the MAC via a PHY-CCA.indication primitive. A PHY-CCA.indication (BUSY, channel-list) primitive is also issued as an initial indication of reception of a signal as specified in 25.6.9.3.2. The channel-list parameter of the PHY-CCA.indication primitive is absent when the operating channel width is 540 MHz. The channel-list parameter is present and includes the element primary when the operating channel width is 1080 MHz.

After the PHY-CCA.indication(BUSY) primitive is issued, the PHY entity shall use the following ZCZ sequences of length 256 for synchronization and channel estimation. If the CE field indicated a SC mode, the receiver is capable of receiving SC mode. The PHY shall decode the CMMG SIG and determine the MCS, length, and other parameters needed for the demodulation of the packet.

Subsequently, if dot11TimingMsmtActivated is true, a PHY-RXSTART.indication(RXVECTOR) primitive shall be issued, and the RX-START_OF_FRAME_OFFSET parameter within the RXVECTOR shall be forwarded (see 25.2.2).

NOTE—The RX_START_OF_FRAME_OFFSET value is used as described in 6.3.57 in order to estimate when the start of the preamble for the incoming frame was detected on the medium at the receive antenna connector.

At the end of the data portion of the packet, the PHY shall indicate PHY-RXEND.ind(No_Error) primitive to the MAC. If the CMMG SIG indicated the presence of the training field, the PHY shall continue to receive these training fields after the data portion of the packet and measure the channel. After the end of the training fields, the PHY shall generate a PHY-CCA.indication(IDLE) primitive.

In the case of signal loss before the decoding of the CMMG SIG or in the case of an invalid header, the PHY shall not generate a PHY-CCA.indication(IDLE) primitive until the received level drops below a value that is 20 dB higher than the receive sensitivity of MCS 1. In the case of signal loss after decoding of a valid CMMG SIG, the PHY shall not generate a PHY-CCA.indication(IDLE) primitive until the expected end of the packet, including the AGC and TRN fields.

A typical state machine implementation of the receive PHY is given in Figure 25-38. This receive procedure and state machine do not describe the operation of optional features, such as STBC.

25.14 CMMG PLME

25.14.1 PLME SAP sublayer management primitive

Table 25-36 lists the MIB attributes that may be accessed by the PHY entities and the intralayer of higher level LMEs. These attributes are accessed via the PLME-GET, PLME-SET, PLME-RESET, and PLME-CHARACTERISTICS primitives defined in 6.5.

25.14.2 PHY MIB

CMMG PHY MIB attributes are defined in Annex C with specific values defined in Table 25-36. The "Operational semantics" column in Table 25-36 contains two types: static and dynamic.

- Static MIB attributes are fixed and cannot be modified for a given PHY implementation.
- Dynamic MIB attributes are interpreted according to the MAX-ACCESS field of the MIB attribute.

When MAX-ACCESS is read-only, the MIB attribute value may be updated by the PLME and read from the MIB attribute by management entities. When MAX-ACCESS is read-write, the MIB attribute may be read and written by management entities but shall not be updated by the PLME.

Table 25-36—CMMG PHY MIB attributes

Managed object	Default value/ range	Operational semantics
dot11PHYOperationTable		
dot11PHYType	cmmg(13)	Static
dot11PHYCMMGTable		
dot11CMMGCurrentChannelWidth	Implementation dependent	Dynamic
dot11CMMGCurrentChannelCenterFrequencyIndex	Implementation dependent	Dynamic
dot11CMMGShortGIOptionImplemented	false/Boolean	Static
dot11CMMGShortGIOptionActivated	false/Boolean	Dynamic
dot11CMMGTxSTBCOptionImplemented	false/Boolean	Static
dot11CMMGTxSTBCOptionActivated	false/Boolean	Dynamic
dot11CMMGRxSTBCOptionImplemented	false/Boolean	Static
dot11CMMGRxSTBCOptionActivated	false/Boolean	Dynamic
dot11CMMGBeamFormingOptionImplemented	false/Boolean	Static
dot11CMMGBeamFormingOptionActivated	false/Boolean	Dynamic

Table 25-36—CMMG PHY MIB attributes *(continued)*

Managed object	Default value/ range	Operational semantics
dot11CMMGMaxNTxChainsImplemented	Implementation dependent	Static
dot11CMMGMaxNTxChainsActivated	Implementation dependent	Dynamic
dot11TransmitBeamformingConfigTable		
dot11ReceiveNDPOptionImplemented	false/Boolean	Static
dot11TransmitNDPOptionImplemented	false/Boolean	Static
dot11ExplicitCSITransmitBeamformingOptionImplemented	false/Boolean	Static
dot11ExplicitTransmitBeamformingCSIFeedbackOptionImplemented	Implementation dependent	Static
dot11ExplicitCompressedBeamformingFeedbackOptionImplemented	Implementation dependent	Static
dot11NumberBeamFormingCSISupportAntenna	Implementation dependent	Static
dot11NumberCompressedBeamformingMatrixSupportAntenna	Implementation dependent	Static
dot11BeamformeeOptionImplemented	false/Boolean	Static
dot11BeamformerOptionImplemented	false/Boolean	Static
dot11NumberSoundingDimensions	Implementation dependent	Static
dot11BeamformeeNTxSupport	Implementation dependent	Static

25.14.3 TXTIME calculation

The value of the TXTIME parameter returned by the PLME-TXTIME.confirm primitive shall be calculated for a SC mode PPDU using Equation (25-77) and for an OFDM mode PPDU using Equation (25-78).

$$TXTIME = T_{STF} + T_{CEF} + T_{SIG} + T_{SCTF} + N_{BL} \times T_{BLK} \tag{25-77}$$

$$TXTIME = T_{STF} + T_{CEF} + T_{SIG} + T_{OSTF} + N_{OCEF} T_{OCEF} + N_{SYM} \times T_{SYM} \tag{25-78}$$

where

T_{STF}, T_{CEF}, T_{SIG}, T_{SCTF}, T_{OSTF}, and T_{OCEF} are defined in Table 25-3.

For an NDP, there is no Data field, and $N_{SYM} = 0$.

For a SC mode PPDU, the total number of data blocks in the Data field, N_{BL}, is given by Equation (25-27).

25.14.4 PHY characteristics

The static CMMG PHY characteristics, provided through the PLME-CHARACTERISTICS service primitive, shall be as shown in Table 25-37. The definitions for these characteristics are given in 6.5.

Table 25-37—CMMG PHY characteristics

PHY parameter	Value
aRIFSTime	1 µs
aSIFSTime	3 µs
aRxRFDelay	Implementation dependent
aRxPHYDelay	Implementation dependent
aRxTxTurnaroundTime	1 µs
aCCATime	3 µs
aTxRFDelay	Implementation dependent
aTxPHYDelay	Implementation dependent
aRxTxSwitchTime	1 µs
aTxRampOnTime	Implementation dependent
aTxRampOffTime	Implementation dependent
aAirPropagationTime	< 600 ns
aPHY-RX-START-Delay	11 µs
aMACProcessingDelay	Implementation dependent
aSlotTime	5 µs
aCWmin	15
aCWmax	1023
aPPDUMaxTime	12 ms
aPSDUMaxLength	262 143 octets
aSCBlockSize	256 for 540 MHz 512 for 1080 MHz
aPreambleLength	8.7 µs

25.15 Parameters for CMMG MCSs

25.15.1 General

The rate-dependent parameters for 540 MHz and 1080 MHz are given in 25.15.2 and 25.15.3. Support for short GI is optional in all cases. Support for CMMG MCSs 4 to 16 is optional in all cases. A CMMG STA shall support single spatial stream CMMG MCSs within the range CMMG MCS 0 to 3 for 540 MHz channel widths for which it has indicated support regardless of the Tx or Rx Highest Supported Long GI Data Rate subfield values in the Supported CMMG MCS and NSS Set field. When more than one spatial stream is supported, the Tx or Rx Highest Supported Long GI Data Rate subfield values in the Supported CMMG

MCS and NSS Set field may result in a reduced CMMG MCS range (cut-off) for $N_{SS} = 2, 3, 4$. Support for 540 MHz with $N_{SS} = 1$ and SC transmission is mandatory. Support for 540 MHz and 1080 MHz with $N_{SS} = 2, 3, 4$ and SC transmission is optional. Support for 540 MHz and 1080 MHz with OFDM transmission is optional.

25.15.2 Parameters for CMMG MCSs with SC mode transmission

The related parameters for different modulation are summarized in Table 25-38 through Table 25-41 for 540 MHz channel bandwidth with SC mode transmission.

Table 25-38—CMMG SC MCSs for mandatory 540 MHz, N_{SS}=1

MCS index	Modulation	*R*	N_{CBPS}	Data rate (Mb/s)	
				Long GI	Short GI
1	π/2-BPSK	1/2	1	165.00	192.50
2	π/2-QPSK	1/2	2	330.00	385.00
3	π/2-QPSK	3/4	2	495.00	577.50
4	π/2-16-QAM	1/2	4	660.00	770.00
5	π/2-16-QAM	3/4	4	990.00	1155.00
6	π/2-64-QAM	5/8	6	1237.50	1443.75
7	π/2-64-QAM	3/4	6	1485.00	1732.50
8	π/2-64-QAM	13/16	6	1608.75	1876.88

Table 25-39—CMMG SC MCSs for optional 540 MHz, N_{SS}=2 (Optional)

MCS index	Modulation	*R*	N_{CBPS}	Data rate (Mb/s)	
				Long GI	Short GI
1	π/2-BPSK	1/2	1	330.00	385.00
2	π/2-QPSK	1/2	2	660.00	770.00
3	π/2-QPSK	3/4	2	990.00	1155.00
4	π/2-16-QAM	1/2	4	1320.00	1540.00
5	π/2-16-QAM	3/4	4	1980.00	2310.00
6	π/2-64-QAM	5/8	6	2475.00	2887.50
7	π/2-64-QAM	3/4	6	2970.00	3465.00
8	π/2-64-QAM	13/16	6	3217.50	3753.75

Table 25-40—CMMG SC MCSs for optional 540 MHz, N_{SS}=3 (Optional)

MCS index	Modulation	R	N_{CBPS}	Data rate (Mb/s)	
				Long GI	Short GI
1	π/2-BPSK	1/2	1	495.00	577.50
2	π/2-QPSK	1/2	2	990.00	1155.00
3	π/2-QPSK	3/4	2	1485.00	1732.50
4	π/2-16-QAM	1/2	4	1980.00	2310.00
5	π/2-16-QAM	3/4	4	2970.00	3465.00
6	π/2-64-QAM	5/8	6	3712.50	4331.25
7	π/2-64-QAM	3/4	6	4455.00	5197.50
8	π/2-64-QAM	13/16	6	4826.50	5630.63

Table 25-41—CMMG SC MCSs for optional 540 MHz, N_{SS}=4 (Optional)

MCS index	Modulation	R	N_{CBPS}	Data rate (Mb/s)	
				Long GI	Short GI
1	π/2-BPSK	1/2	1	660.00	770.00
2	π/2-QPSK	1/2	2	1320.00	1540.00
3	π/2-QPSK	3/4	2	1980.00	2310.00
4	π/2-16-QAM	1/2	4	2640.00	3080.00
5	π/2-16-QAM	3/4	4	3960.00	4620.00
6	π/2-64-QAM	5/8	6	4950.00	5775.00
7	π/2-64-QAM	3/4	6	5940.00	6930.00
8	π/2-64-QAM	13/16	6	6435.00	7507.50

The related parameters for different modulation are summarized in Table 25-42 through Table 25-45 for 1080 MHz channel bandwidth with SC mode transmission.

Table 25-42—CMMG SC MCSs for mandatory 1080 MHz, N_{SS}=1

MCS index	Modulation	R	N_{CBPS}	Data rate (Mb/s)	
				Long GI	Short GI
1	π/2-BPSK	1/2	1	330.00	385.00
2	π/2-QPSK	1/2	2	660.00	770.00
3	π/2-QPSK	3/4	2	990.00	1155.00

Table 25-42—CMMG SC MCSs for mandatory 1080 MHz, N_{SS}=1 *(continued)*

MCS index	Modulation	R	N_{CBPS}	Data rate (Mb/s)	
				Long GI	Short GI
4	π/2-16-QAM	1/2	4	1320.00	1540.00
5	π/2-16-QAM	3/4	4	1980.00	2310.00
6	π/2-64-QAM	5/8	6	2475.00	2887.50
7	π/2-64-QAM	3/4	6	2970.00	3465.00
8	π/2-64-QAM	13/16	6	3217.50	3753.75

Table 25-43—CMMG SC MCSs for optional 1080 MHz, N_{SS}=2 (Optional)

MCS index	Modulation	R	N_{CBPS}	Data rate (Mb/s)	
				Long GI	Short GI
1	π/2-BPSK	1/2	1	660.00	770.00
2	π/2-QPSK	1/2	2	1320.00	1540.00
3	π/2-QPSK	3/4	2	1980.00	2310.00
4	π/2-16-QAM	1/2	4	2640.00	3080.00
5	π/2-16-QAM	3/4	4	3960.00	4620.00
6	π/2-64-QAM	5/8	6	4950.00	5775.00
7	π/2-64-QAM	3/4	6	5940.00	6930.00
8	π/2-64-QAM	13/16	6	6435.00	7507.50

Table 25-44—CMMG SC MCSs for optional 1080 MHz, N_{SS}=3 (Optional)

MCS index	Modulation	R	N_{CBPS}	Data rate (Mb/s)	
				Long GI	Short GI
1	π/2-BPSK	1/2	1	990.00	1155.00
2	π/2-QPSK	1/2	2	1980.00	2310.00
3	π/2-QPSK	3/4	2	2970.00	3465.00
4	π/2-16-QAM	1/2	4	3960.00	4620.00
5	π/2-16-QAM	3/4	4	5940.00	6930.00
6	π/2-64-QAM	5/8	6	7425.00	8662.50
7	π/2-64-QAM	3/4	6	8910.00	10395.00
8	π/2-64-QAM	13/16	6	9652.50	11261.25

Table 25-45—CMMG SC MCSs for optional 1080 MHz, N_{SS}=4 (Optional)

MCS index	Modulation	R	N_{CBPS}	Data rate (Mb/s)	
				Long GI	Short GI
1	π/2-BPSK	1/2	1	1320.00	1540.00
2	π/2-QPSK	1/2	2	2640.00	3080.00
3	π/2-QPSK	3/4	2	3960.00	4620.00
4	π/2-16-QAM	1/2	4	5280.00	6160.00
5	π/2-16-QAM	3/4	4	7920.00	9240.00
6	π/2-64-QAM	5/8	6	9900.00	11550.00
7	π/2-64-QAM	3/4	6	11880.00	13860.00
8	π/2-64-QAM	13/16	6	12870.00	15015.00

25.15.3 Parameters for CMMG MCSs with OFDM mode transmission

The related parameters for different modulation are summarized in Table 25-46 through Table 25-49 for 540 channel bandwidth with OFDM mode transmission.

Table 25-46—CMMG OFDM MCSs for optional 540 MHz, N_{SS}=1 (Optional)

MCS index	Modulation	R	N_{CBPS}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
						Long GI	Short GI
9	BPSK	1/2	1	168	84	173.25	192.50
10	QPSK	1/2	2	336	168	346.50	385.00
11	QPSK	3/4	2	336	252	519.75	577.50
12	16-QAM	1/2	4	672	336	693.00	770.00
13	16-QAM	3/4	4	672	504	1039.50	1155.00
14	64-QAM	5/8	6	1008	630	1299.38	1443.75
15	64-QAM	3/4	6	1008	756	1559.25	1732.50
16	64-QAM	13/16	6	1008	819	1689.19	1876.88

Table 25-47—CMMG OFDM MCSs for optional 540 MHz, N_{SS}=2 (Optional)

MCS index	Modulation	R	N_{CBPS}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
						Long GI	Short GI
9	BPSK	1/2	1	336	168	346.50	385.00
10	QPSK	1/2	2	672	336	693.00	770.00

Table 25-47—CMMG OFDM MCSs for optional 540 MHz, N_{SS}=2 (Optional) *(continued)*

MCS index	Modulation	R	N_{CBPS}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
						Long GI	Short GI
11	QPSK	3/4	2	672	504	1039.50	1155.00
12	16-QAM	1/2	4	1344	672	1386.00	1540.00
13	16-QAM	3/4	4	1344	1008	2079.00	2310.00
14	64-QAM	5/8	6	2016	1260	2598.75	2887.50
15	64-QAM	3/4	6	2016	1512	3118.50	3465.00
16	64-QAM	13/16	6	2016	1638	3378.38	3753.75

Table 25-48—CMMG OFDM MCSs for optional 540 MHz, N_{SS}=3 (Optional)

MCS index	Modulation	R	N_{CBPS}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
						Long GI	Short GI
9	BPSK	1/2	1	504	252	519.75	577.50
10	QPSK	1/2	2	1008	504	1039.50	1155.00
11	QPSK	3/4	2	1008	756	1559.25	1732.50
12	16-QAM	1/2	4	2016	1008	2079.00	2310.00
13	16-QAM	3/4	4	2016	1512	3118.50	3465.00
14	64-QAM	5/8	6	3024	1890	3898.13	4331.25
15	64-QAM	3/4	6	3024	2268	4677.75	5197.50
16	64-QAM	13/16	6	3024	2457	5067.56	5630.63

Table 25-49—CMMG OFDM MCSs for optional 540 MHz, N_{SS}=4 (Optional)

MCS index	Modulation	R	N_{CBPS}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
						Long GI	Short GI
9	BPSK	1/2	1	672	336	693.00	770.00
10	QPSK	1/2	2	1344	672	1386.00	1540.00
11	QPSK	3/4	2	1344	1008	2079.00	2310.00
12	16-QAM	1/2	4	2688	1344	2772.00	3080.00
13	16-QAM	3/4	4	2688	2016	4158.00	4620.00
14	64-QAM	5/8	6	4032	2520	5197.50	5775.00
15	64-QAM	3/4	6	4032	3024	6237.00	6930.00
16	64-QAM	13/16	6	4032	3276	6756.75	7507.50

The related parameters for different modulation are summarized in Table 25-50 through Table 25-53 for 1080 MHz channel bandwidth with OFDM mode transmission.

Table 25-50—CMMG OFDM MCSs for optional 1080 MHz, N_{SS}=1 (Optional)

MCS index	Modulation	R	N_{CBPS}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
						Long GI	Short GI
9	BPSK	1/2	1	336	168	346.50	385.00
10	QPSK	1/2	2	672	336	693.00	770.00
11	QPSK	3/4	2	672	504	1039.50	1155.00
12	16-QAM	1/2	4	1344	672	1386.00	1540.00
13	16-QAM	3/4	4	1344	1008	2079.00	2310.00
14	64-QAM	5/8	6	2016	1260	2598.75	2887.50
15	64-QAM	3/4	6	2016	1512	3118.50	3465.00
16	64-QAM	13/16	6	2016	1638	3378.38	3753.75

Table 25-51—CMMG OFDM MCSs for optional 1080 MHz, N_{SS}=2 (Optional)

MCS index	Modulation	R	N_{CBPS}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
						Long GI	Short GI
9	BPSK	1/2	1	672	336	693.00	770.00
10	QPSK	1/2	2	1344	672	1386.00	1540.00
11	QPSK	3/4	2	1344	1008	2079.00	2310.00
12	16-QAM	1/2	4	2688	1344	2772.00	3080.00
13	16-QAM	3/4	4	2688	2016	4158.00	4620.00
14	64-QAM	5/8	6	4032	2520	5197.50	5775.00
15	64-QAM	3/4	6	4032	3024	6237.00	6930.00
16	64-QAM	13/16	6	4032	3276	6756.75	7507.50

Table 25-52—CMMG OFDM MCSs for optional 1080 MHz, N_{SS}=3 (Optional)

MCS index	Modulation	R	N_{CBPS}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
						Long GI	Short GI
9	BPSK	1/2	1	1008	504	1039.50	1155.00
10	QPSK	1/2	2	2016	1008	2079.00	2310.00
11	QPSK	3/4	2	2016	1512	3118.50	3465.00

Table 25-52—CMMG OFDM MCSs for optional 1080 MHz, N_{SS}=3 (Optional) *(continued)*

MCS index	Modulation	R	N_{CBPS}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
						Long GI	Short GI
12	16-QAM	1/2	4	4032	2016	4158.00	4620.00
13	16-QAM	3/4	4	4032	3024	6237.00	6930.00
14	64-QAM	5/8	6	6048	3780	7796.25	8662.50
15	64-QAM	3/4	6	6048	4536	9355.50	10395.00
16	64-QAM	13/16	6	6048	4914	10135.13	11261.25

Table 25-53—CMMG OFDM MCSs for optional 1080 MHz, N_{SS}=4 (Optional)

MCS index	Modulation	R	N_{CBPS}	N_{CBPS}	N_{DBPS}	Data rate (Mb/s)	
						Long GI	Short GI
9	BPSK	1/2	1	1344	672	1386.00	1540.00
10	QPSK	1/2	2	2688	1344	2772.00	3080.00
11	QPSK	3/4	2	2688	2016	4158.00	4620.00
12	16-QAM	1/2	4	5376	2688	5544.00	6160.00
13	16-QAM	3/4	4	5376	4032	8316.00	9240.00
14	64-QAM	5/8	6	8064	5040	10395.00	11550.00
15	64-QAM	3/4	6	8064	6048	12474.00	13860.00
16	64-QAM	13/16	6	8064	6552	13513.50	15015.00

Annex B

(normative)

Protocol Implementation Conformance Statement (PICS) proforma

B.2 Abbreviations and special symbols

B.2.2 General abbreviations for Item and Support columns

Insert the following abbreviations in alphabetic order in B.2.2:

CDMG-M China directional multi-gigabit (CDMG) medium access control (MAC) features
CDMG-P China directional multi-gigabit (CDMG) physical layer (PHY) features
CMMG-M China Millimeter-wave multi-gigabit (CMMG) medium access control (MAC) features
CMMG-P China Millimeter-wave multi-gigabit (CMMG) physical layer (PHY) features

B.4 PICS proforma

Insert the following rows at the end of the table in B.4.3 (IUT configuration):

B.4.3 IUT configuration

Item	IUT configuration	References	Status	Support
*CFCDMG	China directional multi-gigabit (CDMG) PHY	9.4.2.217	O.2 CFCDMG:M	Yes, No
*CFCMMG	China Millimeter-wave multi-gigabit (CMMG) PHY	9.4.2.227	O.2 CFCMMG:M	Yes, No

Insert the following subclauses, B.4.30 and B.4.31, after B.4.29:

B.4.30 CDMG features

B.4.30.1 CDMG MAC features

Item	Protocol capability	References	Status	Support
	Are the following MAC protocol features supported?			
CDMG-M1	CDMG capabilities signaling			
CDMG-M1.1	CDMG Capabilities element	9.4.2.217	CFCDMG:M	Yes, No, N/A

Item	Protocol capability	References	Status	Support
CDMG-M1.2	Signaling of STA capabilities in Probe Request and (Re)Association Request frames	9.3.3.6, 9.3.3.8, 9.3.3.10, 9.4.2.217)	(CFCDMG AND (CFSTAofAP OR CFIBSS OR CFPBSSnot PCP)):M	Yes, No, N/A
CDMG-M1.3	Signaling of STA and BSS capabilities in DMG Beacon, Probe Response, and (Re)Association Response frames	9.3.3.7, 9.3.3.9, 9.3.3.11, 9.3.4.2), 9.4.2.217	(CFCDMG AND (CFAP OR CFPCP)):M	Yes, No, N/A
CDMG-M2	Dynamic bandwidth control	9.3.4.2, 10.60	CFCDMG:M	Yes, No, N/A
CDMG-M3	Dynamic channel selection	11.49, 9.6.8.37-9.6.8.40, 6.3.118	CFCDMG:O	Yes, No, N/A
CDMG-M4	Opportunistic transmissions	9.4.1.7, 9.4.2.219, 10.36.11	CFCDMG:O	Yes, No, N/A
CDMG-M5	Selection of candidate SPs for spatial sharing	9.4.2.220, 11.32.1, W.1	CFCDMG:O	Yes, No, N/A
CDMG-M6	CDMG AP or PCP clustering	10.37a	CFCDMG:M	Yes, No, N/A
CDMG-M7	CDMG protected period establishment and maintenance	10.36.6.6.2a	CFCDMG:M	Yes, No, N/A
CDMG-M8	Spatial sharing in a CDMG AP or PCP cluster	10.37a.6	CFCDMG:M	Yes, No, N/A
CDMG-M9	CDMG enhanced beam tracking	10.38.9, W.3	CFCDMG:O	Yes, No, N/A
CDMG-M10	CDMG dynamic truncation of service period	10.36.8.2	CFCDMG:M	Yes, No, N/A

B.4.30.2 CDMG PHY features

Item	Protocol capability	References	Status	Support
	Are the following PHY protocol features supported?			
CDMG-P1	PHY operating modes			
CDMG-P1.1	Operation according to Clause 24	Clause 24	CFCDMG :M	Yes, No, N/A
CDMG-P2	CDMG PHY frame format			
CDMG-P2.1	CDMG control mode format	24.4	CFCDMG :M	Yes, No, N/A
CDMG-P2.2	CDMG SC mode format	24.5	CFCDMG :M	Yes, No, N/A
CDMG-P2.3	CDMG low-power SC mode format	24.6	CFCDMG :O	Yes, No, N/A

Item	Protocol capability	References	Status	Support
CDMG-P2.4	Modulation and coding schemes (MCSs)			Yes, No, N/A
CDMG-P2.4.1	MCS 0 of CDMG control mode		CDMG-P2.1:M	Yes, No, N/A
CDMG-P2.4.2	MCSs 1 to 16 of CDMG SC mode			Yes, No, N/A
CDMG-P2.4.2.1	MCSs 1 to 9		CDMG-P2.2:M	Yes, No, N/A
CDMG-P2.4.2.2	MCSs 10 to 16		CDMG-P2.2:O	Yes, No, N/A
CDMG-P2.4.3	MCSs 17 to 23 of CDMG low-power SC mode	24.6	CDMG-P2.3:M	Yes, No, N/A
CDMG-P2.5	Common preamble format	24.3	CFCDMG:M	Yes, No, N/A
CDMG-P2.6	Enhanced mobile device support mode	24.5	CFCDMG:M	Yes, No, N/A

B.4.31 CMMG features

B.4.31.1 CMMG PHY features

Item	Protocol capability	References	Status	Support
	Are the following PHY protocol features supported?			
CMMG-P1	PHY operating modes			
CMMG-P1.1	Operation according to Clause 25	Clause 25	CFCMMG:M	
CMMG-P2	PHY frame format			
CMMG-P2.1	CMMG control mode format	25.4	CFCMMG:M	Yes, No, N/A
CMMG-P2.2	CMMG SC mode format	25.5	CFCMMG:M	Yes, No, N/A
CMMG-P2.3	CMMG OFDM mode format	25.6	CFCMMG:O	Yes, No, N/A
CMMG-P2.4	Modulation and coding schemes (MCSs)			
CMMG-P2.4.1	MCS 0 of CMMG control mode	25.4	CMMG-P2.1:M	Yes, No, N/A
CMMG-P2.4.2	MCSs 1 to 8 of CMMG SC mode			
CMMG-P2.4.2.1	MCSs 1 to 3	25.5	CMMG-P2.2:M	Yes, No, N/A
CMMG-P2.4.2.2	MCSs 4 to 8	25.5	CMMG-P2.2:O	Yes, No, N/A
CMMG-P2.4.3	MCSs 9 to 16 of CMMG OFDM mode	25.6	CMMG-P2.3:M	Yes, No, N/A

Annex C

(normative)

ASN.1 encoding of the MAC and PHY MIB

C.3 MIB detail

Insert the following comments at the end of the "dot11smt OBJECT IDENTIFIER" list in the "Major sections" of C.3:

```
-- dot11CDMGSTAConfigTable                          ::= { dot11smt 39}
-- dot11CMMGSTAConfigTable                          ::= { dot11smt 40}
```

Insert the following comments at the end of the "MAC GROUPS" list in the "Major sections" of C.3:

```
-- dot11CDMGOperationTable                          ::= { dot11mac 11}
```

Insert the following comments at the end of the "PHY GROUPS" list in the "Major sections" of C.3:

```
-- dot11PHYCDMGTable                                ::= { dot11phy 29}
-- dot11PHYCMMGTable                                ::= { dot11phy 30}
```

Change the definitions of "dot11BeaconRprtPhyType," "dot11FrameRprtPhyType," and"dot11RMNeighborReportPhyType" in C.3 as follows:

```
dot11BeaconRprtPhyType OBJECT-TYPE
   SYNTAX INTEGER {
      dsss(2),
      ofdm(4),
      hrdsss(5),
      erp(6),
      ht(7),
      dmg(8),
      vht(9),
      tvht(10),
      s1g(11),
      cdmg(12),
      cmmg(13)}
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a status variable.
      It is written by the SME when a measurement report is completed.

      This attribute indicates the PHY Type for this row of Beacon report."
   ::= { dot11BeaconReportEntry 9 }

dot11FrameRprtPhyType OBJECT-TYPE
   SYNTAX INTEGER {
      dsss(2),
      ofdm(4),
      hrdsss(5),
      erp(6),
      ht(7),
      dmg(8),
      vht(9),
      tvht(10),
      s1g(11),
```

```
        cdmg(12),
        cmmg(13)}
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "This is a status variable.
        It is written by the SME when a measurement report is completed.

        This attribute indicates the PHY used for frame reception in this row of
        the frame report."
    ::= { dot11FrameReportEntry 10 }

dot11RMNeighborReportPhyType OBJECT-TYPE
    SYNTAX INTEGER {
        dsss(2),
        ofdm(4),
        hrdsss(5),
        erp(6),
        ht(7),
        dmg(8),
        vht(9),
        tvht(10),
        s1g(11),
        cdmg(12),
        cmmg(13)}
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "This is a status variable.
        It is written by the SME when a measurement report is completed.

        This attribute indicates the PHY Type of the neighbor AP
        identified by this BSSID."
    ::= { dot11RMNeighborReportEntry 15 }
```

Change the definition of "dot11PhyType" in the "dot11PhyOperation TABLE" in C.3 as follows:

```
dot11PHYType OBJECT-TYPE
    SYNTAX INTEGER {
        dsss(2),
        ofdm(4),
        hrdsss(5),
        erp(6),
        ht(7),
        dmg(8),
        vht(9),
        tvht(10),
        s1g(11),
        cdmg(12),
        cmmg(13)}
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a status variable.
        It is written by the PHY.

        This is an 8-bit integer value that identifies the supported PHY type.
        Currently defined values and their corresponding PHY types are:
        DSSS 2.4 GHz = 02, OFDM = 04, HRDSSS = 05, ERP = 06, HT = 07,
        DMG = 08, VHT = 9, TVHT = 10, S1G = 11, CDMG = 12, CMMG = 13"
    ::= { dot11PhyOperationEntry 1 }
```

Insert the following tables ("dot11CDMGSTAConfigTable") and ("dot11CMMGSTAConfigTable") after the "dot11S1GStationConfigTable" part of C.3:

```
--**********************************************************************
-- * dot11CDMGSTAConfigTable TABLE
--**********************************************************************

dot11CDMGSTAConfigTable OBJECT-TYPE
   SYNTAX SEQUENCE OF Dot11CDMGSTAConfigEntry
   MAX-ACCESS not-accessible
   STATUS current
   DESCRIPTION
      "This is a table management object.
      The dot11CDMGSTAConfig Table"
   ::= { dot11smt 39}

dot11CDMGSTAConfigEntry OBJECT-TYPE
   SYNTAX Dot11CDMGSTAConfigEntry
   MAX-ACCESS not-accessible
   STATUS current
   DESCRIPTION
      "This is an entry in the dot11CDMGSTAConfig Table.
      ifIndex - Each IEEE Std 802.11 interface is represented by an ifEntry.
      Interface tables in this MIB module are indexed by ifIndex."
   INDEX { ifIndex }
   ::= { dot11CDMGSTAConfigTable 1 }

Dot11CDMGSTAConfigEntry ::=
   SEQUENCE {
      dot11CDMGOptionImplemented                          TruthValue,
      dot11DynamicChannelTransferImplemented              TruthValue,
      dot11DynamicChannelTransferActivated                TruthValue,
      dot11OpportunisticTransmissionsActivated            TruthValue,
      dot11CDMGSpatialsharingActivated                    TruthValue,
      dot11CDMGClusteringActivated                        TruthValue
      }

dot11CDMGOptionImplemented OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities.

      CDMG Capable Object
      This attribute, when true, indicates the STA is CDMG
      capable. This attribute, when false, indicates the STA is not CDMG
      capable. The default value of this attribute is false."
   DEFVAL { false }
   ::= { dot11CDMGSTAConfigEntry 1 }

dot11DynamicChannelTransferImplemented OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities.

      This attribute, when true, indicates the CDMG STA is dynamic channel
      selection capable. This attribute, when false, indicates the STA is not
      dynamic channel selection capable. The default value of this attribute is
      false."
```

```
   DEFVAL { false }
   ::= { dot11CDMGSTAConfigEntry 2 }

dot11DynamicChannelTransferActivated OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities.

      This attribute, when true, indicates that the dynamic channel selection is
      activated."
   DEFVAL { false }
   ::= { dot11CDMGSTAConfigEntry 3}

dot11OpportunisticTransmissionsActivated OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities.

      If dot11OpportunisticTransmissionsActivated is true, the STA is capable of
      supporting opportunistic transmissions."
   DEFVAL { false }
   ::= { dot11CDMGSTAConfigEntry 4}

dot11CDMGSpatialsharingActivated OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities.

      If dot11CDMGSpatialsharingActivated is true, the STA is capable of
      supporting CDMG spatial sharing."
   DEFVAL { false }
   ::= { dot11CDMGSTAConfigEntry 5}

dot11CDMGClusteringActivated OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities.

      If dot11CDMGClusteringActivated is true, the STA is capable of supporting
      CDMG AP or PCP clustering."
   DEFVAL { false }
   ::= { dot11CDMGSTAConfigEntry 6}

--******************************************************************
-- * End of dot11CDMGSTAConfigTable TABLE
--******************************************************************

--******************************************************************
-- * dot11CMMGSTAConfigTable TABLE
--******************************************************************

dot11CMMGSTAConfigTable OBJECT-TYPE
```

```
    SYNTAX SEQUENCE OF Dot11CMMGSTAConfigEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "This is a table management object.
        The dot11CMMGSTAConfig Table"
    ::= { dot11smt 40}

dot11CMMGSTAConfigEntry OBJECT-TYPE
    SYNTAX Dot11CMMGSTAConfigEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "This is an entry in the dot11CMMGSTAConfig Table.
        ifIndex - Each IEEE Std 802.11 interface is represented by an ifEntry.
        Interface tables in this MIB module are indexed by ifIndex."
    INDEX { ifIndex }
    ::= { dot11CMMGSTAConfigTable 1 }

Dot11CMMGSTAConfigEntry ::=
    SEQUENCE {
        dot11CMMGMaxMPDULength                          INTEGER,
        dot11CMMGMaxRxAMPDUFactor                       Unsighed32,
        dot11CMMGControlFieldOptionImplemented          TruthValue,
        dot11CMMGTXOPPowerSaveOptionImplemented         TruthValue,
        dot11CMMGRxCMMGMCSMap                           OCTET STRING,
        dot11CMMGRxHighestDataRateSupported             Unsighed32,
        dot11CMMGTxCMMGMCSMap                           OCTET STRING,
        dot11CMMGTxHighestDataRateSupported             Unsighed32,
        dot11CMMGOptionImplemented                      TruthValue,
        dot11CMMGClusteringActivated                    TruthValue
        dot11CMMGOBSSScanCount                          Unsighed32
        }

dot11CMMGMaxMPDULength OBJECT-TYPE
    SYNTAX INTEGER { short(3895), medium(7991), long(11454) }
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.
        This attribute indicates the supported maximum MPDU size."
    DEFVAL { short }
    ::= { dot11CMMGStationConfigEntry 1 }

dot11CMMGMaxRxAMPDUFactor OBJECT-TYPE
    SYNTAX Unsigned32 (0..7)
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.
        This attribute indicates the maximum length of A-MPDU that the STA can
        receive. The Maximum Rx A-MPDU defined by this field is equal to
        2^(13+dot11CMMGMaxRxAMPDUFactor) -1 octets."
    DEFVAL { 0 }
    ::= { dot11CMMGStationConfigEntry 2 }


dot11CMMGControlFieldOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
```

```
        "This is a capability variable.
        Its value is determined by device capabilities.
        This attribute, when true, indicates that the station implementation is
        capable of receiving the CMMG Control field."
    DEFVAL { false }
    ::= { dot11CMMGStationConfigEntry 3 }

dot11CMMGTXOPPowerSaveOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.
        This attribute, when true, indicates that the station implementation is
        capable of TXOP Power Save operation."
    DEFVAL { false }
    ::= { dot11CMMGStationConfigEntry 4 }

dot11CMMGRxCMMGMCSMap OBJECT-TYPE
    SYNTAX OCTET STRING (SIZE(8))
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.
        Each octet represents the highest CMMG-MCS supported (for Rx) on the
        number of streams represented by the octet position (first octet
        represents 1 stream, second octet represents 2 streams, etc.) A value 0
        indicates that CMMG-MCSs SC 1-5 (OFDM 9-13) are supported. A value 1
        indicates that CMMG-MCSs SC 1-6(OFDM 9-14) are supported. A value 2
        indicates that CMMG-MCSs SC 1-7 (OFDM 9-15) are supported. A value 2
        indicates that CMMG-MCSs SC 1-8 (OFDM 9-16) are supported. A value 4-7
        indicates no support for that number of spatial streams."
    ::= { dot11CMMGStationConfigEntry 5 }


dot11CMMGRxHighestDataRateSupported OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.
        Represents the highest data rate in Mb/s that the STA is capable of
        receiving."
    ::= { dot11CMMGStationConfigEntry 6 }

dot11CMMGTxCMMGMCSMap OBJECT-TYPE
    SYNTAX OCTET STRING (SIZE(8))
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.
        Each octet represents the highest CMMG-MCS supported (for Rx) on the
        number of streams represented by the octet position (first octet
        represents 1 stream, second octet represents 2 streams, etc.) A value 0
        indicates that CMMG-MCSs SC 1-5 (OFDM 9-13) are supported. A value 1
        indicates that CMMG-MCSs SC 1-6(OFDM 9-14) are supported. A value 2
        indicates that CMMG-MCSs SC 1-7 (OFDM 9-15) are supported. A value 2
        indicates that CMMG-MCSs SC 1-8 (OFDM 9-16) are supported. A value 4-7
        indicates no support for that number of spatial streams."
    ::= { dot11CMMGStationConfigEntry 7 }
```

```
dot11CMMGTxHighestDataRateSupported OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.
        Represents the highest data rate in Mb/s that the STA is capable of
        receiving."
    ::= { dot11CMMGStationConfigEntry 8 }

dot11CMMGOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        CMMG Capable Object
        This attribute, when true, indicates the STA is CMMG
        capable.  This attribute, when false, indicates the STA is not CMMG
        capable.  The default value of this attribute is false."
    DEFVAL { false }
    ::= { dot11CMMGSTAConfigEntry 9 }

dot11CMMGClusteringActivated OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.

        If dot11CMMGClusteringActivated is true, the STA is capable of supporting
        CMMG AP or PCP clustering."
    DEFVAL { false }
    ::= { dot11CMMGSTAConfigEntry 10 }

dot11CMMGOBSSScanCount OBJECT-TYPE
    SYNTAX Unsigned32 (3..100)
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
        "This is a control variable.
        It is written by an external management entity or the SME.
        Changes take effect as soon as practical in the implementation.
        This attribute indicates the minimum number of scan operations performed
        on a channel to detect another OBSS."
    DEFVAL { 3 }
    ::= { dot11CMMGStationConfigEntry 11 }


--**********************************************************************
-- * End of dot11CMMGSTAConfigTable TABLE
--**********************************************************************
```

Insert the following table ("dot11 Phy CDMG TABLE") after the "dot11 S1G Transmit Beamforming Config TABLE" section in C.3:

```
--********************************************************************
-- * dot11 Phy CDMG TABLE
--********************************************************************

dot11PHYCDMGTable OBJECT-TYPE
   SYNTAX SEQUENCE OF Dot11PHYCDMGEntry
   MAX-ACCESS not-accessible
   STATUS current
   DESCRIPTION
      "Entry of attributes for dot11PhyCDMGTable. Implemented as a table indexed
      on ifIndex to allow for multiple instances on an agent."
   ::= { dot11phy 29}

dot11PHYCDMGEntry OBJECT-TYPE
   SYNTAX Dot11PHYCDMGEntry
   MAX-ACCESS not-accessible
   STATUS current
   DESCRIPTION
      "An entry in the dot11PHYCDMGEntry Table. ifIndex - Each IEEE
      802.11 interface is represented by an ifEntry. Interface tables in this
      MIB module are indexed by ifIndex."
   INDEX {ifIndex}
   ::= { dot11PHYCDMGTable 1 }

Dot11PHYCDMGEntry ::=
   SEQUENCE {
      dot11CDMGLowPowerSCPHYImplemented                      TruthValue,
      dot11CDMGLowPowerSCPHYActivated                        TruthValue
      }

dot11CDMGLowPowerSCPHYImplemented OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a capability variable.
      Its value is determined by device capabilities.

      This attribute, when true, indicates that the CDMG low power SC PHY is
      implemented."
   DEFVAL { false }
   ::= { dot11PHYCDMGEntry 1 }

dot11CDMGLowPowerSCPHYActivated OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-write
   STATUS current
   DESCRIPTION
      "This is a control variable.
      It is written by an external management entity.
      Changes take effect as soon as practical in the implementation.

      This attribute, when true, indicates that the CDMG low power SC PHY is
      activated."
   DEFVAL { false }
   ::= { dot11PHYCDMGEntry 2 }

-- *******************************************************************
-- * End of dot11 PHY CDMG TABLE
-- *******************************************************************
```

```
--*******************************************************************
-- * dot11 Phy CMMG TABLE
--*******************************************************************

dot11PHYCMMGTable OBJECT-TYPE
   SYNTAX SEQUENCE OF Dot11PHYCDMGEntry
   MAX-ACCESS not-accessible
   STATUS current
   DESCRIPTION
      "Entry of attributes for dot11PhyCMMGTable. Implemented as a table indexed
      on ifIndex to allow for multiple instances on an agent."
   ::= { dot11phy 30}

dot11PHYCMMGEntry OBJECT-TYPE
   SYNTAX Dot11PHYCMMGEntry
   MAX-ACCESS not-accessible
   STATUS current
   DESCRIPTION
      "An entry in the dot11PHYCMMGEntry Table. ifIndex - Each IEEE
      802.11 interface is represented by an ifEntry. Interface tables in this
      MIB module are indexed by ifIndex."
   INDEX {ifIndex}
   ::= { dot11PHYCMMGTable 1 }

Dot11PHYCMMGEntry ::=
   SEQUENCE {
      dot11CMMGCurrentChannelWidth                          INTEGER,
      dot11CMMGCurrentChannelCenterFrequencyIndex           Unsigned32,
      dot11CMMGShortGIOptionImplemented                     TruthValue,
      dot11CMMGShortGIOptionActivated                       TruthValue,
      dot11CMMGTxSTBCOptionImplemented                      TruthValue,
      dot11CMMGTxSTBCOptionActivated                        TruthValue,
      dot11CMMGRxSTBCOptionImplemented                      TruthValue,
      dot11CMMGRxSTBCOptionActivated                        TruthValue,
      dot11CMMGBeamFormingOptionImplemented                 TruthValue,
      ddot1CMMGBeamFormingOptionActivated                   TruthValue,
      dot11CMMGMaxNTxChainsImplemented                      TruthValue,
      dot11CMMGMaxNTxChainsActivated                        TruthValue,
      }

dot11CMMGCurrentChannelWidth OBJECT-TYPE
   SYNTAX INTEGER { cbw540(0), cbw1080(1)}
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a status variable.
      This attribute indicates the operating channel width."
   DEFVAL { cbw540 }
   ::= { dot11PhyCMMGEntry 1}

dot11CMMGCurrentChannelCenterFrequencyIndex OBJECT-TYPE
   SYNTAX Unsigned32 (0..200)
   MAX-ACCESS read-only
   STATUS current
   DESCRIPTION
      "This is a status variable.
      For a 540 MHz, 1080 MHz, denotes the channel center frequency.
      See 25.10 (Channelization)."
   DEFVAL { 0 }
   ::= { dot11PhyCMMGEntry 2}

dot11CMMGShortGIOptionImplemented OBJECT-TYPE
   SYNTAX TruthValue
   MAX-ACCESS read-only
```

```
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.
       This attribute, when true, indicates that the device is capable of
       receiving short guard interval packets."
    DEFVAL { false }
    ::= { dot11PhyCMMGEntry 3 }

dot11CMMGShortGIOptionActivated OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by an external management entity.
       Changes take effect as soon as practical in the implementation. Changes
       made while associated with an AP or while operating a BSS should take
       effect only after disassociation or the deactivation of the BSS,
       respectively.
       This attribute, when true, indicates that the reception of short guard
       interval packets is enabled."
    DEFVAL { false }
     ::= { dot11PhyCMMGEntry 4 }

dot11CMMGTxSTBCOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.
       This attribute, when true, indicates that the device is capable of
       transmitting CMMG PPDUs using STBC."
DEFVAL { false }
::= { dot11PhyCMMGEntry 5 }

dot11CMMGTxSTBCOptionActivated OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
       "This is a control variable.
       It is written by an external management entity.
       Changes take effect as soon as practical in the implementation.
       This attribute, when true, indicates that the entity's capability of
       transmitting frames using STBC option is enabled."
    DEFVAL { false }
    ::= { dot11PhyCMMGEntry 6 }

dot11CMMGRxSTBCOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This is a capability variable.
       Its value is determined by device capabilities.
       This attribute, when true, indicates that the device is capable of
       receiving CMMG PPDUs using STBC."
    DEFVAL { false }
    ::= { dot11PhyCMMGEntry 7 }

dot11CMMGRxSTBCOptionActivated OBJECT-TYPE
    SYNTAX TruthValue
```

```
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
        "This is a control variable.
        It is written by an external management entity.
        Changes take effect as soon as practical in the implementation. Changes
        made while associated with an AP or while operating a BSS should take
        effect only after disassociation or the deactivation of the BSS,
        respectively.
        This attribute, when true, indicates that the entity's capability for
        receiving CMMG PPDUs using STBC is enabled."
    DEFVAL { false }
    ::= { dot11PhyCMMGEntry 8 }

dot11CMMGBeamFormingOptionImplemented OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.
        This attribute, when true, indicates that the beamforming option is
        implemented."
    DEFVAL { false }
    ::= { dot11PhyCMMGEntry 9 }

dot11CMMGBeamFormingOptionActivated OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
        "This is a control variable.
        It is written by an external management entity.
        Changes take effect as soon as practical in the implementation.
        This attribute, when true, indicates that the beamforming option is
        enabled."
    DEFVAL { false }
    ::= { dot11PhyCMMGEntry 10 }

dot11CMMGMaxNTxChainsImplemented OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "This is a capability variable.
        Its value is determined by device capabilities.
        This attribute indicates the maximum number of transmit chains within
        this device."
    DEFVAL { 1 }
    ::= { dot11PhyCMMGEntry 11 }

dot11CMMGMaxNTxChainsActivated OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
        "This is a control variable.
        It is written by an external management entity.
        Changes take effect as soon as practical in the implementation.
        This attribute indicates the maximum number of transmit chains that are
        activated within this device, unless this attribute exceeds dot11CMMGMax-
        NTxChainsImplemented, in which case the maximum number of transmit chains
        that are activated within this device is equal to
        dot11CMMGMaxNTxChainsImplemented."
```

```
    DEFVAL { 2147483647}
    ::= { dot11PhyCMMGEntry 12 }

-- ****************************************************************
-- * End of dot11 PHY CMMG TABLE
-- ****************************************************************
```

Insert the following tables ("dot11CDMGOperation TABLE") and ("dot11CMMGOperation TABLE") after the "dot11BSSStatisticsTable" section in C.3:

```
-- ****************************************************************
-- * dot11CDMGOperation TABLE
-- ****************************************************************

dot11CDMGOperationTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Dot11CDMGOperationEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "This is a Table management object.
         The dot11CDMGOperation Table"
    ::= { dot11mac 11}

dot11CDMGOperationEntry OBJECT-TYPE
    SYNTAX Dot11CDMGOperationEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "This is an entry in the dot11CDMGOperation Table.
        ifIndex - Each IEEE Std 802.11 interface is represented by an
        ifEntry.  Interface tables in this MIB module are indexed
        by ifIndex."
    INDEX { ifIndex }
    ::= { dot11CDMGOperationTable 1 }

Dot11CDMGOperationEntry ::=
    SEQUENCE {
        dot11DCSTimeout                                         Unsigned32,
        }

dot11DCSTimeout OBJECT-TYPE
    SYNTAX Unsigned32 (1..64000)
    UNITS "milliseconds"
    MAX-ACCESS read-write
    STATUS current
    DESCRIPTION
        "This is a control variable.
        It is written by the SME or an external management entity.
        Changes take effect as soon as practical in the implementation.

        Dynamic channel selection timeout (in milliseconds)"
    DEFVAL { 1000 }
    ::= { dot11CDMGOperationEntry 1 }

-- ****************************************************************
-- * End of dot11CDMGOperation TABLE
-- ****************************************************************
```

Insert the following groups at the end of the "Groups - units of compliance - RSN" section in C.3:

```
dot11CDMGComplianceGroup OBJECT-GROUP
    OBJECTS {
        dot11CDMGOptionImplemented,
        dot11DynamicChannelTransferImplemented,
```

```
        dot11DynamicChannelTransferActivated,
        dot11OpportunisticTransmissionsActivated,
        dot11CDMGSpatialsharingActivated,
        dot11CDMGClusteringActivated
        }
    STATUS current
    DESCRIPTION
        "Attributes that configure the CDMG Group for IEEE Std 802.11."
    ::= { dot11Groups 95}

dot11CDMGOperationsComplianceGroup OBJECT-GROUP
    OBJECTS {dot11DCSTimeout}
    STATUS current
    DESCRIPTION
        "Attributes that configure the CDMG Operation for IEEE Std 802.11."
    ::= { dot11Groups 96}

dot11CMMGComplianceGroup OBJECT-GROUP
    OBJECTS {
        dot11CMMGOptionImplemented,
        dot11CMMGClusteringActivated
        }
    STATUS current
    DESCRIPTION
        "Attributes that configure the CMMG Group for IEEE Std 802.11."
    ::= { dot11Groups 97}
```

In the "dot11Compliance" module of the "Compliance Statements" section of C.3,

— insert the following text:

```
dot11CDMGComplianceGroup
dot11CMMGComplianceGroup
```

— as the last two lines for the description of mutually exclusive groups for the following groups:

```
dot11PhyDSSSCoplianceGroup
dot11PhyOFDMComplianceGroup3
dot11PhyHRDSSSComplianceGroup
dot11PhyERPComplianceGroup
dot11PhyHTComplianceGroup
dot11PhyVHTComplianceGroup
dot11PhyTVHTComplianceGroup
dot11PhyS1GComplianceGroup
dot11DMGComplianceGroup
```

Insert the following groups after the "GROUP dot11FILSComplianceGroup" of the "Compliance Statements" section of C.3:

```
GROUP dot11CDMGComplianceGroup
    DESCRIPTION
        "Implementation of this group is required when the object
        dot11PHYType has the value of CDMG.
        This group is mutually exclusive to the following groups:
        dot11PhyDSSSComplianceGroup
        dot11PhyOFDMComplianceGroup3
        dot11PhyHRDSSSComplianceGroup
        dot11PhyERPComplianceGroup
        dot11PhyHTComplianceGroup
        dot11PhyVHTComplianceGroup
        dot11PhyTVHTComplianceGroup
        dot11PhyDMGComplianceGroup
```

```
        dot11PhyCMMGComplianceGroup"

GROUP dot11CDMGOperationsComplianceGroup
    DESCRIPTION
        "CDMG Operations Compliance Group"

GROUP dot11CMMGComplianceGroup
    DESCRIPTION
        "Implementation of this group is required when the object
        dot11PHYType has the value of CDMG.
        This group is mutually exclusive to the following groups:
        dot11PhyDSSSComplianceGroup
        dot11PhyOFDMComplianceGroup3
        dot11PhyHRDSSSComplianceGroup
        dot11PhyERPComplianceGroup
        dot11PhyHTComplianceGroup
        dot11PhyVHTComplianceGroup
        dot11PhyTVHTComplianceGroup
        dot11PhyDMGComplianceGroup
        dot11PhyCDMGComplianceGroup"

GROUP dot11CMMGOperationsComplianceGroup
    DESCRIPTION
        "CMMG Operations Compliance Group"
```

Insert the following compliance statements “Compliance Statements – CDMG” and “Compliance Statements – CMMG” at the end of the “Compliance Statements” part in C.3:

```
-- ******************************************************************
-- * Compliance Statements - CDMG
-- ******************************************************************

dot11CDMGCompliance MODULE-COMPLIANCE
    STATUS current
    DESCRIPTION
        "The compliance statement for SNMPv2 entities that implement the IEEE Std
        802.11 MIB for CDMG operation."
        MODULE -- this module
    MANDATORY-GROUPS {
        dot11CDMGComplianceGroup,
        dot11CDMGOperationsComplianceGroup}
    ::= { dot11Compliances 18}

-- ******************************************************************
-- * Compliance Statements - CMMG
-- ******************************************************************

dot11CMMGCompliance MODULE-COMPLIANCE
    STATUS current
    DESCRIPTION
        "The compliance statement for SNMPv2 entities that implement the IEEE Std
        802.11 MIB for CMMG operation."
        MODULE -- this module
    MANDATORY-GROUPS {
        dot11CMMGComplianceGroup,
        dot11CMMGOperationsComplianceGroup}
    ::= { dot11Compliances 19}

-- ******************************************************************
-- * End of 802.11 MIB
-- ******************************************************************
```

Annex E

(normative)

Country elements and operating classes

E.1 Country information and operating classes

Insert the following rows into Table E-5, and adjust the Reserved row accordingly:

Table E-5—Operating classes in China

Operating class	Global operating class (see Table E-4)	Channel starting frequency (GHz)	Channel spacing (MHz)	Channel set	Channel center frequency index	Behavior limits set
10	180	56.16	2160	2,3	—	—
11		56.70	1080	35,36,37,38	—	—
12		42.66	540	1,2,3,4,5,6, 7,8	—	LicenseExemptBehavior
13		47.52	540	9,10	—	LicenseExemptBehavior
14		42.93	1080	11,12,13,14	—	LicenseExemptBehavior
15		47.79	1080	15	—	LicenseExemptBehavior

Insert the following text, Annex W, after Annex V:

Annex W

(informative)

Informative procedures for CDMG STAs

W.1 Selection of candidate SPs for spatial sharing

An AP or PCP uses the SSW Report element (9.4.2.220) to construct a beamforming training table. Based on the beamforming training table, the AP or PCP selects a pair of existing SP and candidate SP to perform spatial sharing according to the procedures described in 11.32.

Each entry of the beamforming training table has three items: source AID, destination AID, and the best sector for transmitting from source STA to destination STA. The AP or PCP stores the beamforming training results between any pair of STAs among its BSS. If a source STA and a destination STA have not performed beamforming training, the best sector item is typically given a default sector number.

The select condition is that any source STA involved in an existing SP does not employ the same transmit sector with the one that it employs to communicate with any other STA involved in a candidate SP, and vice versa. If a pair of existing SP and candidate SP satisfies the above condition, the AP or PCP schedules the existing SP and the candidate SP time-overlapping with each other for spatial sharing.

For the same existing SP, if more than one candidate SP satisfy the above condition, the AP or PCP selects the SP with the largest number of difference between any two of transmit sectors employed by a source STA to communicate with its destination STA and with any other STA involved in the other SP.

W.2 N-phase beamforming codebook for CDMG STAs

W.2.1 General

This annex puts forward a method for *N*-phase beamforming codebook design, which is applicable to CDMG STAs only. The codebook cannot only be used in the multi-beam switching system, but also be applied to 1-D (dimensional) uniform linear phased antenna array and 2-D (dimensional) uniform phased antenna array. The STA can simply choose this beamforming codebook for directional transmission during communication.

W.2.2 1-D (dimensional) antenna array

As to the 1-D uniform linear antenna array, all antenna array elements linearly distribute with the interval of $\lambda/2$ while λ denotes the carrier's wavelength. The beam codebook is a data matrix **W,** and each element of **W** defines the corresponding antenna array element's weights. For phased antenna array, the weights define the phase misalignment, so the element $w_{m,k}$ of **W** satisfies $|w_{m,k}|=1$. Equation (W-1) gives an example of a beam codebook matrix, among which M denotes the number of antenna elements and K denotes the numbers of beam patterns. Each column of the codebook matrix specifies a certain beam pattern, and all columns cover the whole space together. The columns of **W** number from 0.

$$\boldsymbol{W}_{M \times K} = \begin{bmatrix} 1 & j & \ldots & 1 \\ 1 & j & \ldots & j \\ \ldots & \ldots & \ldots & \ldots \\ 1 & j & \ldots & 1 \end{bmatrix}_{M \times K} \tag{W-1}$$

Figure W-1 shows an arrange mode of 1-D uniform linear antenna array.

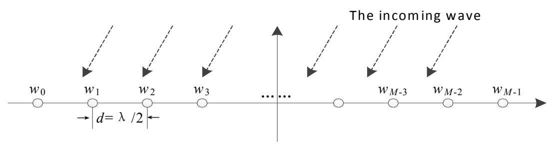


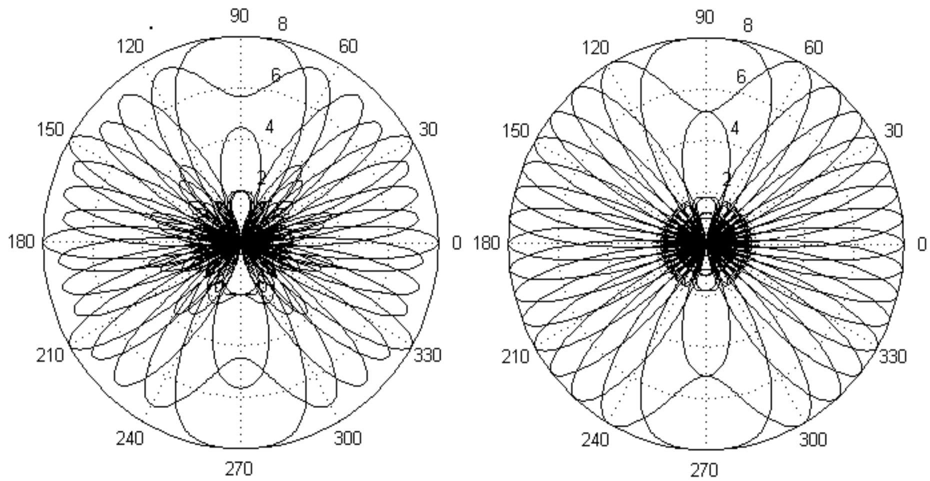
Figure W-1—An arrange mode of 1-D uniform linear antenna array

N-phase beam codebook is shown in Equation (W-2). The matrix's element of line m and column k denotes the antenna weight for the m^{th} antenna element of the k th beam. K is the number of beams, and M is the number of antenna elements. The function fix(x) returns the biggest integer that is less than or equal to x. The modulo arithmetic function mod(x, y) is defined as mod(x, y) = x - y × fix(x/y). N denotes the number of discrete phases, and the size of N is free while each beam gain's loss generated by the codebook is smaller with the increase of N. Generally, N satisfies $N \geq 4$ (i.e., at least 2bit discrete phases) to obtain the beam codebook's performance gain. Meanwhile, N also satisfies $N \leq 2M$ for no more performance gain is acquired when N>2M.

$$W(m, k) = e^{j\frac{2\pi}{N}\mathrm{fix}\left(\frac{m \times \mathrm{mod}(k + K/2, K)}{K/N}\right)} \tag{W-2}$$

$$m = 0, 1, \ldots, M - 1; \; k = 0, 1, \ldots$$

Figure W-2 shows the codebook's beam patterns when m=8 and k=16. Figure W-2(a) shows the beam patterns when N=4, and Figure W-2(b) shows the beam patterns when N=16.



(a) (b)

Figure W-2—Beam patterns generated by the codebook

W.2.3 2-D (dimensional) antenna array

A beam of 2-D linear antenna array is made up of two mutually perpendicular 1-D uniform linear antenna arrays. Figure W-3 shows an arrange mode of 2-D uniform linear antenna array. The antenna elements are arranged in the mutually perpendicular directions of x and z, and the antenna elements' number in the direction of x is M_x with the spacing of d_x while the antenna elements' number in the direction of z is M_z with the spacing of d_z.

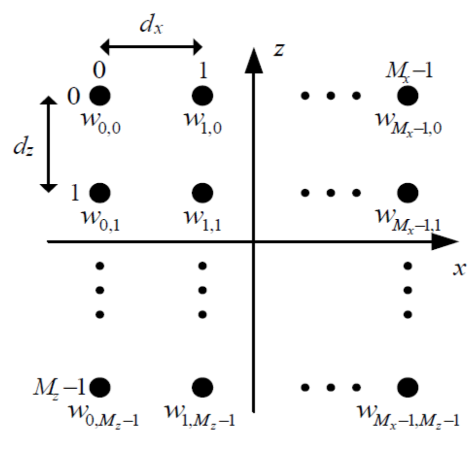


Figure W-3—An arrange mode of 2-D uniform linear antenna array

Each beam pattern of 2-D antenna array is actually superposition of two beam patterns of 1-D antenna array. The weights of antenna elements of 2-D antenna array should be calculated as follows:

$$w_{m_x, m_z} = w_{m_x} w_{m_z};\ \ m_x = 0, 1, \ldots, M_x, m_z = 0, 1, \ldots, M_z \tag{W-3}$$

Among which w_{m_x} and w_{m_z} separately stands for the beam weights of x and z.

W.3 Beam tracking and switching for enhanced beam tracking mechanism

This annex puts forward a method of beam tracking and switching for a CDMG STA pair supporting enhanced beam tracking mechanism to combat link blockage and antenna rotation. After enhanced beam tracking is requested, the e-TRN subfields are transmitted in the end of the PHY frame.

The CDMG STA pair measure the receive signal powers corresponding to the training beam links, including the current transmission link, the neighboring beam links and the current alternative beam link.

The signal power attenuation induced by the link blockage is calculated as the difference value of the power obtained by originally optimal beam link minus maximum power obtained by current transmission and its neighboring beam links. If the signal power attenuation induced by the link blockage is larger than a blockage attenuation threshold, or the power obtained by alternative beam link is larger than the maximum power obtained by current transmission and its neighboring beam links, the link blockage is declared.

If antenna rotation is considered, the signal power attenuation induced by the antenna rotation is calculated as the difference value of maximum power of the current transmission and its neighboring beam links minus the power of the current transmission beam link. If the signal power attenuation induced by the antenna rotation is larger than a predefined rotation attenuation threshold, the antenna rotation is declared, and the rotation compensation angle for the subsequent transmission and alternative beam links is calculated as the difference value of the azimuth of the neighboring beam link that has the maximum signal power minus the azimuth of current transmission beam link.

Finally, according to the switching declaration results and the rotation compensation angle, STAs can switch to the AWV, i.e., azimuth, of the updated alternative beam link to combat link blockage and antenna rotation. Specifically, if the link blockage is declared, the azimuth of the subsequent transmission beam link is to become the azimuth of the current alternative beam link plus the rotation compensation angle, and the azimuth of subsequent alternative beam link is to become the azimuth of the current transmission beam link plus the rotation compensation angle; otherwise, the azimuths of subsequent transmission and alternative beam links are to become their current azimuths plus the rotation compensation angle, respectively.

Consensus

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