IEEE P802.11  
Wireless LANs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Comment resolution for CID 54 | | | | |
| Date: 2017-11-05 | | | | |
| Author(s): | | | | |
| Name | Affiliation | Address | Phone | email |
| Claudio da Silva | Intel |  |  | claudio.da.silva@intel.com |
| Jonathan Kosloff | Intel |  |  |  |
| Carlos Cordeiro | Intel |  |  |  |
| Assaf Kasher | Qualcomm |  |  |  |

Abstract

This submission proposes a resolution to CID 54.

The discussion is in reference to D0.8.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **CID** | **Clause** | **Page** | **Comment** | **Proposed change** |
| 54 | 10.38.9.4.2 | 78.28 | BRP TXSS - when is the change in AWV expected to occur at the initiator | Define when the chagne happens based on the feedgack or the flow in which it is used |

**Discussion**

* As currently defined in the draft, two back-to-back BRP-TXSS procedures can be used to train two STAs that have AWV-level reciprocity (both transmit and receiver settings)



* If one or both STAs do not have AWV-level reciprocity, additional BRP procedures would be necessary depending on the reciprocity characteristics of the STAs.
  + In addition, as noted by the commenter, it is not clear (specification does not define) when the STAs would update their AWVs.
* Proposed flow:



* The responder and initiator of a BRP TXSS start using the AWV configurations identified in the procedure immediately after the transmission of the BRP frame with acknowledgement.
* As defined in the draft, not all phases/training in the BRP TXSS flow are necessary in all cases. Some of them are optional. What determines if a given phase/training is necessary are the reciprocity characteristics of the STAs participating in the procedure.
  + Example 1: Initiator has AWV-level reciprocity, and responder is not reciprocal. In this case,



* + Example 2: Initiator has antenna-level reciprocity, and responder has AWV-level reciprocity. In this case,



* Summary:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Reciprocity characteristics** | | Is Responder BRP TXSS present? | Is receive training of the initiator present? | **Responder BRP TXSS configuration** | | |
| **Initiator** | **Responder** | Does initiator use quasi-omni or directional pattern? | TXSS-PACKETS | TXSS-REPEAT |
| AWV | AWV | No | No | - | - | - |
| AWV | ant | Yes | No | Directional | 0 | 0 |
| AWV | no | Yes | Yes | Quasi-omni | 0 or more | 0 |
| ant | AWV | No | Yes | - | - | - |
| ant | ant | Yes | Yes | Quasi-omni | 0 | 0 |
| ant | no | Yes | Yes | Quasi-omni | 0 or more | 0 |
| no | AWV | No | Yes | - | - | - |
| no | ant | Yes | Yes | Quasi-omni | 0 | 0 or more |
| no | no | Yes | Yes | Quasi-omni | 0 or more | 0 or more |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Reciprocity characteristics** | | **Responder BRP TXSS configuration** | | **RX training of the initiator configuration** | |
| **Initiator** | **Responder** | TX  (sector sweep) | RX | TX | RX  (sector sweep) |
| AWV | AWV | - | - | - | - |
| AWV | ant | Best ant, IBT | Best AWV, IBT | - | - |
| AWV | no | All (impl) | Best ant, IBT | Best AWV, RBT | Best ant, IBT |
| ant | AWV | - | - | Best AWV, RT-Resp | Best ant, IBT |
| ant | ant | Best ant, IBT | Best ant, IBT | Best AWV, RBT | Best ant, IBT |
| ant | no | All (impl) | Best ant, IBT | Best AWV, RBT | Best ant, IBT |
| no | AWV | - | - | Best AWV, RT-Resp | All ants |
| no | ant | Best ant, IBT | All ants (impl) | Best AWV, RBT | Best ant, RBT |
| no | no | All (impl) | All ants (impl) | Best AWV, RBT | Best ant, RBT |

**Key: IBT (Initiator BRP TXSS); RBT (Responder BRP TXSS); RT-Resp (RX training of the responder)**

* Since MIMO BRP TXSS is now used as the SISO phase of SU-MIMO BF, the changes proposed in this document don’t affect this particular flow.

SP: Do you accept the resolution given in 17/1675r0 to CID 54?

*Modify 9.4.2.255 (EDMG BRP Request element) as follows*

* *Modify Figure 51(EDMG BRP Request element format) as follows:*
  + Delete TXSS-RESP-TRN field (1 bit)
  + Delete TXSS-RECIPROCAL field (1 bit)
* *Modify BRP TXSS-related paragraphs as follows:*

The BRP-TXSS field is set to one to indicate either a request to perform BRP TXSS or to acknowledge a request to perform BRP TXSS, as defined in 10.38.9.5. Otherwise, this field is set to zero. When the EDMG BRP Request element is present in a frame, the value of this field overrides the value of the subfield with the same name carried in the BRP Request field.

If the BRP-TXSS field is equal to one, the TXSS-INITIATOR field set to one indicates that the transmitter of the BRP frame is the initiator of a BRP TXSS and the TXSS-INITIATOR field set to zero indicates that the transmitter of the BRP frame is the responder of a BRP TXSS. If the BRP-TXSS field is equal to zero, the TXSS-INITIATOR field is reserved.

If the BRP-TXSS field and the TXSS-INITIATOR are both equal to one, the value in the TXSS-PACKETS fields plus one indicates the number of EDMG BRP-TX packets necessary for the initiator to perform transmit training. If the BRP-TXSS field is equal to one and the TXSS-INITIATOR field is equal to zero, the value in the TXSS-PACKETS fields plus one indicates the number of EDMG BRP-TX packets necessary for the responder to perform transmit training if the procedure includes a Responder BRP TXSS (see 10.38.9.5). If the BRP-TXSS field is equal to one and the TXSS-INITIATOR field is equal to zero, the value in the TXSS-PACKETS fields is equal to zero if the procedure does not include a Responder BRP TXSS. If the BRP-TXSS field is equal to zero, the TXSS-PACKETS field is reserved.

If the BRP-TXSS field and the TXSS-INITIATOR field are both equal to one, the TXSS-REPEAT field plus one indicates the number of times that the EDMG BRP-TX packets transmitted in the Responder BRP TXSS shall be repeated if the BRP TXSS includes a Responder BRP TXSS. If the BRP-TXSS field is equal to one and the TXSS-INITIATOR field is equal to zero, the TXSS-REPEAT field plus one indicates the number of times that the EDMG BRP-TX packets transmitted in the Initiator BRP TXSS shall be repeated. Otherwise, the TXSS-REPEAT field is reserved.

If the BRP-TXSS field and the TXSS-INITIATOR field are both equal to one, the TXSS-MIMO field set to one indicates that the requested BRP TXSS is a MIMO BRP TXSS (see 10.38.9.5) and the TXSS-MIMO field set to zero indicates that the requested BRP TXSS is a SISO BRP TXSS (see 10.38.9.5). If the BRP-TXSS field and the TXSS-INITIATOR field are not both equal to one, the TXSS-MIMO field is reserved.

*Modify 10.38.9.5 (BRP transmit sector sweep (BRP TXSS)) as follows*

10.38.9.5 BRP transmit sector sweep (BRP TXSS)

10.38.9.5.1 General

Beam refinement protocol transmit sector sweep (BRP TXSS) is a procedure which makes use of BRP frames to perform transmit sector sweep and receive training and determine improved antenna configuration for transmission and reception.

In BRP TXSS, the STA that initiates the procedure through the transmission of a BRP frame is referred to as the initiator, and the recipient STA of the BRP frame that participates in a BRP TXSS with the initiator is referred to as the responder.

A BRP TXSS is comprised of a mandatory setup phase, a mandatory transmit training phase by the initiator with feedback, referred to as Initiator BRP TXSS, optional receive training phase of the responder, an optional transmit training phase by the responder with feedback, referred to as Responder BRP TXSS, optional receive training phase of the initiator, and a mandatory acknowledgement phase. An example of BRP TXSS is shown in Figure 94 for the case when the procedure is comprised of all mandatory and optional phases. In Figure 94 and in the remainder of 10.38.9.5, *Ninit* is the value of the TXSS-PACKETS subfield within the EDMG BRP Request element in the BRP frame sent by the initiator to start the BRP TXSS, *Rresp* is the value of the TXSS-REPEAT subfield within the EDMG BRP Request element in the BRP frame sent by the responder to confirm the procedure, *Nresp* is the value of the TXSS-PACKETS subfield within the EDMG BRP Request element in the BRP frame sent by the responder to confirm the procedure, and *Rinit* is the value of the TXSS-REPEAT subfield within the EDMG BRP Request element in the BRP frame sent by the initiator to start the BRP TXSS.



Figure 94 — Example of BRP TXSS

As shown in Figure 94 and as defined in 10.38.9.5.3, the setup phase consists of the transmission of a BRP frame that requests transmit training by the initiator followed by the transmission of a BRP frame that confirms the procedure by the responder. After receiving confirmation of the BRP TXSS request from the responder, the initiator performs an Initiator BRP TXSS. As defined in 10.38.9.5.2, in an Initiator BRP TXSS the initiator transmits *Ninit* + 1 EDMG BRP-TX packets consecutively Rresp + 1 times, and the same DMG antenna or set of DMG antennas is used by the responder when receiving the TRN field of all *Ninit* +1 EDMG BRP-TX packets within one of the *Rresp* + 1 repetitions. The feedback sent by the responder within the Initiator BRP TXSS consists of a BRP frame with feedback of the measurements it performed during the reception of EDMG BRP-TX packets. If receive training of the responder is included in the procedure, the TRN field of the EDMG BRP-RX packet sent immediately after the Initiator BRP TXSS is transmitted by the initiator and received by the responder using antenna configurations determined in the preceding Initiator BRP TXSS. In a Responder BRP TXSS, if present, the responder transmits *Nresp* + 1 EDMG BRP-TX packets consecutively *Rinit* + 1 times, and the same DMG antenna or set of DMG antennas is used by the initiator when receiving the TRN field of all *Nresp* +1 EDMG BRP-TX packets within one of the *Rinit* +1 repetitions. The feedback sent by the initiator within the Responder BRP TXSS consists of a BRP frame with feedback of the measurements it performed during the reception of EDMG BRP-TX packets transmitted by the responder. If receive training of the initiator is included in the procedure, the TRN field of the one or more EDMG BRP-RX packets sent immediately after the Responder BRP TXSS are transmitted by the responder and received by the initiator using antenna configurations determined in the preceding phases of the procedure. The BRP TXSS is concluded with the transmission of a BRP frame with acknowledgement.

As defined in 10.38.9.5.2, if the BRP frames used in a BRP TXSS are sent with a single transmit chain, the TRN field of EDMG BRP-TX and EDMG BRP-RX packets sent in the procedure may be transmitted with a different DMG antenna than the one used in the setup phase. Also, the TRN field of EDMG BRP-TX and EDMG BRP-RX packets used in the procedure may be received with a DMG antenna that is not the same one used in the setup phase.

If both initiator and responder of a BRP TXSS are SU-MIMO capable (as defined in 10.38.9.2.3.1), EDMG BRP-TX packets used in a BRP TXSS may be sent using multiple transmit chains simultaneously. As described in 10.38.9.2.3, the procedure in this case corresponds to the SISO phase of SU-MIMO beamforming training, and the MIMO phase of SU-MIMO beamforming training shall be performed after completion of the BRP TXSS.

As defined in 30.9.2.2.2, the TRN field in EDMG BRP packets sent as part of BRP TXSS is transmitted over the entire channel bandwidth. Therefore, the BRP TXSS allows for transmit sector sweep over the entire channel bandwidth when the initiator and responder operate on a 4.32 GHz, 6.48 GHz, or 8.64 GHz channel.

10.38.9.5.2 BRP TXSS configuration

10.38.9.5.2.1 General

A SISO BRP TXSS is a BRP TXSS in which EDMG BRP-TX packets used in the procedure are transmitted using a single transmit chain. A MIMO BRP TXSS is a BRP TXSS in which EDMG BRP-TX packets used in the procedure are transmitted using multiple transmit chains.

10.38.9.5.2.2 SISO BRP TXSS configuration

BRP frames transmitted in a BRP TXSS during the setup phase, with feedback within an Initiator BRP TXSS and a Responder BRP TXSS, and with acknowledgement at the end of the procedure shall be transmitted and received with the same DMG antennas and AWVs used in the setup phase. Also, these frames shall not include a TRN field.

All fields except for the TRN field of EDMG BRP-TX and EDMG BRP-RX packets used in SISO BRP TXSS shall be transmitted with the same DMG antenna and AWV used in the setup phase. The TRN field of EDMG BRP-TX and EDMG BRP-RX packets used in SISO BRP TXSS may be transmitted with a different DMG antenna than the one used in the transmission of the remaining fields of the same packet.

All fields of EDMG BRP-TX and EDMG BRP-RX packets used in SISO BRP TXSS except for the TRN field shall be received with the same DMG antenna and AWV used in the setup phase. The TRN field of EDMG BRP-TX and EDMG BRP-RX packets used in SISO BRP TXSS may be received with a DMG antenna that is not the same one used in the reception of the remaining fields of the same packet.

The Initiator BRP TXSS shall consist of the transmission of + 1 EDMG BRP-TX packets consecutively repeated *Rresp* + 1 times by the initiator followed by the transmission of a BRP frame with feedback by the responder. The EDMG BRP-TX packets transmitted in an Initiator BRP TXSS shall be configured as follows:

* The TRN-Unit RX Pattern field in the EDMG-Header-A shall be set to 1;
* The EDMG-Header-A of the *ith* EDMG BRP-TX packet within each of the *Rresp* + 1 repetitions, where , shall have the same value for the fields EDMG TRN Length, EDMG TRN-Unit P, EDMG TRN-Unit M and EDMG TRN-Unit N;
* The TRN subfields of the *ith* EDMG BRP-TX packet within each of the *Rresp* + 1 repetitions, where , shall be transmitted using the same DMG antenna and the same AWVs; and
* The DMG antenna used when transmitting the TRN field of the *Ninit* + 1 EDMG BRP-TX packets within one of the *Rresp* + 1 repetitions in an Initiator BRP TXSS should be different.

Similarly, the Responder BRP TXSS, if present, shall consist of the transmission of *Nresp* +1 EDMG BRP-TX packets consecutively repeated *Rinit* + 1 times by the responder followed by the transmission of a BRP frame with feedback by the initiator. The EDMG BRP-TX packets transmitted in a Responder BRP TXSS shall be configured as follows:

* The value of the TRN-Unit RX Pattern field in the EDMG-Header-A shall be set according to the Antenna Pattern Reciprocity and the DMG Antenna Reciprocity subfields within the DMG STA Capability Information field of both initiator and responder, as defined in 10.38.9.5.2.1.1;
* The EDMG-Header-A of the *ith* EDMG BRP-TX packet within each of the *Rinit* + 1 repetitions, where , shall have the same value for the fields EDMG TRN Length, EDMG TRN-Unit P, EDMG TRN-Unit M and EDMG TRN-Unit N;
* The TRN subfields of the *ith* EDMG BRP-TX packet within each of the *Rinit* + 1 repetitions, where , shall be transmitted using the same DMG antenna and the same AWVs; and
* The DMG antenna used when transmitting the TRN field of the *Nresp* + 1 EDMG BRP-TX packets within one of the *Rinit* + 1 repetitions in a Responder BRP TXSS should be different.

In both Initiator BRP TXSS and Responder BRP TXSS, the DMG antenna or set of DMG antennas used when receiving the TRN subfields of EDMG BRP-TX packets of different repetitions should be different.

Receive training of the responder after the Initiator BRP TXSS is mandatory in SISO BRP TXSS, and it consists of the transmission of one EDMG BRP-RX packet by the initiator that allows for the responder to determine its receive configuration for the transmit configuration determined in the preceding Initiator BRP TXSS. The TRN field of the EDMG BRP-RX packet used for receive training of the responder,

* Shall be transmitted with the best AWV identified in the preceding Initiator BRP TXSS.
* Shall be received with the DMG antenna corresponding to the best AWV configuration identified in the preceding Initiator BRP TXSS.
* The length of the TRN field shall be equal to the value of the L-RX field requested by the responder in the BRP frame sent to confirm the procedure.

Receive training of the initiator shall be performed if the value of the L-RX field in the BRP frame sent by the initiator to start the BRP TXSS is greater than 0. If the L-RX field in the BRP frame sent to start the BRP TXSS is equal to 0, receive training of the initiator is not performed. Receive training of the initiator consists of the transmission of one or more EDMG BRP-RX packets by the responder that allows for the initiator to determine its receive configuration for the transmit configuration determined of the responder. The TRN field of the EDMG BRP-RX packets used for receive training of the initiator,

* Shall be transmitted with the best AWV identified in the preceding Responder BRP TXSS or in the receive training of the responder, as defined in 10.38.9.5.2.1.1.
* Shall be received with the DMG antenna corresponding to the best AWV identified in the Responder BRP TXSS or in the Initiator BRP TXSS, or with multiple DMG antennas, as defined in 10.38.9.5.2.1.1.
* The length of the TRN field shall be equal to the value of the L-RX field requested by the initiator in the BRP frame sent to start the procedure.

An example of a BRP TXSS is shown in Figure 95 for a scenario in which the initiator has two DMG antennas, the responder has three DMG antennas, and both the initiator and responder use one DMG antenna when performing measurements. It is assumed in this example that the best AWV configuration identified in the Initiator BRP TXSS was obtained when the initiator used DMG antenna 0 and the responder used DMG antenna 1, and that the best AWV configuration identified in the Responder BRP TXSS was obtained when the responder used DMG antenna 2 and the initiator used DMG antenna 0. If the responder in this example was capable of processing all of its antennas simultaneously, the duration of the BRP TXSS could be shortened as shown in Figure 96.



Figure 95 — Example of BRP TXSS



Figure 96 — Example of BRP TXSS

The first TRN-Unit in an EDMG BRP packet used in a SISO BRP TXSS may be used for the initiator and responder to switch DMG antennas and shall not be processed by the receiver. Therefore, EDMG BRP-TX and EDMG BRP-RX packets transmitted during SISO BRP TXSS, the value of the TXVECTOR parameter EDMG\_TRN\_LEN shall be set to *k* + 1, where *k* is the number of TRN-Units used for transmit or receive training. The TRN subfields that comprise the first TRN-Unit in EDMG BRP-TX packets used as part of a BRP TXSS shall not be included in the TRN subfield and AWV feedback ID indexing procedures described in 30.9.2.2.5.

When transmitting an EDMG BRP-TX packet or an EDMG BRP-RX packet as part of a SISO BRP TXSS, an EDMG STA may change the DMG antenna used in the transmission of its TRN field during the first TRN-Unit and shall not change DMG antenna during the remaining TRN-Units.

When receiving an EDMG BRP-TX packet or an EDMG BRP-RX packet as part of SISO BRP TXSS, an EDMG STA may change the DMG antenna used in the reception of the TRN field during the first TRN-Unit and shall not change DMG antenna during the remaining TRN-Units.

For EDMG BRP-TX packets used in a BRP TXSS, the AWV used in the transmission of the first P TRN subfields of each TRN-Unit depends on whether the DMG antenna used in the transmission of an EDMG BRP-TX packet changes at the beginning of the TRN field. As defined in 30.9.2.2.5, if the TRN field of an EDMG BRP-TX packet is transmitted with the same DMG antenna as the remaining fields of the packet, the first P TRN subfields of each TRN-Unit shall be transmitted using the same AWV as the remaining fields of the packet. If the DMG antenna used in the transmission of an EDMG BRP-TX packet changes at the beginning of the TRN field, the AWV used in the transmission of the first P TRN subfields of each TRN-Unit shall be selected in an implementation dependent manner and should be the same for all TRN-Units.

**10.38.9.5.2.1.1 Reciprocity and SISO BRP TXSS configuration**

A SISO BRP TXSS shall not include a Responder BRP TXSS if the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the responder is equal to 1. A SISO BRP TXSS procedure shall include a Responder BRP TXSS in all other cases.

If the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the initiator is equal to 1 and the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the responder is equal to 1,

* The TXSS-REPEAT field in the EDMG BRP Request element within the BRP frame sent by the initiator to start the BRP TXSS shall be set to 0;
* The L-RX field in the EDMG BRP Request element within the BRP frame sent by the initiator to start the BRP TXSS shall be set to 0;
* The TRN-Unit RX Pattern field in the EDMG-Header-A of EDMG BRP-TX packets used in the Responder BRP TXSS shall be set to 0; and
* The TRN field of the EDMG BRP-TX packets used in the Responder BRP TXSS shall be received with the RX AWV configuration corresponding to the best AWV configuration identified in the Initiator BRP TXSS.

If the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the initiator is equal to 1 and the Antenna Pattern Reciprocity subfield and the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the responder are both equal to 0,

* The TXSS-REPEAT field in the EDMG BRP Request element within the BRP frame sent by the initiator to start the BRP TXSS shall be set to 0;
* The L-RX field in the EDMG BRP Request element within the BRP frame sent by the initiator to start the BRP TXSS shall be set to a value greater than 0;
* The TRN-Unit RX Pattern field in the EDMG-Header-A of EDMG BRP-TX packets used in the Responder BRP TXSS shall be set to 1; and
* The TRN field of the EDMG BRP-TX packets used in the Responder BRP TXSS shall be received with the DMG antenna corresponding to the best AWV configuration identified in the Initiator BRP TXSS.

If the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the initiator is equal to 1 and the SISO BRP TXSS includes a Responder BRP TXSS,

* The TXSS-REPEAT field in the EDMG BRP Request element within the BRP frame sent by the initiator to start the BRP TXSS shall be set to 0;
* The L-RX field in the EDMG BRP Request element within the BRP frame sent by the initiator to start the BRP TXSS shall be set to a value greater than 0;
* The TRN-Unit RX Pattern field in the EDMG-Header-A of EDMG BRP-TX packets used in the Responder BRP TXSS shall be set to 1; and
* The TRN field of the EDMG BRP-TX packets used in the Responder BRP TXSS shall be received with the DMG antenna corresponding to the best AWV configuration identified in the Initiator BRP TXSS.

If the Antenna Pattern Reciprocity subfield and the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the initiator are both equal to 0 and the SISO BRP TXSS includes a Responder BRP TXSS,

* The TXSS-REPEAT field in the EDMG BRP Request element within the BRP frame sent by the initiator to start the BRP TXSS may be set to a value greater than 0;
* The L-RX field in the EDMG BRP Request element within the BRP frame sent by the initiator to start the BRP TXSS shall be set to a value greater than 0; and
* The TRN-Unit RX Pattern field in the EDMG-Header-A of EDMG BRP-TX packets used in the Responder BRP TXSS shall be set to 1.

If the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the initiator and the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the responder are both equal to 1, the L-RX field in the EDMG BRP Request element within the BRP frame sent by the initiator to start the BRP TXSS shall be set to 0.

If the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the initiator and the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the responder are both equal to 1, the L-RX field in the EDMG BRP Request element within the BRP frame sent by the initiator to start the BRP TXSS shall be set to a value greater than 0.

If the Antenna Pattern Reciprocity subfield and the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the initiator are both equal to 0 and the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the responder is equal to 1, the L-RX field in the EDMG BRP Request element within the BRP frame sent by the initiator to start the BRP TXSS shall be set to a value greater than 0.

If the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the responder is equal to 1,

* The TXSS-PACKETS field in the EDMG BRP Request element within the BRP frame sent by the responder to acknowledge the BRP TXSS request shall be set to 0; and
* The TRN field of the EDMG BRP-TX packets used in the Responder BRP TXSS shall be transmitted using the DMG antenna corresponding to the best AWV configuration identified in the Initiator BRP TXSS.

If the Antenna Pattern Reciprocity subfield and the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the responder are both equal to 0, the TXSS-PACKETS field in the EDMG BRP Request element within the BRP frame sent by the responder to acknowledge the BRP TXSS request may be set to a value greater than 0.

If the Antenna Pattern Reciprocity subfield and the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the initiator are both equal to 0 and the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the responder is equal to 1, the receive training of the initiator consist of the transmission of *Rinit* + 1 EDMG BRP-RX packets. For all other cases, the receive training of the initiator consists of the transmission of one EDMG BRP-RX packet.

If the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the initiator is equal to 1, the EDMG BRP-RX packet sent in the receive training of the initiator is received using the DMG antenna corresponding to the best AWV configuration identified in the Initiator BRP TXSS.

If the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the initiator is equal to 1 and the Antenna Pattern Reciprocity subfield and the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the responder are both equal to 0, the EDMG BRP-RX packet sent in the receive training of the initiator is received using the DMG antenna corresponding to the best AWV configuration identified in the Initiator BRP TXSS.

If the Antenna Pattern Reciprocity subfield and the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the initiator are both equal to 0 and the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the responder is equal to 0, the EDMG BRP-RX packet sent in the receive training of the initiator is received using the DMG antenna corresponding to the best AWV configuration identified in the Responder BRP TXSS.

The AWV configuration used in the transmission of the TRN field of the one or more EDMG BRP-RX packets by the responder corresponds to the best AWV configuration identified in the receive training for the responder for the following cases

* If the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the initiator is equal to 1 and the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the responder is equal to 1; and
* If the Antenna Pattern Reciprocity and the DMG Antenna Reciprocity subfields in the DMG STA Capability Information field of the initiator are both equal to 0 and the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the responder is equal to 1.

The AWV configuration used in the transmission of the TRN field of the one or more EDMG BRP-RX packets by the responder corresponds to the best AWV configuration identified in the Responder BRP TXSS for the following cases

* If the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the initiator is equal to 1 and the Antenna Pattern Reciprocity subfield and the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the responder are both equal to 0;
* If the DMG Antenna Reciprocity subfield in the DMG STA Capability Information fields of the initiator and responder are both equal to 1;
* If the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the initiator is equal to 1, and the Antenna Pattern Reciprocity and the DMG Antenna Reciprocity subfields in the DMG STA Capability Information field of the responder are both equal to 0;
* If the Antenna Pattern Reciprocity and the DMG Antenna Reciprocity subfields in the DMG STA Capability Information field of the initiator are both equal to 0 and the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the responder is equal to 1; and
* If the Antenna Pattern Reciprocity and the DMG Antenna Reciprocity subfields in the DMG STA Capability Information field of the responder and the initiator are both equal to 0.

The examples given in Figures 95 and 96 correspond to a scenario in which the Antenna Pattern Reciprocity subfield and the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field are both equal to 0 for both the initiator and the responder.

An example BRP TXSS for the case when the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the initiator is set to 1, and the Antenna Pattern Reciprocity subfield and the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the responder are both equal to 0 is shown in Figure 97.



**Figure 97—Example of BRP TXSS**

An example BRP TXSS for the case when the DMG Antenna Reciprocity subfield in the DMG STA Capability Information field of the initiator is set to 1, and the Antenna Pattern Reciprocity subfield in the DMG STA Capability Information field of the responder is equal to 1 is shown in Figure 98.



**Figure 98—Example of BRP TXSS**

10.38.9.5.2.3 MIMO BRP TXSS configuration

Receive training of the responder and receive training of the initiator shall not be performed in a MIMO BRP TXSS procedure. The L-RX field within the EDMG BRP Request element in the BRP frames transmitted during the setup phase of a MIMO BRP TXSS shall be set to zero.

Responder BRP TXSS is mandatory in MIMO BRP TXSS.

All fields of EDMG BRP-TX packets used in MIMO BRP TXSS shall be transmitted with all transmit chains of the transmitter and use an EDMG PPDU defined for MIMO transmission. The TRN field of EDMG BRP-TX packets used in MIMO BRP TXSS shall consist of *N* orthogonal waveforms, where *N* is the number of transmit chains used in the transmission of the packet, as defined in 30.9.2.

A STA that is part of a MIMO BRP TXSS and that receives EDMG BRP-TX packets shall perform channel measurements using all of its DMG antennas simultaneously and provide feedback for each of its DMG antennas, as defined in 10.38.9.5.4.

The TRN-Unit RX Pattern field in the EDMG-Header-A of an EDMG BRP-TX packet used in MIMO BRP TXSS shall be set to 1.

For EDMG BRP-TX packets transmitted in a MIMO BRP TXSS, the value of the TXVECTOR parameter EDMG\_TRN\_LEN shall be set to *k*, where *k* is the number of TRN-Units used in the transmit training.

10.38.9.5.3 BRP TXSS execution

A BRP TXSS shall complete within the CBAP or SP in which it was initiated.

The FBCK-REQ subfield in the DMG Beam Refinement element carried within the BRP frame that initiates a BRP TXSS shall be set to 10001 (binary).

To request a BRP TXSS, the initiator sends a BRP frame with the BRP-TXSS field and the TXSS-INITIATOR field within the EDMG BRP Request element both set to one and the TXSS-PACKETS field set to indicate the number of EDMG BRP-TX packets necessary for the initiator to perform transmit training. To confirm the BRP TXSS execution, the responder shall respond with a BRP frame MBIFS interval after the reception of the BRP frame sent by the initiator with the BRP-TXSS field within the EDMG BRP Request element set to one, the TXSS-INITIATOR field set to zero, and the TXSS-REPEAT field set to indicate the number of requested repetitions of the EDMG BRP-TX packets sent by the initiator.

If the procedure includes a Responder BRP TXSS, the TXSS-REPEAT field in the BRP frame sent by the initiator shall be set to indicate the number of requested repetitions of the EDMG BRP-TX packets sent by the responder, and the TXSS-PACKETS field in the BRP frame sent by the responder shall be set to indicate the number of EDMG BRP-TX packets necessary for the responder to perform transmit training. If the procedure does not include a Responder BRP TXSS, the TXSS-REPEAT field in the BRP frame sent by the initiator shall be set to zero and the TXSS-PACKETS field in the BRP frame sent by the responder shall be set to zero.

The TXSS-MIMO subfield in the EDMG BRP Request element of the BRP frame that initiates the BRP TXSS shall be set to 1 when the procedure is a MIMO BRP TXSS. If the procedure is a SISO BRP TXSS, the TXSS-MIMO subfield shall be set to 0. Both initiator and responder of a BRP TXSS shall be SU-MIMO capable (as defined in 10.38.9.2.3.1) for the TXSS-MIMO subfield to be set to 1.

The initiator shall transmit the first EDMG BRP-TX packet MBIFS interval after the reception of the BRP frame sent by the responder confirming the BRP TXSS execution.

The EDMG BRP-TX packets sent by the initiator in a BRP TXSS procedure shall be separated by SIFS interval. The responder shall then send a BRP frame to the initiator containing feedback based on measurements it performed during the Initiator BRP TXSS. The BRP frame with feedback transmitted by the responder is separated from the last EDMG BRP-TX packet transmitted by the initiator by an MBIFS interval.

A BRP frame with feedback transmitted in a BRP TXSS shall have the SNR Present subfield within the FBCK-TYPE field set to 1, the Sector ID Order subfield set to 1, the EDMG Extension Flag set to 1 and the EDMG Channel Measurement Present set to 1. In the EDMG Sector ID Order subfield the SISO IDs indicate the AWV IDs, TX antennas and RX Antennas of Sectors that were received in the last BRP TXSS. The SNRs subfield in the Channel Measurement Feedback indicates the SNRs with which these sectors have been received. The BRP-CDOWNs associated with each SISO ID indicate the BRP-CDOWN of the packet in which the sector has been received.

In an Initiator BRP TXSS, the BRP CDOWN field within the EDMG BRP Request element in each transmitted EDMG BRP-TX packet shall contain the total number of transmissions remaining until the end of the Initiator BRP TXSS, such that the first EDMG BRP-TX packet transmitted in the Initiator BRP TXSS has the BRP CDOWN field set to (*Ninit* + 1) × (*Rresp* + 1) – 1 and the last packet has the BRP CDOWN field set to 0. The use of BRP CDOWN is illustrated in Figure 95 and Figure 96.

If the BRP TXSS includes receive training of the responder, the initiator shall transmit one EDMG BRP-RX packet MBIFS interval after the reception of the BRP frame sent by the responder with feedback of the Initiator BRP TXSS.

If the procedure includes a Responder BRP TXSS, the responder shall send the first EDMG BRP-TX packet MBIFS after the EDMG BRP-TX packet sent by the initiator or, if receive training of the responder is not performed, the BRP frame with feedback transmitted by the responder within the Initiator BRP TXSS. The EDMG BRP-TX packets sent by the responder in a BRP TXSS procedure shall be separated by SIFS interval.

The BRP CDOWN field within the EDMG BRP Request element in each transmitted EDMG BRP-TX packet shall contain the total number of transmissions remaining until the end of the Responder BRP TXSS, such that the first EDMG BRP-TX packet transmitted in the Responder BRP TXSS has the BRP CDOWN field set to (*Nresp* + 1) × (*Rinit* + 1) – 1, and the last packet has the BRP CDOWN field set to 0.

If the BRP TXSS includes a Responder BRP TXSS, the initiator shall send a BRP frame to the responder containing feedback based on measurements it performed. The BRP frame with feedback transmitted by the initiator is separated from the last EDMG BRP-TX packet transmitted by the responder by an MBIFS interval.

If the BRP TXSS includes receive training of the initiator, the responder shall transmit the first EDMG BRP-RX packet MBIFS interval after the reception of the BRP frame sent by the responder with feedback of the Initiator BRP TXSS or, if Responder BRP TXSS is not performed, of the EDMG BRP-RX packet transmitted by the responder. The EDMG BRP-RX packets sent by the responder shall be separated by SIFS interval.

If the BRP TXSS includes receive training of the initiator, the initiator shall transmit a BRP frame with acknowledgement MBIFS interval after the reception of the last EDMG BRP-RX packet transmitted by the responder if it was successfully received. If the BRP TXSS does not include receive training of the initiator, the responder shall transmit a BRP frame with acknowledgement if the last BRP frame sent by the initiator was successfully received.

In the BRP TXSS procedure, a BRP frame with acknowledgement is defined as a BRP frame that has the TX-TRN-OK field within the DMG Beam refinement element set to 1.

The responder and initiator of a SISO BRP TXSS shall start using the AWV configurations identified in the procedure immediately after the transmission of the BRP frame with acknowledgement.

For a MIMO BRP TXSS procedure, the receiver shall obtain channel measurements during the reception of the transmitted EDMG BRP-TX packets using all of its DMG antennas simultaneously, and provide feedback for each of its DMG antennas, as defined in 10.38.9.5.4.

If the TXSS-MIMO subfield in the EDMG BRP Request element of the BRP frame that initiated the BRP TXSS was set to 1, the initiator shall start the MIMO phase of SU-MIMO beamforming training an MBIFS interval following the completion of the BRP TXSS.

**References:**