### **IEEE P802.11Wireless LANs**

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| PDT for Rx\_OP\_Gain\_Type and Rx\_OP\_Gain\_Index in CSI Report |
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**Revisions**

* R0: Created by Julia Feng based on D0.5 to add Rx\_OP\_Gain\_Type and Rx\_OP\_Gain\_Index
* R1: Modified by Julia Feng on Rx OP index definition. Modified by Julia to add Rui’s changes for Rx gain index definition.
* R2: Editorial changes
* R3: Modified by Julia to move detailed descriptions of Rx\_OP\_Gain\_Index to a newly added section ***Clause 11.55.1.5.4.*** Modified descriptions to resolve comments.
* R4: Modified to clarify definition of Rx\_OP\_Gain\_Type = ‘00’ or ‘11’

R5: Modified PDT in Clause 11.55.1.5.4 to resolve comments.

**Introduction**

This document provides proposed draft text for IEEE 802.11bf D0.5.

The following Motions apply to this PDT:

(Motion 186, 11-22/1254r3) Add fields RX\_OP\_Gain\_Type and Rx\_OP\_Gain\_Index along with CSI in 11bf sub-7GHz sensing measurement report to indicate the Rx OP index or Rx gain index.

* RX\_OP\_Gain\_Type: 2 bits (b1b0)

 • 00: neither Rx OP index nor Rx gain index is reported, and Rx\_OP\_Gain\_Index values are invalid

 • 01: Rx OP index is reported in Rx\_OP\_Gain\_Index. The details of receiver OP categorization method(s) are TBD

 • 10: Rx gain index is reported in Rx\_OP\_Gain\_Index. The details of Rx gain index definition are TBD

 • 11: reserved

 • Note: Receiver determines value of Rx\_OP\_Gain\_Type as it sees the best fit. Rx\_OP\_Gain\_Type value doesn’t change during a sensing measurement setup. No need of capability info to use this field. No need of initiator assigning the use of this field.

* Rx\_OP\_Gain\_Index:

 • It’s a fixed size field, number of bits TBD.

 • Its content depends on the value of RX\_OP\_Gain\_Type

 • Reporting value per receive antenna is TBD



***TGbf editor: Please make the following changes in Clause 9.4.1.75.3:***

* Sensing Measurement Report Control field(Motion 125)

The Sensing Measurement Report Control field provides the information needed to process the Sensing Measurement Report field. The Sensing Measurement Report Control field signals the channel width (CW), the number of transmit antennas (), the number of receive antennas (), the number of bits () used for each encoded CSI value, an indicator () of the subcarrier grouping, and an indicator of reporting receiver operating point (OP) index or gain index (Rx\_OP\_Gain\_Type).

The fields of the Sensing Measurement Report Control field are specified in Table 9-127g (Sensing Measurement Report Control field definition).

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| * Sensing Measurement Report Control field definition
 |
| Field | Size (bits) | Definition | Meaning |
| Report Control Length | 8 | Indicates the number of octets in the Sensing Measurement Report Control field, including the one octet for the Report Control Length subfield | Set to the number of octets in the Sensing Measurement Report Control field. |
| Presence & Control Bitmap | 8 | Includes fields to indicate presence of optional subfields in the Sensing Measurement Report Control field, or other control bits | The fields of the Presence and Control Bitmap field are specified in Figure 9-144m (Presence & Control Bitmap field format) |
| CW | 4 | Channel width | (Encoding of CW subfield is TBD) |
|  | 3 | Indicates the number of transmit antennas | Set to the number of transmit antennas minus 1. |
|  | 3 | Indicates the number of receive antennas | Set to the number of receive antennas minus 1. |
|  | 1 | Indicates the number of bits for each CSI value | Set to 0 for an 8-bit word size. Set to 1 for a 10-bit word size. |
|  | 1 | Indicates the subcarrier grouping setting | Set to 0 to indicate a subcarrier grouping of  if there are less than or equal to four transmit antennas.Set to 0 to indicate a subcarrier grouping of  if there are five or more transmit antennas and the channel width is 80 MHz or less.Set to 0 to indicate a subcarrier grouping  if there are five or more transmit antennas and the channel width is 160 MHz.Set to 1 to indicate a subcarrier grouping of .NOTE:  is optionally supported. |
| Rx\_OP\_Gain\_Type | 2 | Indicates the type of report in Rx\_OP\_Gain\_Index | Set to ‘00’ to indicate neither Rx OP index nor Rx gain index is reported, and value in Rx\_OP\_Gain\_Index field is invalid.Set to ‘01’ to indicate Rx OP index is reported in Rx\_OP\_Gain\_Index.Set to ‘10’ to indicate Rx gain index is reported in Rx\_OP\_Gain\_Index. Set to ‘11’ to indicate this field is reserved, and value in Rx\_OP\_Gain\_Index field is invalid. |
| Reserved | 2 |  |  |

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| --- | --- | --- |
|  | Last SBP Report | Reserved |
| Bits: | 1 | 7 |
| * Presence & Control Bitmap field format
 |

The Last SBP Report field indicates the last SBP report in the current availability window. The Last SBP Report subfield is set to 1 in an SBP Report frame sent in the SBP reporting procedure, if there is no more SBP Report frame to be sent in the current sensing availability window. Otherwise, it is set to 0. This subfield is reserved if sent in a Sensing Measurement Report frame.

Rx\_OP\_Gain\_Type is reported by the sensing receiver to indicate the type of index reported in Rx\_OP\_Gain\_Index field. The same type of index is indicated for all receive antenna, and it can be OP index, gain index, or invalid. The sensing receiver determines the value of Rx\_OP\_Gain\_Type as it sees the best fit based on its implementation. Once set, the sensing receiver won’t change Rx\_OP\_Gain\_Type value during a sensing measurement setup.

***TGbf editor: Please make the following changes in Clause 9.4.1.75.4:***

* Sensing Measurement Report field(Motion 125)

The size of the Sensing Measurement Report field depends on the values in the Sensing Measurement Report Control field. The Sensing Measurement Report field contains a Sensing Measurement Report information or successive portions thereof in the case of segmented sensing measurement report (see 11.55.1.5.3.4 (Rules for generating segmented sensing measurement reports(#294))).

Rx\_OP\_Gain\_Index fields are contained in the Sensing Measurement Report field. The Rx\_OP\_Gain\_Index fields are ordered by receive antenna index. Valid value of each 8-bits Rx\_OP\_Gain\_Index field indicates a receive antenna’s OP index or gain index used to obtain CSIs in this sensing measurement report field depending on the setting of Rx\_OP\_Gain\_Type field in the Sensing Measurement Report Control field (see Table 9-127g (Sensing Measurement Report Control field definition)).

When Rx\_OP\_Gain\_Type field is set to value ‘01’, each Rx\_OP\_Gain\_Index field represents a Rx OP index. The Rx OP index indicates the receiver’s operating point which is determined by severity of receiver’s nonlinearity effects on CSI estimation.

When Rx\_OP\_Gain\_Type field is set to value ‘10’, each Rx\_OP\_Gain\_Index field represents a Rx gain index. The Rx gain index indicates sensing receiver’s RF/analog and digital gains.

When Rx\_OP\_Gain\_Type field is set to value ‘00’ or ‘11’, value in each Rx\_OP\_Gain\_Index field is invalid.

The scaled and quantized CSI values are contained in the Sensing Measurement Report information.

The fields of the Sensing Measurement Report information are specified in Table 9-127h (Sensing Measurement Report information).

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| * Sensing Measurement Report information
 |
| Field | Size (bits) | Meaning |
| Rx\_OP\_Gain\_Index(1) | 8 | Rx OP index for receive Antenna 1 if Rx\_OP\_Gain\_Type = ‘01’;Rx gain index for receive Antenna 1 if Rx\_OP\_Gain\_Type = ‘10’;invalid value if Rx\_OP\_Gain\_Type = ‘00’ or ‘11’ |
| Rx\_OP\_Gain\_Index(2) | 8 | Rx OP index for receive Antenna 2 if Rx\_OP\_Gain\_Type = ‘01’;Rx gain index for receive Antenna 2 if Rx\_OP\_Gain\_Type = ‘10’;invalid value if Rx\_OP\_Gain\_Type = ‘00’ or ‘11’ |
|  |  |  |
| Rx\_OP\_Gain\_Index() | 8 | Rx OP index for receive Antenna if Rx\_OP\_Gain\_Type = ‘01’;Rx gain index for receive Antenna if Rx\_OP\_Gain\_Type = ‘10’;invalid value if Rx\_OP\_Gain\_Type = ‘00’ or ‘11’ |
|  | 12 | Scaling factor for transmit antenna 1 and receive antenna 1. |
|  | 12 | Scaling factor for transmit antenna 1 and receive antenna 2. |
| … | … | … |
|  | 12 | Scaling factor for transmit antenna 1 and receive antenna . |
|  | 12 | Scaling factor for transmit antenna 2 and receive antenna 1. |
|  | 12 | Scaling factor for transmit antenna 2 and receive antenna 2. |
| … | ... | … |
|  | 12 | Scaling factor for transmit antenna 2 and receive antenna . |
| … | ... | … |
|  | 12 | Scaling factor for transmit antenna and receive antenna 1. |
|  | 12 | Scaling factor for transmit antenna and receive antenna 2. |
| … | ... | … |
|  | 12 | Scaling factor for transmit antenna and receive antenna . |
| Padding | 0 or 4 | The Padding subfield is used so that the next subfield is aligned on an octet boundary. |
|  |  | CSI for transmit antenna 1 and receive antenna 1, for subcarrier  |
|  |  | CSI for transmit antenna 1 and receive antenna 2, for subcarrier  |
| … | … | … |
|  |  | CSI for transmit antenna 1 and receive antenna , for subcarrier  |
|  |  | CSI for transmit antenna 2 and receive antenna 1, for subcarrier  |
|  |  | CSI for transmit antenna 2 and receive antenna 2, for subcarrier  |
| … | … | … |
|  |  | CSI for transmit antenna 2 and receive antenna , for subcarrier  |
| … | … | … |
|  |  | CSI for transmit antenna  and receive antenna 1, for subcarrier  |
|  |  | CSI for transmit antenna  and receive antenna 2, for subcarrier  |
|  |  | CSI for transmit antenna  and receive antenna , for subcarrier  |

The subcarrier indices for  and  are provided in Table 9-124 (Subcarrier indices for compressed beamforming feedback matrix). The subcarrier indices for a channel width of 160 MHz and  are provided in Table 9-127i (Number of subcarriers as a function of channel width and Ng).

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| * Number of subcarriers as a function of channel width and Ng
 |
| Channel width | Ng | Number of subcarriers |
| 20 MHz | 4 | 64 |
| 16 | 20 |
| 40 MHz | 4 | 122 |
| 16 | 32 |
| 80 MHz | 4 | 250 |
| 16 | 64 |
| 160 MHz | 8 | 252 |
| 16 | 128 |

Since the scaling and quantization is performed for each TX/RX antenna pair, the scaled and quantized CSI values are ordered by TX/RX pair. The set of scaling factors for each TX/RX antenna pair is ordered before CSI values in the Sensing Measurement report field.

For each TX/RX-antenna pair there is a 12-bit positive scaling factor. If there is an odd number of scaling factors, then the set of scaling factors is followed by a 4-bit padding subfield.

For each TX/RX-antenna pair the in-phase (real) component of the CSI is entered first and followed by the quadrature (imaginary) component of the CSI. This begins with the lowest frequency subcarrier, and is repeated for each subcarrier. The number of subcarriers  depends on the channel width and the value of . The number of subcarriers is provided in Table 9-127j (Subcarrier indices for Sensing CSI field for channel width of 160 MHz and Ng = 8).

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| * Subcarrier indices for Sensing CSI field for channel width of 160 MHz and Ng = 8
 |
| Channel width | Ng | Meaning |
| 160 MHz | 8 | -1012, -1004, … -20, -12, 12, 20, … 1004, 1012 |

NOTE—Thesize of the Sensing Measurement Report information, in octets, is given by Equation (9-5f).

*

NOTE—The size of the Sensing Measurement Report information increases with the number of transmit antennas, the number of receive antennas, the channel width, the smaller subcarrier grouping size, and the larger number of quantization bits for each real and imaginary component of CSI. The smallest Sensing Measurement Report field is 43 octets, and the largest Sensing Measurement Report field is 80744 octets.

***TGbf editor: Please add the following as*** ***Clause 11.55.1.5.4:***

**11.55.1.5.4 Indication of receiver operating condition in sensing measurement report**

The operating condition of a sensing receiver may affect the accuracy of its CSI estimates. The operating condition is reported in Rx\_OP\_Gain\_Index sub-field as defined in the Sensing Measurement Report field (see Table 9-127h (Sensing Measurement Report information)). When Rx\_OP\_Gain\_Type sub-field in the Sensing Measurement Report Control field (see Table 9-127g (Sensing Measurement Report Control field definition)) is set to ‘01’, the sensing receiver reports Rx OP index as operating condition; when Rx\_OP\_Gain\_Type sub-field is set to ‘10’, the sensing receiver reports Rx gain index as operating condition; and when Rx\_OP\_Gain\_Type sub-field is set to ‘00’ or ‘11’, the sensing receiver reports invalid operating condition and it should be ignored. The Rx OP index allows the sensing receiver to indicate its operating point in estimating CSI values, while the Rx gain index allows the receiver to indicate its gain setting adopted for the CSI estimation.

The Rx OP indices are derived by categorizing severity of the sensing receiver’s nonlinear effects on CSI estimates and underlying operating conditions into operating points (OPs), then mapping the OPs to indices. Each 8 bits value for Rx OP index represents an operating point index from 0 to 255. The categorization of Rx OP index is implementation specific, and it may follow the following rules:

* Rx OPs are categorized to the sensing receiver’s best knowledge of variations of its nonlinear effects on CSI estimates. These variations of nonlinear effects manifest as variations in receive frequency response. They are caused by sensing receiver’s implementation impairments when changes occur to its operating conditions such as receive signal strength level, channel bandwidth, environment, interferences, and etc. The metrics of nonlinear effects on CSI estimates, OP step size, and the cap of OP index value the sensing receiver uses to categorize its operating points are implementation dependent. A larger Rx OP index indicates a more severe nonlinear effect the sensing receiver has on CSI estimates. In the case the sensing receiver is certain that variation of nonlinear effects is neglectable, it may report a fixed OP index value of 0 in Rx\_OP\_Gain\_Index field.
* Rx OP index value may vary from one to another sensing instance for the same sensing measurement setup. The change of Rx OP index value indicates the change of sensing receiver OP, and thus the change of sensing receiver’s nonlinear effects on the CSI estimates.
* The same Rx OP index value may be reported for two sensing instances with the same sensing measurement setup. It indicates the sensing receiver operates at the same operating point when CSIs are estimated for these two instances. It further indicates the sensing receiver’s nonlinear effects on these two sets of CSI estimates are the same.

The Rx gain index indicates sensing receiver’s RF/analog and digital gains. Among the 8 bits representing a RX gain index, B0-B5 contains the RF/analog gain index, and B6-B7 contains the digital gain index. The RF/analog gain index is defined as a mapping of the gain in analog domain mainly contains the gain of AGC and other components. The digital gain index is defined as a mapping index of the gain in digital domain. If the digital gain index is not available, B6-B7 shall be set to ‘00’. Although the step size the sensing receiver uses to map the gains are implementation dependent, a larger gain index always indicates a larger gain. Rx gain index value may vary from one to another sensing instance for the same sensing measurement setup and the change of Rx gain index value indicates the change of the sensing receiver gain setting.

Note: For some sensing applications, the effects on CSI estimates caused by sensing receiver’s operating condition changes may be taken into consideration when sensing initiator processes CSI estimates from sensing instances with the same sensing measurement setup. A sensing application may use reported Rx\_OP\_Gain\_Index values from the same device to evaluate whether the sensing receiver’s operating conditions are changed when the corresponding CSI values are estimated. Usage of indication of sensing receiver operating condition changes depends on sensing initiator’s application. For example, if a sensing application sees the same Rx\_OP\_Gain\_Index values reported for two sensing instances from the same device in the same sensing measurement setup, it may compare the two sets of reported CSI to detect small CSI changes with high confidence.