IEEE P802.11Wireless LANs

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| 802.11[802.11az Spec Text for Phase Shift Feedback in LMR](relative to 11az D0.6) |
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**Abstract**

This submission proposes P802.11az draft amendment text for the phase shift feedback in RSTA-to-ISTA and ISTA-to-RSTA LMR. The baseline documents that this proposal depends on are:

1. D0.6 of 802.11az

History:

#### *TGaz Editor: add a new section after existing section 11.22.6.4.6*

#### 11.22.6.4.6a Time of Arrival estimationusing Phase Shift Feedback

Based on the Figure 11-35d and equation (xx), to enable the ISTA to derive the RTT, the RSTA needs to compute TOA t2 and feed t2 and t3 back to ISTA using RSTA-to-ISTA LMR. Instead of utilizing TOA t2 for RTT computation, a phase shift feedback can be prepared by RSTA and fed back to ISTA for deriving RTT.

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Figure 11-xx Timing diagram of a Measurement Sounding part in TB Ranging based on phase shift of UL NDP and DL NDP

As shown in Figure 11-xx, in the phase shift (PS) feedback method, the ISTA transmits UL NDP at TOD t1, and after RSTA receiving the UL NDP, the RSTA calculate a phase shift tp2 of UL NDP, and the phase shift tp2 is calculated based on the phase slope of frequency domain channel estimation of the UL NDP. An example for calculating phase shift is shown in Annex XX. The RSTA sends the DL NDP at TOD t3, and after receiving the DL NDP, the ISTA calculate the phase shift tp4 and TOA t4 of DL NDP. The value of tp2 and tp4 are calculated utilizing the frequency domain channel estimation of UL NDP and DL NDP.

The phase shift (PS) is defined as the average linear phase shift between two adjacent tones normalized by the tone spacing. To enable the ISTA calculate the RTT, the RSTA should feeds phase shift tp2 and TOD t3 back to the ISTA using RSTA-to-ISTA LMR, and the ISTA can calculate the RTT as

RTT = (t4 – t1) – (t3 – t2’’), with t2’’ = tp2 – (tp4 – t4) (11-xx)

When the ISTA-to-RSTA LMR with phase shift feedback is negotiated between ISTA and RSTA, ISTA-to-RSTA LMR carries phase shift tp4 and TOD t1, then RSTA can calculate the RTT as

RTT = (t4’’ – t1) – (t3 – t2), with t4’’ = tp4 – (tp2 – t2) (11-yy)

#### *TGaz Editor: add a new row to the table 9-283 – Extended Capabilities element in section 9.4.2.26 Extended Capabilities element*

#### Table 9-283 Extended Capabilities element

|  |  |  |
| --- | --- | --- |
| Bits  | Information  | Notes |
| <NAN> | Phase Shift Feedback Support | A STA sets the Phase Shift Feedback Support field to 1 when dot11PhaseShiftFeedbackImplemented is true. It indicates the LMR transmitted by the STA can carry Phase Shift Feedback. Otherwise, the STA sets the Phase Shift Feedback Support field to 0. |

#### *TGaz Editor: add a new paragraph in section 11.22.6.2 FTM capabilities*

If the STA in which dot11TriggerBasedRangingRespImplemented or dot11NonTriggerBasedRangingRespImplemented is true supports

1. Phase Shift Feedback, it shall set the Phase Shift Feedback Support field in the Extended Capabilities element to 1. Otherwise it shall set the Phase Shift Feedback Support field in the Extended Capabilities element to 0.

#### *TGaz Editor: add a new paragraph in section 11.22.6.3.1 Range Measurement Negotiation*

An ISTA and an RSTA may negotiate a phase shift feedback mode of the non-TB ranging and TB ranging protocol, for either the RSTA-to-ISTA LMR and/or ISTA-to-RSTA LMR. In this case, instead of the TOA t2 of the UL NDP, the RSTA-to-ISTA LMR carries the phase shift tp2 of UL NDP. For the ISTA-to-RSTA LMR, instead of the TOA t4 of the DL NDP, the ISTA-to-RSTA LMR carries phase shift tp4 of DL NDP. The ISTA and RSTA can use equations (11-xx) and (11-yy) to derive the RTT.

An RSTA in which dot11PhaseShiftFeedbackImplemented is true shall set the Phase Shift Feedback Support field in the Extended Capabilities element to 1. An ISTA which has set the ISTA-to-RSTA LMR feedback field to 1 and which is capable to send LMR carrying phase shift feedback shall set the ISTA-to-RSTA Phase Shift Feedback field to 1 in the Ranging Parameter field in an initial Fine Timing Measurement Request frame to indicate the ISTA’s capability.

When an RSTA has set the Phase Shift Feedback Support field to 1 in the Extended Capabilities element that it transmits, an ISTA may set the RSTA-to-ISTA Phase Shift Feedback subfield in the Ranging Parameter field in an initial Fine Timing Measurement Request frame to 1 to activate a RSTA-to-ISTA phase shift feedback mode between the ISTA and the RSTA. The RSTA may set the RSTA-to-ISTA Phase Shift Feedback subfield in the Ranging Parameter field in an initial Fine Timing Measurement frame to 1 to confirm a RSTA-to-ISTA phase shift feedback, andin this case the RSTA shall carry the phase shift tp2 of UL NDP in the RSTA-to-ISTA LMR.

When an ISTA has set the ISTA-to-RSTA LMR feedback field to 1 and has set the ISTA-to-RSTA Phase Shift Feedback subfield to 1 in the Ranging Parameter field in an initial Fine Timing Measurement Request frame it transmits, an RSTA may set the ISTA-to-RSTA Phase Shift Feedback subfield to 1 in the Ranging Parameter field in an initial Fine Timing Measurement frame to activate a ISTA-to-RSTA phase shift feedback mode between the ISTA and the RSTA. In this case the ISTA shall carry the phase shift tp4 of DL NDP in the ISTA-to-RSTA LMR.

#### *TGaz Editor: add a new paragraph at the end of section 11.22.6.4.3.4 TB Ranging Measurement Reporting Part*

In TB ranging measurement reporting part, if RSTA-to-ISTA LMR reporting or ISTA-to-RSTA LMR reporting carries phase shift feedback, then the RSTA-to-ISTA LMR reporting or the ISTA-to-RSTA LMR reporting shall be immediate feedback.

#### *TGaz Editor: add a new paragraph at the end of section 11.22.6.4.4.3 Non-TB Ranging Measurement Reporting Part*

In Non-TB ranging measurement reporting part, if RSTA-to-ISTA LMR reporting or ISTA-to-RSTA LMR reporting carries phase shift feedback, then the RSTA-to-ISTA LMR reporting or the ISTA-to-RSTA LMR reporting shall be immediate feedback.

#### *TGaz Editor: update the Figure 9-610b Ranging Parameters field format and the corresponding descriptions in section 9.4.2.278 Ranging Parameters*



Figure 9-610b Ranging Parameters field format

The RSTA-to-ISTA Phase Shift Feedback field is set to 1 in the initial Fine Timing Measurement Request frame to activate the phase shift feedback in the RSTA-to-ISTA LMR. Otherwise, the RSTA-to-ISTA Phase Shift Feedback field is set to 0.

The ISTA-to-RSTA Phase Shift Feedback field is set to 1 in the initial Fine Timing Measurement Request frame to indicate that ISTA supports phase shift feedback in the ISTA-to-RSTA LMR. The ISTA-to-RSTA Phase Shift Feedback field is set to 1 in the initial Fine Timing Measurement frame to activate the phase shift feedback in the ISTA-to-RSTA LMR. Otherwise, the ISTA-to-RSTA Phase Shift Feedback field is set to 0.

#### *TGaz Editor: add the following figure and the corresponding descriptions in section 9.6.7.37 Location Measurement Report frame format*

 

Figure 9-xxxx Format of the TOA Error Field

The Feedback Type field contains an indication of the feedback type of the ToA field. In the RSTA-to-ISTA LMR frame, the Feedback type field is set to 0, if the ToA field contains the ToA value of the corresponding UL or DL NDP, and the Feedback Type field is set to 1, if the ToA field contains the Phase Shift value of the corresponding UL or DL NDP.

####  *TGaz Editor: please add the following paragraphs to the annex part*

#### Annex XX Phase Shift Feedback Calculation

####  (informative)

Assume there is a single Tx and Rx RF chain between the ISTA and RSTA and denote the frequency domain channel estimation of UL NDP and DL NDP as a column vector $h=\left[h\_{1},h\_{2},…,h\_{N}\right]^{T}$ and $N$ is the number of subcarriers, then the corresponding phase shift (PS) may be calculated as:

$PS=-\frac{angle (h\_{0}^{H}h\_{K})}{2πK∆\_{F,  HE-LTF} }+t\_{HE-LTF,  DFT Boundary}-T\_{GI,HE-LTF}-T\_{HE-STF}- T\_{Pre-HE portion} $ (aa-xx)

where $h\_{0}=\left[h\_{1},h\_{2},…,h\_{N-K}\right]^{T}$, $h\_{K}=\left[h\_{K+1},h\_{K+2},…,h\_{N}\right]^{T}$, $\left(•\right)^{T}$ denotes the transpose of a vector, $\left(•\right)^{H}$ represents the Hermitian transpose of a vector, $angle (•)$ is the phase angle of a complex number, the value $K $ is implementation specific, $∆\_{F,  HE-LTF}$ is the frequency subcarrier spacing for the HE-LTF field, $t\_{HE-LTF,  DFT Boundary}$ is the timing boundary of the DFT window for the HE-LTF symbol expressed in the receiver’s local clock, $T\_{GI,HE-LTF}$ is the guard interval duration for the HE-LTF portion, $T\_{HE-STF}$ is the HE-STF field duration in Ranging NDP or TB Ranging NDP, and $ T\_{Pre-HE portion}$ is the duration of the pre-HE portion in the preamble of Ranging NDP or TB Ranging NDP. Channel estimates may be filtered for noise reduction and ranging accuracy improvement before they are applied in Equations (aa-xx).

When the ISTA and RSTA have multiple Tx and Rx chains, the frequency domain channel estimation vector between the $i$th Tx spatial stream and $j$th Rx antenna is denoted as $h\_{i,j}=\left[h\_{i,j,1},h\_{i,j, 2},…,h\_{i,j,N}\right]^{T}$, and the PS is calculated as:

$PS=-\frac{angle (\sum\_{i}^{}\sum\_{j}^{}h\_{i,j,0}^{H}h\_{i,j,K})}{2πK∆\_{F,  HE-LTF} }+t\_{HE-LTF,  DFT Boundary}-T\_{GI,HE-LTF}-T\_{HE-STF}- T\_{Pre-HE portion}$ (aa-yy)

where $h\_{i,j,0}=\left[h\_{i,j,1},h\_{i,j,2},…,h\_{i,j,N-K}\right]^{T}$, $h\_{i,j,K}=\left[h\_{i,j,K+1},h\_{i,j, K+2},…,h\_{i,j,N}\right]^{T}$.