USB 3.1 ENGINEERING CHANGE NOTICE FORM

Title: Retimer PTM

Applied to: USB3.1

Brief description of the functional changes:
Add retimer support for Precision Time Management (PTM). Three new functions must be supported by a retimer: 1) it must participate in the Link Delay Measurement (LDM) protocol on its Downstream Facing Port (DFP), 2) it must initiate an LDM protocol on its Upstream Facing Port (UFP) to determine the delay on its upstream link, and 3) it must correct the parameters of the Isochronous Timestamp Packets (ITPs) that pass through it for the delay that it and its upstream link introduce.

Benefits as a result of the changes:
PTM provides an extremely accurate global time reference for pro-audio, video, motion control, and other applications that must coordinate activities of multiple independent devices. The original design of retimers did not comprehend PTM (which is a required feature of USB 3.1 compliant host controllers and hubs), introducing timing delays and asymmetries that broke PTM for devices attached through a retimer. This ECR fixes that problem.

An assessment of the impact to the existing revision and systems that currently conform to the USB specification:
This ECR only effects retimers. No changes are required to USB host controllers, hubs, or devices.

An analysis of the hardware implications:
Retimer designs will be updated to reflect the changes identified by this ECR. No changes are required to USB host controllers, hubs, or devices.

An analysis of the software implications:
None.

An analysis of the compliance testing implications:
Retimer compliance testing will have to valid the LDM protocol on both the UFP and DFP of a retimer, and it will need to validate that the ITP delay parameters are correctly updated when they are passed through a retimer.

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Actual Change

Insert Section E.1

From Text:

E.5 Compliance

To Text:

E.5 Retimer Precision Time Measurement Support

Refer to section 8.4.8 for an overview of Precision Time Measurement (PTM).

E.5.1 Retimer LDM Support

Sections 8.4.8.2 through 8.4.8.4 define the PTM *Link Delay Measurement* (LDM) protocol.

The Upstream Facing Port (UFP) of a retimer shall act as an LDM Requestor, initiating an LDM Request and receiving an LDM Response. And the Downstream Facing Port (DFP) of a retimer shall act as an LDM Responder, receiving an LDM Request and generating an LDM Response. The LDM protocol is described in section 8.4.8.2.

E.5.2 Retimer ITP Regeneration

A retimer shall maintain a *Retimer ITP Delay Counter* that is incremented by the PTM Clock.

If an ITP is received by a retimer and the Delayed (DL) bit is not set, then the retimer shall apply the following rules:

- Set the *Retimer ITP Delay Counter* to zero.
- When an ITP is received, then the retimer shall queue an ITP for transmission on its downstream facing port.
- When transmitting an ITP, a retimer shall:
  - Copy the value of *Bus Interval Boundary*$_{(RxITP)}$ to the *Bus Interval Boundary*$_{(TxITP)}$ subfield of the *Isochronous Timestamp* field in the downstream ITP.
  - Calculate the value of *Delta*$_{(TxITP)}$ subfield using the following method:

    Determine the *Delta* value at time the ITP shall be transmitted (tITPDFP) using the formula:

$$Delta_{(tITPDFP)} =$$

$$LDM\ Link\ Delay + Delta_{(RxITP)} + ITP\ Delay\ Counter - Correction_{(RxITP)}$$

    Where *Delta*$_{(tITPDFP)}$ is the *Delta* value at time tITPDFP.

If $Delta_{(tITPDFP)}$ is greater than or equal zero or less than 7500, the retimer shall set $Delta_{(TxITP)}$ equal to $Delta_{(tITPDFP)}$ and the $Correction_{(TxITP)}$ value to zero.

If $Delta_{(tITPDFP)}$ is greater than or equal to 7500, the retimer shall set $Delta_{(TxITP)}$ equal to 7500.

If $Delta_{(tITPDFP)}$ is negative, the retimer shall set $Delta_{(TxITP)}$ to zero and calculate the $Correction_{(TxITP)}$ value using the following formula:

$$Correction_{(TxITP)} = - Delta_{(tITPDFP)}$$

- Re-calculate the CRC-16 for the modified ITP.

If an ITP is received by a retimer and the Delayed (DL) bit is set, then the retimer shall apply the following rules:

- Forward the received ITP without modification.

The Isochronous Timestamp values used in the ITP being transmitted shall be the values present at the time of transmission, e.g. if other packets are queued for transmission at the time the ITP is queued, the values used shall not be the values present at the time of queuing, but adjusted for the actual time of transmission (tITPDFP). Refer to section 8.4.8.7 for more information.

E.6 Compliance