USB 3.0 ENGINEERING CHANGE NOTICE FORM

Title: USB3.1 U3/U2 TX Common Mode Specification
Applied to: USB3.1

Brief description of the functional changes:

This ECR pertains to the common-mode behavior during U3 and U2. The production version of the spec currently has no constraint on the common-mode levels produced by devices or hosts while in U3 or U2. This lack of constraint makes it impossible to design and fully validate the LFPS receiver against all possible behaviors. This can result in interoperability issues if an unexpected behavior is introduced as well as reliability concerns if a port introduces frequent large CM excursions on the receiver pins.

This ECR proposes to place some reasonable bounds on the allowed common mode behavior. This bound should be different than the $V_{TX\text{-}DC\text{-}CM}$ absolute DC limits since LFPS functionality is required during these CM events and overall long-term reliability must be met. Furthermore, several existing devices from multiple manufacturers have been observed with -500mV CM shifts while in U3 so requiring $V_{TX\text{-}DC\text{-}CM}$ to be met during U2/U3 will have the undesirable effect of making established devices non-compliant. To constrain the problem we recommend adding a requirement that any common-mode shift during U2/U3 not result in an ideal, ground terminated receiver exceeding +600/-600mV. This can be met by either managing the magnitude of the CM shift or the slew rate of the shift. The positive CM shift limit is consistent with maximum allowed RX.detect behavior so no change in RX.detect is required. The negative CM limit is consistent with behavior observed from existing devices so no existing devices are expect to be in violation.

Note that this is a re-submission of an ECR for the USB 3.0 spec that was reviewed and approved in April 2013, but did not make it into the USB 3.1 spec when it was published in July 2013. This ECR has been updated to reflect the correct page numbers and table numbers per the USB 3.1 spec. Otherwise, the ECR is identical to the one that was approved last year.

Benefits as a result of the changes:

The change provides a clear, reasonable limit to the amount of common-mode shift that a USB3 receiver is required to tolerate and will help ensure future transmitter designs do not have behavior that will create interoperability or reliability issues with existing designs.

An assessment of the impact to the existing revision and systems that currently conform to the USB specification:

The change has no impact to the performance or interoperability of SuperSpeed USB links, including those already in the market.

An analysis of the hardware implications:

The change has no known impact to existing designs. Many different phy manufacturers were examined and all already comply with this proposal.

An analysis of the software implications:

None.

An analysis of the compliance testing implications:

Compliance testing has no mechanism to place the DUT into U3 so no additional compliance test is expected. It will be up to the manufacturers to ensure this requirement is met.

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Actual Change

(a). From Text : Section 6.7.1, page 6-30, Table 6-17

Table Error! No text of specified style in document.**-1. Transmitter Normative Electrical Parameters**

Symbol	Parameter	Gen 1 (5.0 GT/s)	Gen 2 (10 GT/s)	Units	Comments
UI	Unit Interval	199.94 (min) 200.06 (max)	99.97 (min) 100.03 (max)	ps	The specified UI is equivalent to a tolerance of ±300 ppm for each device. Period does not account for SSC induced variations.
$V_{TX-DIFF-PP}$	Differential p-p Tx voltage swing	0.8 (min) 1.2 (max)	0.8 (min) 1.2 (max)	V	Nominal is 1 V p-p
$V_{TX-DIFF-PP-LOW}$	Low-Power Differential p-p Tx voltage swing	0.4 (min) 1.2 (max)	0.4 (min) 1.2 (max)	V	Refer to Section **Error! Reference source not found.**. There is no de-emphasis requirement in this mode. De-emphasis is implementation specific for this mode.
$V_{TX-DE-RATIO}$	Tx de-emphasis	3.0 (min) 4.0 (max)	Not applicable	dB	Nominal is 3.5 dB for Gen 1 operation. Gen 2 transmitter equalization recommendations are described in section **Error! Reference source not found.**.
$R_{TX-DIFF-DC}$	DC differential impedance	72 (min) 120 (max)	72 (min) 120 (max)	Ω	
$V_{TX-RCV-DETECT}$	The amount of voltage change allowed during Receiver Detection	0.6 (max)	0.6 (max)	V	Detect voltage transition should be an increase in voltage on the pin looking at the detect signal to avoid a high impedance requirement when an “off” receiver’s input goes below ground.
$C_{AC-COUPLING}$	AC Coupling Capacitor	75 (min) 200 (max)	75 (min) 265 (max)	nF	All Transmitters shall be AC coupled. The AC coupling is required either within the media or within the transmitting component itself.
$t_{CDR\_SLEW\_MAX}$	Maximum slew rate	10	Not applicable	ms/s	See the jitter white paper for details on this measurement. This is a df/ft specification; refer to Section **Error! Reference source not found.** for details.
SSC_{dfdt}	SSC df/dt	Not applicable	1250 (max)	ppm/μs	See note 1.

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To Text : Section 6.7.1, page 6-30, Table 6-17

Table Error! No text of specified style in document.**-2. Transmitter Normative Electrical Parameters**

Symbol	Parameter	Gen 1 (5.0 GT/s)	Gen 2 (10 GT/s)	Units	Comments
UI	Unit Interval	199.94 (min) 200.06 (max)	99.97 (min) 100.03 (max)	ps	The specified UI is equivalent to a tolerance of ±300 ppm for each device. Period does not account for SSC induced variations.
$V_{TX-DIFF-PP}$	Differential p-p Tx voltage swing	0.8 (min) 1.2 (max)	0.8 (min) 1.2 (max)	V	Nominal is 1 V p-p
$V_{TX-DIFF-PP-LOW}$	Low-Power Differential p-p Tx voltage swing	0.4 (min) 1.2 (max)	0.4 (min) 1.2 (max)	V	Refer to Section **Error! Reference source not found.**. There is no de-emphasis requirement in this mode. De-emphasis is implementation specific for this mode.
$V_{TX-DE-RATIO}$	Tx de-emphasis	3.0 (min) 4.0 (max)	Not applicable	dB	Nominal is 3.5 dB for Gen 1 operation. Gen 2 transmitter equalization recommendations are described in section **Error! Reference source not found.**.
$R_{TX-DIFF-DC}$	DC differential impedance	72 (min) 120 (max)	72 (min) 120 (max)	Ω	
$V_{TX-RCV-DETECT}$	The amount of voltage change allowed during Receiver Detection	0.6 (max)	0.6 (max)	V	Detect voltage transition should be an increase in voltage on the pin looking at the detect signal to avoid a high impedance requirement when an "off" receiver's input goes below ground.
$C_{AC-COUPLING}$	AC Coupling Capacitor	75 (min) 200 (max)	75 (min) 265 (max)	nF	All Transmitters shall be AC coupled. The AC coupling is required either within the media or within the transmitting component itself.
$t_{CDR\_SLEW\_MAX}$	Maximum slew rate	10	Not applicable	ms/s	See the jitter white paper for details on this measurement. This is a df/ft specification; refer to Section **Error! Reference source not found.** for details.
SSC_{dfdt}	SSC df/dt	Not applicable	1250 (max)	ppm/μs	See note 1.
$V_{Tx-CM-IDLE-DELTA}$	Transmitter idle common-mode voltage change	+600 (max) -600 (min)	+600 (max) -600 (min)	mV	The maximum allowed instantaneous common-mode voltage at the connector side of the AC coupling capacitors while the transmitter is in U2 or U3 and not actively transmitting LFPS. Note that this is an absolute voltage spec referenced to the receive-side termination ground but serves the purpose of limiting the magnitude and/or slew rate of Tx common mode changes.

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(b). From Text : Section 6.9.1, page 6-45, Table 6-29

Table Error! No text of specified style in document.**-3. LFPS Transmitter Timing for SuperSpeed Designs[1]**

	tBurst				tRepeat		
	Min	**Typ**	**Max**	**Minimum Number of LFPS Cycles[2]**	**Min**	**Typ**	**Max**
Polling.LFPS	0.6 µs	1.0 µs	1.4 µs		6 µs	10 µs	14 µs
Ping.LFPS[8]	40 ns		200 ns	2	160 ms	200 ms	240 ms
Ping.LFPS for SuperSpeedPlus[9]	40 ns		160ns	2			
tReset[3]	80 ms	100 ms	120 ms				
U1 Exit[4,5]	600 ns[7]		2 ms				
U2 / Loopback Exit[4,5]	80 µs[7]		2 ms				
U3 Wakeup[4,5]	80 µs[7]		10 ms				

Notes:

1. If the transmission of an LFPS signal does not meet the specification, the receiver behavior is undefined.
2. Only Ping.LFPS has a requirement for minimum number of LFPS cycles.
3. The declaration of Ping.LFPS depends on only the Ping.LFPS burst.
4. Warm Reset, U1/U2/Loopback Exit, and U3 Wakeup are all single burst LFPS signals. tRepeat is not applicable.
5. The minimum duration of an LFPS burst shall be transmitted as specified. The LFPS handshake process and timing are defined in Section **Error! Reference source not found.**.
6. A Port in U2 or U3 is not required to keep its transmitter DC common mode voltage. When a port begins U2 exit or U3 wakeup, it may start sending LFPS signal while establishing its transmitter DC common mode voltage. To make sure its link partner receives a proper LFPS signal, a minimum of 80 µs tBurst shall be transmitted. The same consideration also applies to a port receiving LFPS U2 exit or U3 wakeup signal.
7. A port is still required to detect U1 LFPS exit signal at a minimum of 300ns. The extra 300ns is provided as the guard band for successful U1 LFPS exit handshake.
8. This requirement applies to SuperSpeed only designs (are only capable of operating at 5Gb/s).
9. This requirement applies to SuperSpeedPlus designs (capable of operating at 10Gb/s and higher speeds).

To Text : Section 6.9.1, page 6-45, Table 6-29

Table Error! No text of specified style in document.**-4. LFPS Transmitter Timing for SuperSpeed Designs[1]**

	tBurst				tRepeat		
	Min	**Typ**	**Max**	**Minimum Number of LFPS Cycles[2]**	**Min**	**Typ**	**Max**
Polling.LFPS	0.6 µs	1.0 µs	1.4 µs		6 µs	10 µs	14 µs
Ping.LFPS[8]	40 ns		200 ns	2	160 ms	200 ms	240 ms
Ping.LFPS for SuperSpeedPlus[9]	40 ns		160ns	2			
tReset[3]	80 ms	100 ms	120 ms				
U1 Exit[4,5]	600 ns[7]		2 ms				
U2 / Loopback Exit[4,5]	80 µs[7]		2 ms				
U3 Wakeup[4,5]	80 µs[7]		10 ms				

	tBurst				tRepeat		
	Min	**Typ**	**Max**	**Minimum Number of LFPS Cycles**[2]	**Min**	**Typ**	**Max**

Notes:

1. If the transmission of an LFPS signal does not meet the specification, the receiver behavior is undefined.
2. Only Ping.LFPS has a requirement for minimum number of LFPS cycles.
3. The declaration of Ping.LFPS depends on only the Ping.LFPS burst.
4. Warm Reset, U1/U2/Loopback Exit, and U3 Wakeup are all single burst LFPS signals. tRepeat is not applicable.
5. The minimum duration of an LFPS burst shall be transmitted as specified. The LFPS handshake process and timing are defined in Section **Error! Reference source not found.**.
6. ~~A Port in U2 or U3 is not required to keep its transmitter DC common mode voltage.~~ A port in U2 or U3 is not required to keep its transmitter DC common mode voltage but must not exceed the $V_{TX\text{-}CM\text{-}IDLE\text{-}DELTA}$ spec at TP1. This can be met by either managing the magnitude of the CM shift or the slew rate of the shift. Accordingly, LFPS detectors must tolerate positive and negative CM excursions up to $V_{TX\text{-}CM\text{-}IDLE\text{-}DELTA}$ without false detection. When a port begins U2 exit or U3 wakeup, it may start sending LFPS signal while establishing its transmitter DC common mode voltage. To make sure its link partner receives a proper LFPS signal, a minimum of 80 µs tBurst shall be transmitted. The same consideration also applies to a port receiving LFPS U2 exit or U3 wakeup signal.
7. A port is still required to detect U1 LFPS exit signal at a minimum of 300ns. The extra 300ns is provided as the guard band for successful U1 LFPS exit handshake.
8. This requirement applies to SuperSpeed only designs (are only capable of operating at 5Gb/s).
9. This requirement applies to SuperSpeedPlus designs (capable of operating at 10Gb/s and higher speeds).