USB 3.2 ENGINEERING CHANGE NOTICE

Title: VCM and TxDetect
Applied to: USB 3.2 Revision 1.0

Brief description of the functional changes:
This ECN defines the voltage levels presented at the receiver side of the AC cap during any common mode excursions and/or during receive presence detection as -500mV to 1.0V. Note this does not include the +/- 250mV that may be present due to ground current offset.

Benefits as a result of the changes:
Allows continued integration of USB technology on contemporary manufacturing processes.

An assessment of the impact to the existing revision and systems that currently conform to the USB specification:
Existing parts may or may not meet this requirement.

An analysis of the hardware implications:
Newer process technologies constrain max IO voltage in the vicinity of 1V to prevent against oxide overstress and transistor breakdown. With this constraint, there is a strong need to bound the Transmitter DC common-mode voltage excursions including during receive detect to prevent device breakdown due to electrical overstress. The current Informative specification on Transmitter DC common mode voltage VTX-DC_CM provides a wider range 0 to 2.2V, does not define the load impedance, and is only informative. The high voltage seen on the Receiver can create electrical overstress scenarios and failures especially in newer process technology nodes. A clamping device can be implemented to protect the IC but it can present an unintended termination presence indication and cause a functional failure due to its low impedance (transient). This ECR specifies the voltage levels and test load impedance to prevent EOS scenarios as well as functional failures associated with special EOS protection circuits.

An analysis of the software implications:
None

An analysis of the compliance testing implications:
A compliance test will be added and also provide for a 24 or 36-month waiver window.

Actual Change

All quantities are measured at TP2 in Figure 6-6 unless otherwise specified.

(a)Table 6-18

From Text:

Table 6-18. 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) 200.34 (min) 200.46 (max)	99.97 (min) 100.03 (max) 100.17 (min) 100.23 (max)	ps ps	The specified UI is equivalent to a tolerance of ±300 ppm for each device. Period does not account for SSC induced variations. Alternate limits apply to "radio friendly" clocking mode which employs a clock whose center frequency is downshifted by 2000ppm. This mode is to be used with a +0/-3000ppm spread.
$V_{TX-DIFF-PP}$	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 6.7.2. 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)	See section 6.7.5.2.	dB	Nominal is 3.5 dB for Gen 1 operation. Gen 2 transmitter equalization requirements are described in section 6.7.5.2.
$R_{TX-DIFF-DC}$	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) 265 (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 6.5.4 for details.
SSC_{dfdt}	SSC df/dt	Not applicable	1250 (max)	ppm/µs	See note 1.

Symbol	Parameter	Gen 1 (5.0 GT/s)	Gen 2 (10 GT/s)	Units	Comments
$V_{Tx\text{-}CM\text{-}IDLE\text{-}DELTA}$	Transmitter idle common-mode voltage change	+600 (max) -600 (min)	+600 (max) -600 (min)	mV	The maximum allowed instantaneous common-mode voltage at TP2 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.

To Text:

Table 6-18. 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) 200.34 (min) 200.46 (max)	99.97 (min) 100.03 (max) 100.17 (min) 100.23 (max)	ps ps	The specified UI is equivalent to a tolerance of ±300 ppm for each device. Period does not account for SSC induced variations. Alternate limits apply to "radio friendly" clocking mode which employs a clock whose center frequency is downshifted by 2000ppm. This mode is to be used with a +0/-3000ppm spread.
$V_{TX\text{-}DIFF\text{-}PP}$	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
$V_{TX\text{-}DIFF\text{-}PP\text{-}LOW}$	Low-Power Differential p-p Tx voltage swing	0.4 (min) 1.2 (max)	0.4 (min) 1.2 (max)	V	Refer to Section 6.7.2. There is no de-emphasis requirement in this mode. De-emphasis is implementation specific for this mode.
$V_{TX\text{-}DE\text{-}RATIO}$	Tx de-emphasis	3.0 (min) 4.0 (max)	See section 6.7.5.2.	dB	Nominal is 3.5 dB for Gen 1 operation. Gen 2 transmitter equalization requirements are described in section 6.7.5.2.
$R_{TX\text{-}DIFF\text{-}DC}$	DC differential impedance	72 (min) 120 (max)	72 (min) 120 (max)	Ω	
$V_{TX\text{-}RCV\text{-}DETECT}$	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.
$C_{AC\text{-}COUPLING}$	AC Coupling Capacitor	75 (min) 265 (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 6.5.4 for details.
SSC_{dfdt}	SSC df/dt	Not applicable	1250 (max)	ppm/μs	See note 1.

Symbol	Parameter	Gen 1 (5.0 GT/s)	Gen 2 (10 GT/s)	Units	Comments
$V_{TX-DC+AC-CONN}$[1][2]	Instantaneous DC+AC voltages at the connector side of the AC coupling capacitors.	-0.5 (min1) -0.3 (min2) 1.0 (max)	-0.5 (min1) -0.3 (min2) 1.0 (max)	V	The absolute single-ended voltage seen by the receiver. This requirement applies to all link states and during power-on, and power-off. (min1, max) is measured with a 200KΩ receiver load, and (min2, max) is measured with a 50Ω receiver load.
VTx-CM-IDLE-DELTA	Transmitter idle common-mode voltage change	+600 (max) -300 (min)	+600 (max) -300 (min)	mV	The maximum allowed instantaneous common-mode voltage at TP2 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.

Note [1]: The DC ground offset between a DFP and UFP does not contribute to $V_{TX-DC+AC-CONN}$. The AC ground offset, is not included.
Note [2]: There may exist a scenario where an un-powered transmitter may also be exposed to a large common mode voltage excursion when a receiver of its link partner powers up or powers down. It is system implementation's responsibility to address these potential EOS issues and is out of the scope of the specification.

(b)Table 6-19
From Text:

Table 6-19. Transmitter Informative Electrical Parameters at TP1 (unless otherwise specified)

Symbol	Parameter	5.0 GT/s	10 GT/s	Units	Comments
$t_{MIN-PULSE-Dj}$	Deterministic min pulse	0.96	0.96	UI	Tx pulse width variation that is deterministic
$t_{MIN-PULSE-Tj}$	Tx min pulse	0.90	0.90	UI	Min Tx pulse at 10^{-12} including Dj and Rj
t_{TX-EYE}	Transmitter Eye	0.625 (min)	0.646 (min)	UI	Includes all jitter sources
$t_{TX-DJ-DD}$	Tx deterministic jitter	0.205 (max)	0.170 (max)	UI	Deterministic jitter only assuming the Dual Dirac distribution
$C_{TX-PARASITIC}$	Tx input capacitance for return loss	1.25 (max)	1.1 (max)	pf	Parasitic capacitance to ground
R_{TX-DC}	Transmitter DC common mode impedance	18 (min) 30 (max)	18 (min) 30 (max)	Ω	DC impedance limits to guarantee Receiver detect behavior. Measured with respect to AC ground over a voltage of 0-500 mV.
$I_{TX-SHORT}$	Transmitter short-circuit current limit	60 (max)	60 (max)	mA	The total current Transmitter can supply when shorted to ground.
$V_{TX-DC-CM}$	Transmitter DC common-mode voltage	0 (min) 2.2 (max)	0 (min) 2.2 (max)	V	The instantaneous allowed DC common-mode voltages at the connector side of the AC coupling capacitors.
$V_{TX-CM-AC-PP\_ACTIVE}$	Tx AC common mode voltage active	100	100 (max)	mVp-p	Maximum mismatch from Txp + Txn for both time and amplitude.

Symbol	Parameter	5.0 GT/s	10 GT/s	Units	Comments
$V_{TX-CM-DC-ACTIVE-IDLE-DELTA}$	Absolute DC Common Mode Voltage between U1 and U0	200 (max)	200 (max)	mV	
$V_{TX-IDLE-DIFF-AC-pp}$	Electrical Idle Differential Peak –Peak Output Voltage	0 (min) 10 (max)	0 (min) 10 (max)	mV	
$V_{TX-IDLE-DIFF-DC}$	DC Electrical Idle Differential Output Voltage	0 (min) 10 (max)	0 (min) 10 (max)	mV	Voltage shall be low pass filtered to remove any AC component. This limits the common mode error when resuming U1 to U0.

To Text:

Table 6-19. Transmitter Informative Electrical Parameters at TP1 (unless otherwise specified)

Symbol	Parameter	5.0 GT/s	10 GT/s	Units	Comments
$t_{MIN-PULSE-Dj}$	Deterministic min pulse	0.96	0.96	UI	Tx pulse width variation that is deterministic
$t_{MIN-PULSE-Tj}$	Tx min pulse	0.90	0.90	UI	Min Tx pulse at 10^{-12} including Dj and Rj
t_{TX-EYE}	Transmitter Eye	0.625 (min)	0.646 (min)	UI	Includes all jitter sources
$t_{TX-DJ-DD}$	Tx deterministic jitter	0.205 (max)	0.170 (max)	UI	Deterministic jitter only assuming the Dual Dirac distribution
$C_{TX-PARASITIC}$	Tx input capacitance for return loss	1.25 (max)	1.1 (max)	pf	Parasitic capacitance to ground
R_{TX-DC}	Transmitter DC common mode impedance	18 (min) 30 (max)	18 (min) 30 (max)	Ω	DC impedance limits to guarantee Receiver detect behavior. Measured with respect to AC ground over a voltage of 0-500 mV.
$I_{TX-SHORT}$	Transmitter short-circuit current limit	60 (max)	60 (max)	mA	The total current Transmitter can supply when shorted to ground.
$V_{TX-CM-AC-PP\_ACTIVE}$	Tx AC common mode voltage active	100	100 (max)	mVp-p	Maximum mismatch from Txp + Txn for both time and amplitude.
$V_{TX-CM-DC-ACTIVE-IDLE-DELTA}$	Absolute DC Common Mode Voltage between U1 and U0	200 (max)	200 (max)	mV	
$V_{TX-IDLE-DIFF-AC-pp}$	Electrical Idle Differential Peak –Peak Output Voltage	0 (min) 10 (max)	0 (min) 10 (max)	mV	
$V_{TX-IDLE-DIFF-DC}$	DC Electrical Idle Differential Output Voltage	0 (min) 10 (max)	0 (min) 10 (max)	mV	Voltage shall be low pass filtered to remove any AC component. This limits the common mode error when resuming U1 to U0.

(c)Table 6-23

From Text:

Table 6-23. Receiver Informative Electrical Parameters

Symbol	Parameter	Gen 1 (5.0 GT/s)	Gen 2 (10 GT/s)	Units	Comments
$V_{RX-DIFF-PP-POST-EQ}$	Differential Rx peak-to-peak voltage	30 (min)	30 (min)	mV	Measured after the Rx EQ function (Section 6.8.2).
t_{RX-TJ}	Max Rx inherent timing error	0.45 (max)	0.394 (max)	UI	Measured after the Rx EQ function (Section 6.8.2).
$t_{RX-DJ-DD}$	Max Rx inherent deterministic timing error	0.285 (max)	0.21 (max)	UI	Maximum Rx inherent deterministic timing error
$C_{RX-PARASITIC}$	Rx input capacitance for return loss	1.1 (max)	1.0 (max)	pF	
$V_{RX-CM-AC-P}$	Rx AC common mode voltage	150 (max)	150 (max)	mV Peak	Measured at Rx pins into a pair of 50 Ω terminations into ground. Includes Tx and channel conversion, AC range up to 5 GHz
$V_{RX-CM-DC-ACTIVE-IDLE-DELTA\_P}$	Rx AC common mode voltage during the U1 to U0 transition	200 (max)	200 (max)	mV Peak	Measured at Rx pins into a pair of 50 Ω terminations into ground. Includes Tx and channel conversion, AC range up to 5 GHz

To Text:

Table 6-23. Receiver Informative Electrical Parameters

Symbol	Parameter	Gen 1 (5.0 GT/s)	Gen 2 (10 GT/s)	Units	Comments
$V_{RX-DIFF-PP-POST-EQ}$	Differential Rx peak-to-peak voltage	30 (min)	30 (min)	mV	Measured after the Rx EQ function (Section 6.8.2).
t_{RX-TJ}	Max Rx inherent timing error	0.45 (max)	0.394 (max)	UI	Measured after the Rx EQ function (Section 6.8.2).
$t_{RX-DJ-DD}$	Max Rx inherent deterministic timing error	0.285 (max)	0.21 (max)	UI	Maximum Rx inherent deterministic timing error
$C_{RX-PARASITIC}$	Rx input capacitance for return loss	1.1 (max)	1.0 (max)	pF	
$V_{RX-CM-AC-P}$	Rx AC common mode voltage	150 (max)	150 (max)	mV Peak	Measured at Rx pins into a pair of 50 Ω terminations into ground. Includes Tx and channel conversion, AC range up to 5 GHz

Symbol	Parameter	Gen 1 (5.0 GT/s)	Gen 2 (10 GT/s)	Units	Comments
$V_{RX-CM-DC-ACTIVE-IDLE-DELTA\_P}$	Rx AC common mode voltage during the U1 to U0 transition	200 (max)	200 (max)	mV Peak	Measured at Rx pins into a pair of 50 Ω terminations into ground. Includes Tx and channel conversion, AC range up to 5 GHz
$V_{RX-CM-DC\_CONN}$ [1][2]	Instantaneous DC common mode voltage coupled from the far-end Tx	-0.5 (min1) -0.3 (min2) 1.0 (max)	-0.5 (min1) -0.3 (min2) 1.0 (max)	V	Apply to all link states and during power-on, and power-off. (min1, max) is observed at receiver side of the connector when Rx termination is equivalent of 200KΩ, and (min2, max) when Rx termination is 50Ω.

Note [1]: Not include +/-250mV AC ground offset.
Note [2]: The receiver designs must survive legacy implementations with $V_{TX-DC+AC-CONN}$ common mode transient up to 2.2V.