USB 3.1 ENGINEERING CHANGE NOTICE FORM

Title: PHY 023 Ux LFPS Exit
Applied to: USB Specification Version 3.1

Brief description of the functional changes:

1. To accommodate for propagated cable delay during U1 exit
    a. Extend (t11-t10) from 900ns (max) to 2us
    b. Extend (t12-t11) from 900ns (max) to 2us
2. To add additional guard band by extending (t13-t11) min to 900ns for normal Ux LFPS exit
3. To add additional guard band by extending (t12-t11) min to 600ns for simultaneous Ux LFPS exit

Benefits as a result of the changes:

1. To accommodate the new connectivity models with multiple retimers up to four and long active cable, when both host and device implemented based on this ECR.
2. To ease the implementation by providing more timing margin for a port to differentiate U1_LFPS exit signal from Ping.LFPS.

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

1. The existing U1 to U0 exit latency is dependent on U1 LFPS exit and subsequent training delay in Recovery which can be channel dependent.

An analysis of the hardware implications:

Any new USB3.1 and USB3.0 host and device implementations to follow the new ECR. this will enable future host and device ecosystem to support 4 retimers with extended cable reach of >5m

An analysis of the software implications:

The legacy SW may under-estimate the U1 exit latency and it may degrade the BW utilization.

An analysis of the compliance testing implications:

Will need to be updated to reflect the change of the timers and add new compliance procedures are needed in order to budget timing margin for propagation delays due to cable and retimer.

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Actual Change

(a). From Text (and location): Table 6-30

Table 6-30. LFPS Handshake Timing for U1/U2 Exit, Loopback Exit, and U3 Wakeup

	U1 Exit		U2/Loopback Exit		U3 Wakeup	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**
t11 – t10	0.3 μs	0.9 μs/2ms[1]-900ns)	0.3 μs	2 ms	0.3 μs	10 ms
t13 – t10	0.9 μs	2ms		2 ms		20 ms
t12 – t11	0.3 μs	0.9 μs[1]	0	2 ms	0	10 ms
t13 – t11	0.6 μs	0.9[1] μs	80 μs	2 ms	80 μs	10 ms
t12 – t10	0.6 μs	2ms[1]	80 μs	2 ms	80 μs	10 ms
tNoLFPSResponseTimeout		2 ms		2 ms		10 ms

Note:

1. There are two sets of maximum timing requirements. The set with short timing requirement applies to normal operations when U2_Inactivity_Timer is disabled. The set with relaxed timing requirement applies to operations when U2_Inactivity_Timer is enabled. It also includes one corner case wehere U2_Inactivity_Timer is disabled and the port, upon entry to U1, initiating U1 exit immediately.
2. In a case where U2_Inactivity_Timer is enabled, it is the responsibility of each link partner to respond accordingly depending on its U1 or U2 state. For example, when link partner 1 initiates exit in U1 and link partner 2 is in U2, it is expected that both link partners will eventually enter U0 with respective timings starting from different U1/U2 states. Essentially, t12-t10 of link partner 1 follows U1 Exit tBurst timing and t13-t11 of link partner 2 follows U2 Exit tBurst timing.

(a). To Text (and location): Table 6-30

Table 6-30. LFPS Handshake Timing for U1/U2 Exit, Loopback Exit, and U3 Wakeup

	U1 Exit		U2/Loopback Exit		U3 Wakeup	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**
t11 – t10	0.3 μs	2.0μs/2ms[1]	0.3 μs	2 ms	0.3 μs	10 ms
t13 – t10	1.2 μs	2ms		2 ms		20 ms
t12 – t11	0.6 μs	2.0 μs[1]	0.6 μs	2 ms	0.6 μs	10 ms
t13 – t11	0.9 μs	1.2[1] μs	80 μs	2 ms	80 μs	10 ms
t12 – t10	0.9 μs	2ms[1]	80 μs	2 ms	80 μs	10 ms
tNoLFPSResponseTimeout		2 ms		2 ms		10 ms

Note:

1. There are two sets of maximum timing requirements. The set with short timing requirement applies to normal operations when U2_Inactivity_Timer is disabled. The set with relaxed timing requirement applies to operations when U2_Inactivity_Timer is enabled. It also includes one corner case where U2_Inactivity_Timer is disabled and the port, upon entry to U1, initiating U1 exit immediately. Note that it is highly desired to implement the LFPS exit handshake with minimum delay for better quality of service.
2. In a case where U2_Inactivity_Timer is enabled, it is the responsibility of each link partner to respond accordingly depending on its U1 or U2 state. For example, when link partner 1 initiates exit in U1 and link partner 2 is in U2, it is expected that both link partners will eventually enter U0 with respective timings starting from different U1/U2 states. Essentially, t12-t10 of link partner 1 follows U1 Exit tBurst timing and t13-t11 of link partner 2 follows U2 Exit tBurst timing.

(b) From Text (and location): Table 6-29

	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 6.9.2.
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).

(b). To Text (and location): Table 6-29

	tBurst				tRepeat		
	Min	**Typ**	**Max**	**Minimum Number of LFPS Cycles**[2]	**Min**	**Typ**	**Max**
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Ping.LFPS for SuperSpeedPlus[9]	40 ns		160ns	2			
tReset[3]	80 ms	100 ms	120 ms				
U1 Exit[4,5]	900 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 6.9.2.
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 600ns 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).

(c) From Text (and location): Table 6-30

t12 – When Link Partner 1 validates the received LFPS of the required t12-t11 and t12-t10 durations and starts to transmit SS signaling.

(c) To Text (and location): Table 6-30

t12 –When Link Partner 1 completes the validation of receiving at least 300-ns LFPS signal from Link Partner 2 and has transmitted additional 600-ns LFPS signal upon receiving the LFPS signal from Link Partner 2.

(d) From Text (and location): Section 6.9.2

- A successful handshake is declared for link partner 1 if the following conditions are met within "tNoLFPSResponseTimeout" after t10 (see Figure 6-30 and Table 6-30):
  1. Valid LFPS is received from link partner 2.
     Note: in case of concurrent U1 exit, where both ports initiate U1 exit simultaneiously, both ports will assume to be Link partner 1. Both ports will start receiving LFPS signal before t10. And received U1 LFPS exit signal may be validated around t10. This may result in a minimum duration of U1 exit LFPS signal. To ensure successful U1 exit under such situations, both ports shall transmit U1 LFPS exit signal for 600ns before exiting U1.
  2. For U1 exit, U2 exit, U3 Wakeup and not Loopback exit, link partner 1 is ready to transmit the training sequences and the maximum time gap after an LFPS transmitter stops transmission and before a SuperSpeed transmitter starts transmission is 20 ns.

(d) To Text (and location): Section 6.9.2

- A successful handshake is declared for link partner 1 if the following conditions are met within "tNoLFPSResponseTimeout" after t10 (see Figure 6-30 and Table 6-30):
  3. Valid LFPS is received from link partner 2.
     Note: in case of concurrent U1 exit, where both ports initiate U1 exit simultaneously at t10,

both ports will assume to be Link partner 1. Both ports will start receiving LFPS signal before t11. And received U1 LFPS exit signal may be validated around t11. This may result in a minimum duration of U1 exit LFPS signal. To ensure successful U1 exit under such situations, both ports shall transmit U1 LFPS exit signal for 900 ns before exiting U1 at t12. Note that implementations based on USB 3.1 Specification Revision 1.0 (July 26, 2013) and earlier revision may transmit the minimum 600 ns LFPS signal under this scenario.

4. For U1 exit, U2 exit, U3 Wakeup and not Loopback exit, link partner 1 is ready to transmit the training sequences and the maximum time gap after an LFPS transmitter stops transmission and before a SuperSpeed transmitter starts transmission is 20 ns.