USB ENGINEERING CHANGE NOTICE

Title: USB 2.0 eUSB2 repeater effects update

Applies to: Universal Serial Bus Specification, Revision 2.0 Summary of ECN

Changes relative to eUSB2 HS repeater

- Explicitly allow transmitting the first SYNC bit of a HS packet and require receivers to accept packet which starts with a short K bit, or a full UI J bit.
- Recommend receivers to accept a HS packet which starts with a short bit of K or J.
- Allow the up to 4 UI duration of random HS EOP dribble, to include partial UI toggles.
- Define a descriptor field to notify host that device has an eUSB2 repeater.
- Include eUSB2 repeater in references to number of hub repeater tiers.
- Reduce number of HS repeater tiers between host and device to 3 or 4.

Changes relative to eUSB2 FS/LS repeater

- Reduce number of FS repeater tiers between HS host or HS hub and FS/LS device to 1 or 3.

Optional descriptor field to report presence of eUSB2 repeater to aid diagnostics.

Reasons for ECN

Repeaters defined by eUSB2 Ver 1.2
- are not required to be retimers and, when not,
  - before the eUSB2 Ver 1.2 ECR Repeater HS SYNC, cannot guarantee the width of the first SYNC bit, and that first SYNC bit may be a K or J.
  - after the eUSB2 Ver 1.2 ECR Repeater HS SYNC, can guarantee the first SYNC bit of any amplitude or UI if it is a K, or fully compliant to the transmit waveform template 1 at TP2 if it is J.
  - cannot guarantee dribble bits of a HS packet that is repeated from eUSB2 to USB 2.0.
- are similar to hub repeaters in the following ways, even if implemented as retimers, and consequently limit the number of hubs in their paths
  - truncate the HS sync field and add HS EOP dribble
  - distort first sync bit and EOP SE0 timing and add jitter to FS/LS packets

This ECR is intended to avoid interoperability issues by
- explicitly allowing the transmitted HS SYNC pattern to include partial UI if it is a partial K or full UI J and require the HS receiver to be capable of performing data recovery under such conditions.
- Recommend the HS receiver to be capable of performing data recovery if the first SYNC bit it received is a partial J, such SYNC pattern behavior exists in a system with an eUSB2 repeater that is not compliant to the eUSB2 Ver 1.2 ECR Repeater HS SYNC.
- explicitly allowing the transmitted HS dribbled values to include partial UI and requiring receivers to ignore partial UI within EOP dribble.
- Optionally reporting presence of eUSB2 repeater in device's USB 2.0 extension descriptor for test and diagnostics.

Impact on Existing Peripherals and Systems

Partial UI: So far, have found interoperability issue with some legacy USB 2.0 device IPs that are sensitive to the 1st SYNC bit an eUSB2 repeater forwarded, that 1st SYNC bit is J with less than 1 HS UI. No hosts, hubs or peripherals rejected a packet with partial UI of EOP dribble.

eUSB2 Descriptor field: won't be recognized by existing hosts and won't be reported by eUSB2 v1.1 devices.

Hardware Implications:

HS Clock and Data Recovery (CDR) and packet decode is

- required to accept otherwise USB 2.0-compliant HS packets when the first bit of sync is a partial K or full UI J.
- recommended to accept otherwise USB 2.0-compliant HS packets when the first bit of sync is a partial J.
- required to accept otherwise USB 2.0-compliant HS packets when any differential value within dribble is less than 1 full UI as defined by templates.

Software Implications:

eUSB2 devices may report new descriptor field and USB 2.0 hosts may process it for test or diagnostics.
A host should assume two eUSB2 repeaters are in the path, unless it has is explicit knowledge of presence or absence of eUSB2 repeaters. With that assumption, it should not enumerate more than 3 HS hubs or 1 FS hub with exposed (i.e., walk-up) ports. Hosts without an eUSB2 repeater in the path should not enumerate more than 4 HS hubs or 3 FS hubs with exposed ports. With or without assumption of an eUSB2 repeater in the path, an additional HS hub or FS hub with no exposed ports may be enumerated.

Compliance Testing Implications:

Compliance tests for eUSB2 products already accept the HS sync truncation and EOP dribble along with FS/LS effects by using hub test option and by changing the gold tree to limit the number of hubs in the path from a host repeater or to a peripheral repeater.

Hub test already comprehends HS sync truncation in a way that does not require first bit to be a full UI. Hub test verifies EOP width and total dribble width.

Add eUSB2 peripheral repeater and eUSB2 host repeater to interop testing to check if a USB 2.0 host or device under test work with partial UI at start of HS packets and more randomness within EOP dribble. This test is informative to evaluate interoperability of a part under test with eUSB2 repeaters that may or may not comply to the eUSB2 v1.2 ECR Repeater HS SYNC.

Check the new eUSB2 descriptor field if supported.

Specification Changes

(a). Section 7.1.4.2 High-speed Receiver Characteristics

From Text:

The definition of a high-speed packet's SYNC pattern, together with the requirements for high-speed hub repeaters, guarantee that a receiver will see at least 12 bits of SYNC (KJKJKJKJKJKK) followed by the data portion of the packet. This means that the combination of squelch response time, DLL lock time, and end of SYNC detection must occur within 12 bit times. This is required to assure that the first bit of the packet payload will be received correctly.

To Text:

The definition of a high-speed packet's SYNC pattern, together with the requirements for high-speed hub and eUSB2 repeaters, guarantee that a receiver will see at least 12 uncorrupted bits of SYNC (KJKJKJKJKJKK) followed by the data portion of the packet. This means that the combination of squelch response time, DLL lock time, and end of SYNC detection must occur within 12 bit times. The first bit repeated by an eUSB2 repeater may be either a partial K of any amplitude or UI not meeting the transmit waveform template 1 at TP2, or a J meeting the transmit waveform template 1 at TP2. Consequently, it is required that the DLL tolerate such conditions of the first sync bit presented by an eUSB2 repeater. This is required to assure that the first bit of the packet payload will be received correctly. In another situation, there exists in some first generation eUSB2 repeater products, where the first bit repeated by an eUSB2 repeater may be a partial J not meeting the transmit waveform template 1 at TP2, it is recommended that the DLL tolerate such condition presented by an eUSB2 repeater.

(b). Section 7.1.10 Sync Pattern

From Text:

Hubs are allowed to drop up to 4 bits from the start of the SYNC pattern when repeating packets. Hubs must not corrupt any repeated bits of the SYNC field, however. Thus, after being repeated by 5 hubs, a packet's SYNC field may be as short as 12 bits.

To Text:

Hubs and eUSB2 repeaters are allowed to drop any number of bits up to 4 bits from the start of the SYNC pattern when repeating packets. If an eUSB2 repeater consumes 4 SYNC bits to exit from squelch and starts repeating a packet from the fifth received SYNC bit, it must comply to the transmit waveform template 1 at TP2. If an eUSB2 repeater consumes less than 4 SYNC bits to exit from squelch and starts repeating a packet, it may transmit the first sync bit of K of any amplitude or UI not meeting the transmit waveform template 1 at TP2, or a J meeting the transmit waveform template 1 at TP2. The second and subsequent bits that are repeated by the eUSB2 repeater must not be corrupted. Hubs must not corrupt any repeated bits of the SYNC field. Thus, after being repeated by 5 hubs or 4 hubs and 1 eUSB2 repeater or 3 hubs and 2 eUSB2 repeaters, a packet's SYNC field may be as short as 12 uncorrupted bits.

(c). Section 7.1, Table 7-1

From Table:

Table 7-1. Description of Functional Elements in the Example Shown in Figure 7-1

Element	Description
High-speed Current Driver	The high-speed current driver is used for high-speed data transmission. A current source derived from a positive supply is switched into either the D+ or D- lines to signal a J or a K, respectively. The nominal value of the current source is 17.78 mA. When this current is applied to a data line with a 45Ω termination to ground at each end, the nominal high level voltage (V$_{HSOH}$) is +400 mV. The nominal differential high-speed voltage (D+ - D-) is thus 400 mV for a J and -400 mV for a K. The current source must comply with the Transmit Eye Pattern Templates specified in Section 7.1.2.2, starting with the first symbol of a packet. One means of achieving this is to leave the current source on continuously when a transceiver is operating in high-speed mode. If this approach is used, the current can be directed to the port ground when the transceiver is not transmitting (the example design in Figure 7-1 shows a control line called HS_Current_Source_Enable to turn the current on, and another called HS_Drive_Enable to direct the current into the data lines.) The penalty of this approach is the 17.78 mA of standing current for every such enabled transceiver in the system. The preferred design is to fully turn the current source off when the transceiver is not transmitting.

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(d). Section 11.7.1.1 Squelch Circuit

From Text:

Because of squelch detection, the initial bits of the SYNC field may not be seen in the rest of the repeater. At most, 4 bits of the SYNC field may be sacrificed in the entire repeater path.

The squelch circuit may take at most 4 bit times to disable the repeater after the bus returns to the Idle state. This results in bits being added after the end of the packet. This is also known as EOP dribble and up to 4 random bits may get added after the packet by the entire repeater path.

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The squelch circuit may take at most 4 bit times to disable the repeater after the bus returns to the Idle state. This results in bits being added after the end of the packet. This is also known as EOP dribble and up to 4 bit time duration may get added after the packet by the entire repeater path. The duration between any possible toggles within dribble may be random and not a multiple of bit times.

(e). Section 4.1.1 Bus Topology

From Text:

Due to timing constraints allowed for hub and cable propagation times, the maximum number of tiers allowed is seven (including the root tier). Note that in seven tiers, five non-root hubs maximum can be supported in a communication path between the host and any device. A compound device (see Figure 4-1) occupies two tiers; therefore, it cannot be enabled if attached at tier level seven. Only functions can be enabled in tier seven.

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Due to timing constraints allowed for hub and cable propagation times, the maximum number of tiers allowed is seven (including the root tier). Note that in seven tiers, five non-root hubs maximum can be supported in a communication path between the host and any device. A compound device (see Figure 4-1) occupies two tiers; therefore, it cannot be enabled if attached at tier level seven. Only functions can be enabled in tier seven. The number of HS tiers is additionally affected by eUSB2 repeaters operating at HS due to sync field truncation and EOP dribble. Consequently, each eUSB2 repeater operating at HS counts as 1 HS tier. The number of FS tiers is also affected by eUSB2 repeaters due to their contributions to first bit and EOP SE0 distortions and to jitter. Each eUSB2 repeater operating at FS or LS counts as 2 FS tiers.

(f). Table for USB Device Capabilities – USB 2.0 Extension Descriptor

From Table:

Offset	Field	Size	Value	Description	
0	*bLength*	1	Number	Size of this descriptor.	
1	*bDescriptorType*	1	Constant	Descriptor type: DEVICE CAPABILITY Type.	
2	*bDevCapabilityType*	1	Constant	Capability type: USB 2.0 EXTENSION (002H)	
3	*bmAttributes*	4	Bitmap	Bitmap encoding of supported device level features. A value of one in a bit location indicates a feature is supported; a value of zero indicates it is not supported. Encodings are:	
				Bit	**Encoding**
				0	**Reserved.** Must be set to zero.

				1	**LPM.** A value of one in this bit location indicates that this device supports the Link Power Management protocol.
				2	BESL & Alternate HIRD definitions supported. The LPM bit must be set to a one when this bit is a one.
				3	Recommended Baseline BESL valid
				4	Recommended Deep BESL valid
				11:8	Recommended Baseline BESL value. Field shall be ignored by system software if bit [3] is a zero.
				15:12	Recommended Deep BESL value. Field shall be ignored by system software if bit [4] is a zero.
				31:16	**Reserved.** Must be set to zero.

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0	*bLength*	1	Number	Size of this descriptor.	
1	*bDescriptorType*	1	Constant	Descriptor type: DEVICE CAPABILITY Type.	
2	*bDevCapabilityType*	1	Constant	Capability type: USB 2.0 EXTENSION (002H)	
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				Bit	**Encoding**
				0	**Reserved.** Must be set to zero.
				1	**LPM.** A value of one in this bit location indicates that this device supports the Link Power Management protocol.
				2	BESL & Alternate HIRD definitions supported. The LPM bit must be set to a one when this bit is a one.
				3	Recommended Baseline BESL valid
				4	Recommended Deep BESL valid
				11:8	Recommended Baseline BESL value. Field shall be ignored by system software if bit [3] is a zero.
				15:12	Recommended Deep BESL value. Field shall be ignored by system software if bit [4] is a zero.
				16	Includes an eUSB2 repeater. A value of one in this bit location indicates that this device includes an eUSB2 repeater. Its purpose is for diagnostics only and reporting is optional.
				31:17	**Reserved.** Must be set to zero.