Errata for USB 2.0 ECN: Link Power Management (LPM) – 7/2007

Host Initiated Resume latency changes

Background:

The existing definition of the Host Initiated Resume Duration (HIRD) (see section 4.1) has an upper bound that is too short for devices to achieve desired power savings states. They need a selection of longer times that will allow them to shut off more logic.

In order to provide a more robust and useful feature, the device needs information about how long it may take the host to service the device after a resume event, regardless of whether the resume is initiated by the device or the host. In order to accomplish this, the following types of changes are made.

- The SetandTestPortFeature(L1) command's HIRD parameter is renamed and redefined in several ways.

  - The name of the HIRD field is changed to Best Effort Service Latency (BESL).

  - The value of BESL indicates the best effort to resumption of service to the device after the initiation of the resume event. Think about it as the point in time after a resume start to the start of transactions to a device endpoint. This time is not a guarantee, but a best effort will be made by the host to service the device by that time.

  - The encoding of BESL is different than that of the original HIRD field.

- The ClearPortFeature(L1) command's HIRD parameter encoding is changed to support BESL.

  Note that the hub is not required to retain the BESL value. The host is required to provide the time to drive resume in the ClearPortFeature(L1,HIRD) command via the HIRD parameter. For this erratum, this model stays the same. The encodings of the HIRD field are redefined so that they are complementary to the associated BESL value.

- Added fields to the USB 2.0 Extension descriptor that allows a device to communicate to the host its optimized power savings design points.

Change: Table 2-3 as follows:

Table x-x. LPM Token *bmAttributes* Field Definition

Bits	Field	Description
10:9	*Reserved*	Reserved for future use
8	*bRemoteWake*	A value of one (1B) in this field enables the addressed device to wake the host upon any meaningful application-specific event (e.g. an interrupt for a device with one or more interrupt endpoints). A value of zero (0B) disables the device from initiating remote wake.
7:4	~~*HIRD*~~*BESL*	~~Host Initiated Resume Duration~~Best Effort Service Latency. See Section 4.1 for value definition.
3:0	*bLinkState*	The link state (Lx) the addressed device must transition to after responding to this transaction with an ACK. Valid values for this field are:

		Value	**Description**
		0000B	Reserved for future use
		0001B	L1 (Sleep)
		0010B – 1111B	Reserved for future use

Change Table 3-1 to:

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)

Offset	Field	Size	Value	Description
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 2 **Reserved.** Must be set to zero.

Add the following text after the last paragraph in section 3:

The BESL field in the LPM transaction token (section 2.2.1) provides a range of values, offering an implementation a wide range of opportunities for differentiation. Device implementations may select a subset of specific design points for optimization within the full range. The recommended BESL fields in the *bmAttributes* provide a simple framework for a device implementation to communicate to the host up to two values of BESL to which the implementation has optimized behavior. The recommended use of these fields is that the *baseline BESL* field will have a value less than the *deep BESL* field. The expected use is the *baseline BESL* value communicates a nominal power savings design point and the *deep BESL* value communicates a significant power savings design point. The use of the recommended BESL fields is optional.

Change figure 4-1 to:

Add the following sentence to the end of the first paragraph following figure 4-1:

If the device responds with a STALL handshake, the port is returned to the enabled state and a completion code of STALL is sent back to the host.

Replace the last three paragraphs in section 4.1 with:

The host system provides an indication of the recovery service latency (best effort) in the BESL (Best Effort Service Latency) parameter of the LPM transaction. The value of this parameter indicates the amount of time from the start of a resume to when the host will attempt to begin issuing transactions to the device. This parameter holds regardless of whether the resume is initiated by the host or the device. The host can resume transaction service to the device sooner, but must provide at least ($T_{L1ExitDevRecovery}$) of recovery time after the transition to L0 is complete. The host can resume transaction service to the device later, but must resume issuing transactions to asynchronous endpoints within two micro-frames after BESL and to periodic endpoints within two service intervals, plus two micro-frames, after BESL; based on the current, active configured endpoints. Note, host implementations are recommended to minimize the delay after BESL in servicing periodic endpoints in order to maximize the opportunity for longer L1 residency and increase the effectiveness of the use of L1.

The device can use the value of BESL to help determine what power optimization features it can employ in response. For example the device could use long BESL values as an indicator it idle significantly more logic (clocks, logic, etc.) than it would with short BESL values. The power optimizations and commensurate power savings are device implementation specific.

The definition of BESL values are listed in Table X-X1.

Change the paragraph after Figure 4-6 to:

A host initiating L1 exit drives resume signaling for a minimum of $T_{L1ExitHostDrvResume1(min)}$ [t1→t2] and provides at least $T_{L1ExitDevRecovery}$ [t2→t3] of resume recovery time between the end of resume signaling (EOP) and transmittal of the first transaction that targets the resumed device. The duration of the resume signaling is specified by the host in a parameter of the ClearPortFeature(L1) command called the HIRD (Host Initiated Resume Duration). The host shall use a HIRD encoding associated with the BESL value as indicated in Table X1. and is in the range between $T_{L1HubDrvResume1(min)}$ and $T_{L1HubDriveResume1(max)}$. The total L1 exit latency expected from a host initiated L1 exit is the range of $T_{L1ExitLantency1}$ [t1→t3].

Change the last sentence in section 4.8.4 to replace 9 with 38:

Either of these transitions must happen within ~~9~~44μs after entering Restart_L1S state; otherwise, the port must transition back to the L1Suspended state.

Change table 4-8 in section 4.10.1 to:

Bits	Field Name	Description
15..8	Selector	Identifies the port indicator selector when clearing a port indicator.
7..4	HIRD	Host Initiated Resume Duration. The encoded value of the minimum time the hub must drive resume on the designated port. The encodings for this field are defined in ~~Section 4.1~~Table X-X1. **~~NOTE: the host must ensure the HIRD values used in SetAndTestPortFeature and ClearPortFeature (to the same device) are consistent.~~NOTE: the host must ensure that HIRD value used in the ClearPortFeature command is the same as the BESL value used in the preceding SetAndTestPortFeature command (to the same port where the device is connected).**
3..0	Port	The downstream port number for the L1 feature.

Change the min/max values for $T_{L1HubDrvResume1}$ in Table 4-6:

Host initiated L1 Exit Host drives resume time	$T_{L1HubDrvResume1}$	Figure 4–6 [Note 1]	75~~50~~ ±1	9960~~1200~~ ±1	μs

Add the following after table 4-8 in section 4.10.1:

The value of HIRD must be consistent with the BESL value used in the preceding LPM transaction. The valid combinations for use are listed in Table X-X1.

Table X-X1. BESL & HIRD Encodings

Value	BESL (μs)	HIRD (μs)
0	125	75
1	150	100
2	200	150
3	300	250
4	400	350
5	500	450
6	1000	950
7	2000	1950
8	3000	2950
9	4000	3950
10	5000	4950
11	6000	5950
12	7000	6950
13	8000	7950
14	9000	8950
15	10000	9950

Change table 4-11 in section 4.10.3.

Table 4-11. Set and Test Port Feature Details

Feature	wIndex		wLength	Data	
PORT_L1	**Bits**	**Value**	One	Completion Code. Value encodings are:	
	3..0	Port Number		**Value**	**Meaning**
	7..4	~~HIRD~~BESL		00H	Success
	14..8	Device Address		01H	Reserved
				10H	NYET
	15	Remote Wake Enable		11H	Timeout
				30H	STALL

Change the last paragraph in section 4.10.3 to:

The value of the ~~HIRD~~ BESL field (~~Host Initiated Resume Duration~~Best Effort Service Latency) field is passed directly through to the ~~<<tbd>>~~BESL field of the LPM transaction. System software sets this field to indicate to the recipient device the amount of time from the start of a resume to when the host will attempt to begin issuing transactions to the device. ~~how long the host will drive resume if it (the host) initiates and exit from L1 via ClearPortFeature().~~ Refer to Table X-X1~~Section 4.1~~ for the definition of how values in this field are encoded.

Miscellaneous Changes

In the core USB 2.0 specification, Chapter 11, change Table 11-16 to:

Table 11-16. Hub Class Request Codes

bRequest	Value
GET_ STATUS	0
CLEAR_ FEATURE	1
RESERVED (used in previous specifications for GET_STATE)	2
SET_ FEATURE	3
Reserved for future use	*4-5*
GET_DESCRIPTOR	6
SET_DESCRIPTOR	7

bRequest	Value
CLEAR_TT_BUFFER	8
RESET_TT	9
GET_TT_STATE	10
STOP_TT	11
SET_AND_TEST	12

Add the following sentence at the end of the first paragraph in section 4.1.1:

Note: $T_{L1TOKENRETRY(MAX)}$ is set to ensure a fast transition to L1 for all device speeds (assuming no retries required) and full-speed and high-speed devices with recoverable transaction errors. If the device is low-speed, the transition to L1 is allowed to exceed $T_{L1TOKENRETRY(MAX)}$ by the nominal time it takes to complete the transaction retries.

Change Table 4-1 as follows:

Port States			Description
Hub DS Port (Remote Wake)	**Hub US Port**	**Adj. DS Port**	**Description**
L1 → L0	L0	L0	**General:** The DS link where the device is connected is the only port that makes a transition. When L1 exit is complete, a port change bit is set (to a 1b) which results in a subsequent port change notification. No effect on adjacent ports.
		L1	
		L2	
	L1	L0	**This combination should not be allowed by the host because the resume signaling will not recover the devices attached to adjacent L0 ports (see policy statement above).**
		L1	No effect on adjacent ports that are not in the enabled state.
		L2	**This combination should not be allowed by the host (see policy statement above).**
	L2	L0	**This combination should not be allowed by the host (see policy statement above).**
		L1	Resume signaling is only transmitted through (downstream) ports that are in L0.
		L2	
L2→ L0	L0	L0	**General**: USB2 defined resume signaling (remote wake) on a suspended port. Hub upstream facing port is in L0, so only suspended port transitions; a port change bit is set (to a 1b) which results in a subsequent port change notification. No effect on adjacent ports.
		L1	
		L2	
	L1	L0	**This combination should not be allowed by the host (see policy statement above).**
		L1	
		L2	

| Port States			
Hub DS Port (Remote Wake)	**Hub US Port**	**Adj. DS Port**	**Description**
	L2	L0	USB2 defined resume. Hub reflects resume signaling upstream (transitions upstream port out of L2) and down all enabled (L0) ports.
		L1	Resume signaling is only transmitted through (downstream) ports that are in L0.
		L2	

Change section 4.8.2 L1Suspended, first bullet to:

- From the WLPM state when the LPM TE signals that the LPM transaction is complete and that the response is L1OK. LPM TE will only return L1OK when the device responded with a~~n NYET~~ ACK handshake to the LPM transaction.

Insert the following paragraph to section 2.2.1 after the caption for figure 2-2.

The value of the ENDP (Endpoint) field shall be set to zero (0).

Change figure 4-8 to the following (changed L1TimingSE0 state to L1ReceivingSE0 so that it matches the name of the section that describes the state (section 4.4.3)):
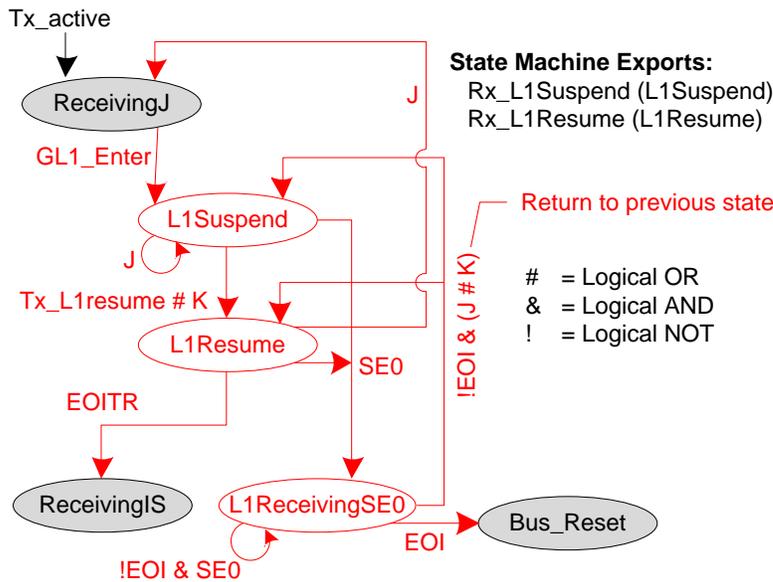
Change the title of section 4.10.2.1.1 to:

4.10.2.1.1 Port_L1