
***On-The-Go and Embedded Host
Supplement to the USB Revision 3.0
Specification***

Revision 1.1

May 10, 2012

Revision History

| Revision | Issue Date | Comment |
|----------|---------------|---|
| 1.0 | July 01, 2011 | Revision 1.0 of the Supplement. |
| 1.1 | May 10, 2012 | <p>Includes following errata:</p> <p>Added a general transition in A3 state machine for disconnects that are detected with a foot note that clarifies the DS port that are relevant.</p> <p>Modified figure and text for transition that happens when u1_u2_exit_fail from a3/b3_ds_resetting to a3/b3_ds_error to instead be from a3/b3_ds_host to a3/b3_ds_error.</p> <p>Modified figure and text to add transition from a3_us_rsp to a3_us_disconnected with condition: a3_b_wreset_detected & !b3_ntf_host_rel with a footnote to clarify behavior.</p> <p>Added transition to figure and text from a3/b3_us_peripheral to a3/b3_us_error when U1/U2 exit fails.</p> <p>Changed mandate to not use LMP Tiebreaker bits into an informative note that OTG devices do not use the bits.</p> <p>Recovery Timeout fixed to exit to *_us_error state in both A3 and B3 State Machines.</p> <p>Fixed figure and text to add transitions to *_us_disconnected if a warm reset is received prior to RSP Step 2.</p> <p>Added missing loopback-related transitions to figure and text.</p> <p>Includes changes related to making RSP optional for SS-OTG devices.</p> <p>Added transition in B3 State Machine related to Disabled Count expiration.</p> <p>Added note that relevant missing LTSSM transitions apply.</p> <p>Fixed recovery timeout transition in the *_us_rsp states.</p> <p>Fixed port configuration timeout in b3 state diagram.</p> |

Universal Serial Bus Specification Supplement
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1 Introduction

1.1 Overview

The Universal Serial Bus (USB), originally designed as an interface between PCs and peripherals, has become the most successful general-purpose PC interface in the history of computing. The [USB3.0] specification has added the capability for SuperSpeed communications over USB.

By definition, USB communication occurs between a host and a peripheral. The original intent was to place the heavier workload on the PC (host) and to allow USB peripherals to be fairly simple. Accordingly, the USB specification requires that PCs:

- provide power to peripherals (for [USB2.0] 0.5A at ~5V, for [USB3.0] 0.9A at ~5V)
- support all defined speeds (SuperSpeed, Low Speed, Full Speed and High Speed)
- support all defined data flow types (control, bulk, interrupt and isochronous)

As computing resources have become less expensive, the line between PCs and other products has blurred. Today many devices that are not PCs in the classic sense have a need to connect directly to peripherals: Printers connect directly with cameras, for example, or mobile phones may need to connect to USB headsets.

These non-PCs have the computing resources to manage a USB host function, but they need to function in ways that differ from standard PC hosts. Although they will provide host capability for some devices, it's unreasonable to require them to support the full range of USB peripherals. For example, connecting a camera to a printer makes a lot of sense, but the printer manufacturers may not think it is quite as important for the printer to support a USB GPS dongle.

This specification defines these non-PC hosts as Targeted Hosts. A Targeted Host is a USB host that supports a specific, targeted set of peripherals. The developer of each Targeted Host product defines the set of supported peripherals on a Targeted Peripheral List (TPL). A Targeted Host needs to provide only the power, bus speeds, data flow types, etc., that the peripherals on its TPL require.

There are two categories of Targeted Hosts:

1. **Embedded Hosts:** An Embedded Host (EH) product provides Targeted Host functionality over one or more Standard-A or Micro-AB receptacles. Embedded Host products may also offer USB peripheral capability, delivered separately via one or more Type-B receptacles.
2. **On-The-Go:** An OTG product is a portable device that uses a single Micro-AB receptacle (and no other USB receptacles) to operate at times as a USB Targeted Host and at times as a USB peripheral. OTG devices shall always operate as a standard peripheral when connected to a standard USB host.

OTG devices can also be attached to each other. This specification enables the underlying driver components to optionally swap between the role of either USB host or USB peripheral, without needing to physically turn the cable around.

[OTG&EH2.0] applies to all Universal Serial Bus products. This supplement covers products which have a SuperSpeed capability (as defined in the [USB3.0] specification) in addition to having capabilities defined in [OTG&EH2.0]. The following additional configurations are covered by this supplement:

1. **SuperSpeed Embedded Host or SS-EH:** An Embedded Host which can operate at SuperSpeed through its one or more Standard-A or Micro-AB receptacles in addition to EH capability defined in [OTG&EH2.0] for example support for SRP and ADP.

2. **SuperSpeed Peripheral Only** or **SS-PO**: A peripheral-only B-device which can operate at SuperSpeed in addition to having peripheral-only B-device capabilities as described in [OTG&EH2.0].

3. **SuperSpeed Peripheral Capable OTG Device** or **SSPC-OTG**: An OTG device compliant with [OTG&EH2.0] which can also operate as a SuperSpeed peripheral. Products with this configuration are not able to operate as a SuperSpeed host. When operating as a peripheral, they can operate at either SuperSpeed or [OTG&EH2.0] speeds. However they may only be able to swap roles when operating at [OTG&EH2.0] speeds.

4. **SuperSpeed OTG Device** or **SS-OTG**: An OTG Device compliant with [OTG&EH2.0] which can also operate as a SuperSpeed Host or a SuperSpeed Peripheral. Products with this configuration may be able to dynamically swap host/peripheral roles while operating at SuperSpeed using the mechanisms defined in this supplement.

Devices which conform to [OTG&EH2.0] are referred to as [USB2.0] devices in this supplement: USB2.0 EH, USB2.0 OTG and USB2.0 PO.

1.2 Related Documents

This is not a stand-alone document. It is a supplement to [USB3.0]. Any aspects of USB which are not specifically changed by this supplement are governed by [USB3.0].

The following referenced documents can be found on the USB-IF website www.usb.org:

| | |
|-----------------|---|
| [USB3.0] | <i>Universal Serial Bus Revision 3.0 Specification including ECNs and errata.</i> |
| [Micro-USB1.01] | <i>Universal Serial Bus Micro-USB Cables and Connectors Supplement to the USB 2.0 Specification, revision 1.01.</i> |
| [USB2.0] | <i>Universal Serial Bus Revision 2.0 Specification including ECNs and errata.</i> |
| [OTG&EH2.0] | <i>On-The-Go and Embedded Host Supplement to the Universal Serial Bus Revision 2.0 Specification including ECNs and errata.</i> |
| [USBattery1.2] | <i>USB Battery Charging Specification, revision 1.2.</i> |
| [xHCI] | <i>eXtensible Host Controller Interface for Universal Serial Bus (xHCI), revision 1.0</i> |

1.3 Terminology

“Shall” is normative and used to indicate mandatory requirements which are to be followed strictly in order to conform with this standard.

“Should” is normative and used to indicate a recommended option or possibility.

“may” is normative and used to indicate permitted behavior.

“can” is informative and used to indicate behavior which is possible or may be seen

The use of “must” and “will” is deprecated for requirements and shall only be used for statements of fact.

1.4 Acronyms and Terms

This section lists and defines terms and abbreviations used throughout this specification.

| | |
|---------------------|--|
| ACA | Accessory Charger Adapter (see [USBBattery1.2]). |
| A-Device | Device with a Standard-A receptacle or a device with a Micro-A plug attached to its receptacle. The A-device supplies power to VBUS and is host at the start of a session. |
| A-Host | A-Device operating as a host. |
| A-Port | Port featuring an A-type receptacle. |
| A-Peripheral | A-Device operating as a peripheral. |
| AB-Port | Port featuring an AB-type receptacle. |
| ADP | Attach Detection Protocol. A protocol which enables an OTG device or EH to detect when a remote device has been attached or detached (as defined in [OTG&EH2.0]). |
| ADP-capable | Device which is able to perform ADP probing and ADP sensing ¹ . |
| ADP probing | This enables the local A-device or B-device to probe VBUS and determine whether a device is attached. |
| ADP sensing | This enables the local B-device to detect ADP probing generated by an attached device. ADP sensing is not a requirement for A-devices. |
| Application | A generic term referring to any software that is running on a device that can control the behavior or actions of the USB port(s) on a device. |
| Attach | This specification makes a distinction between the words “attach” and “connect”. A downstream device is considered to be attached to an upstream port when there is a physical cable between the two. |
| B-Device | Device with: <ul style="list-style-type: none">• a Standard-B receptacle or,• Mini-B receptacle, or• Micro-B receptacle, or• Micro-AB receptacle with either a Micro-B plug or no plug attached to its receptacle, or• a captive cable ending in a Standard-A or Micro-A plug. The B-device is a peripheral at the start of a session. |
| B-Host | B-Device operating as a host. |
| B-Port | Port featuring a B-type receptacle. |
| B-Peripheral | B-Device operating as a peripheral. |
| Connect | This specification makes a distinction between the words “attach” and “connect”. A downstream device is considered to be connected to an attached upstream port when the upstream port has either pulled the D+ or D- data line high |

¹ An ADP-capable EH is not required to do ADP sensing since it is not able to operate in the B-device position.

through a 1.5 kΩ resistor to enter Low Speed, Full Speed or High Speed signaling or the upstream port has asserted Rx terminations to enter SuperSpeed signaling.

| | |
|------------------------|--|
| Downstream(DS) | The direction of data flow from the host or away from the host. A downstream port is the port on a hub electrically farthest from the host that generates downstream data traffic. Downstream ports receive upstream data traffic. |
| Downstream port | The port on a host or hub to which a device is connected. A EH's root ports are downstream ports. The port on an OTG Device can operate as a downstream or upstream port. |
| EH | Embedded Host. |
| Embedded Host | A product that has one or more Standard-A and/or Micro-AB receptacles supported by a USB Host Controller. Embedded Hosts have a particular set of targeted peripherals, as described in their TPL. |
| FS | Full Speed (as defined in [USB2.0]). |
| HS | High Speed (as defined in [USB2.0]). |
| Host | A physical entity that is attached to a USB cable and is acting in the role of the USB host as defined in [USB2.0]. This entity initiates all data transactions and provides periodic Start of Frames (SOF's). |
| HNP | Host Negotiation Protocol (as defined in [OTG&EH2.0]). |
| ID | Identification. Denotes the pin on the Micro connectors that is used to differentiate a Micro-A plug (ID pin is FALSE) from a Micro-B plug (ID pin is TRUE). See [USB3.0] for details. |
| LPM | Link Power Management (as defined in [USB2.0]). |
| LS | Low Speed (as defined in [USB2.0]). |
| OTG | On-The-Go. |
| OTG device | Device that provides both host and peripheral capabilities over a single Micro-AB receptacle, as outlined in Section 2.1 |
| Peripheral | A physical entity that is attached to a USB cable and is currently operating as a "device" as defined in [USB2.0]. The peripheral responds to low level bus requests from the host. |
| PO | Peripheral Only. Used to denote devices that can only function as a peripheral and as a B-Device |
| SE0 | Single Ended Zero (as defined in [USB2.0]). |
| Session | The period of time that VBUS is powered (as defined in [OTG&EH2.0]) |
| RSP | Role Swap Protocol |
| SOF | Start of Frame (as defined in [USB2.0]). |
| SRP | Session Request Protocol |
| SRP-capable | Device which is able to generate or respond to SRP signaling. |
| SS | SuperSpeed (as defined in [USB3.0]) |
| SS-EH | SuperSpeed Embedded Host. An Embedded Host with SuperSpeed capability. |
| SS-OTG | SuperSpeed OTG Device. An OTG Device which is capable of SuperSpeed operation as both a Host and Peripheral. |

| | |
|---------------------------------|---|
| SSPC-OTG | SuperSpeed Peripheral Capable OTG Device. An USB 2.0 OTG Device which can also operate as a SuperSpeed peripheral. |
| SS-PO | SuperSpeed Peripheral-Only. A SRP-capable and/or ADP-capable peripheral-only B-device which has SuperSpeed capability |
| Targeted Host | A host that is only required to support the peripherals on its Targeted Peripheral List. OTG devices and Embedded Hosts both have Targeted Host functionality. |
| Targeted Peripheral List | A list of USB peripherals that a particular Targeted Host can support (see Section 2.5.3). |
| TPL | Targeted Peripheral List. |
| Upstream(US) | The direction of data flow towards the host. An upstream port is the port on a device electrically closest to the host. Upstream ports receive downstream data traffic. |
| Upstream port | A port used to connect to a host or a hub. Any B-port is an upstream port. The port on an OTG Device can operate as a downstream or upstream port. |
| USB | Universal Serial Bus. |
| USB2.0 EH | EH capable of only USB 2.0 data rates (HS, FS, LS) |
| USB2.0 OTG | OTG Device capable of only USB 2.0 data rates (HS, FS, LS) |
| USB2.0 PO | Peripheral-only B-device capable of only USB 2.0 data rates (HS, FS, LS) |
| USB-IF | USB Implementers Forum (See www.usb.org). |

2 OTG and EH key features

When operating at USB 2.0 data rates **SS-EH**, **SSPC-OTG**, **SS-OTG** and SRP-capable or ADP-capable **SS-PO** products shall be compliant with [OTG&EH2.0] with the exception of the connector which shall comply with [USB3.0]. The following sections describe the additional key features in such products.

2.1 Connectors, cable assemblies and cable adapters

2.1.1 SS-OTG and SSPC-OTG Devices

An **SS-OTG** or **SSPC-OTG** device shall have one, and only one USB connector: a USB 3.0 Micro-AB receptacle as defined in [USB3.0]. This receptacle is capable of accepting either a Micro-A plug or a Micro-B plug attached to any of the legal cables and adapters defined in [Micro-USB1.01] and [USB3.0].

2.1.2 SS-PO Devices

SRP-capable **SS-PO** Devices shall have a compliant B-device side connector as for other **SS-PO** B-devices, for example: a Micro-B or captive connector. Compliant B Type connectors are defined in [USB3.0].

2.1.3 SS-EH Devices

An **SS-EH** Device shall have either one or more Standard-A receptacles and/or one or more Micro-AB receptacles as defined in [USB3.0]. An **SS-EH** Device may contain one or more Standard-A receptacles as defined in [USB2.0]. An **SS-EH** Device may contain one or more Micro-AB receptacles as defined in [Micro-USB1.01]. An **SS-EH** Device may contain one or more Type-B receptacles as defined in either [USB2.0] or [USB3.0] but these shall be implemented such that the user is unlikely confuse the **SS-EH** Device with a USB hub.

Where an **SS-EH** employs either a Micro-AB as defined in [USB3.0] or a Micro-AB as defined in [Micro-USB1.01], it is possible for a user to attach another USB host to the **SS-EH** via a Micro-B plug. In order to avoid back-driving VBUS in such a scenario, an Embedded Host which supports Micro-AB shall only enable Vbus when the ID pin becomes FALSE as defined in [USB3.0] or [Micro-USB1.01]. On detection of a valid voltage above the range defined by VOTG_SESS_VLD in [OTG&EH2.0] an Embedded Host should display a non-silent failure message to the end user.

2.2 Support for USB 3.0 and 2.0

In order to maintain backwards compatibility with [OTG&EH2.0], devices which operate as **SS-OTG** or **SSPC-OTG** devices shall also have the capability to operate as **USB2.0 OTG** devices. Similarly, an **SS-EH** shall also be able to operate as a **USB2.0 EH**. SRP-capable **SS-PO** devices shall also be able to operate as **USB2.0 PO** devices.

2.3 Symmetry

Symmetrical operation of **SS-OTG** and **SSPC-OTG** devices is a highly desirable feature but shall be optional for such devices. It is not required for role swapping, by either HNP or RSP, to be supported by **SS-OTG** or **SSPC-OTG** devices. The level of symmetry exhibited depends on the type of devices attached to each other. The following describes device operations which shall be exhibited when symmetrical operation is supported by both devices (i.e., both devices support RSP described in Section 5.4).

For the rest of this specification, unless otherwise stated, all SuperSpeed RSP swap operations described assume "RSP Support =1" is reported in the OTG Descriptor as defined in Section 5.1.

SS-OTG devices attached to each other shall demonstrate the same SuperSpeed behavior to the end user regardless of whether they are attached as the A-device or the B-device. When the user interacts

with one **SS-OTG** device, this causes a session to be started, and the user is able to access or control the second **SS-OTG** device at SuperSpeed using applications running on the first OTG device. During a session, the role of host can be transferred back and forth between the A-device and the B-device any number of times, using the Role Swap Protocol. When operating at SuperSpeed, an **SS-OTG A-Host** shall always initiate the Role Swap Protocol (RSP) when it receives the request from a **B-Peripheral** to become the host (See Section 6.4.3). Similarly, the **B-Host** shall initiate the Role Swap Protocol whenever the **A-Peripheral** requests to become the host. When an **SS-OTG** device is attached to an **SSPC-OTG** device, RSP is not supported but it may be possible to swap roles at [OTG&EH2.0] data rates. Please see Appendix A SSPC-OTG Device Operations for more information.

SSPC-OTG devices support SuperSpeed capability only as a peripheral. They do not support the USB3.0 based Role Swap Protocol and as a result will not demonstrate symmetry in the speed of the connection. A suitable message may be displayed to the user to indicate that reversing the cable may allow for a SuperSpeed capable session. Symmetry may be demonstrated by allowing control of an attached **SS-OTG** A-device at High Speed using HNP defined in [OTG&EH2.0]. In order to swap roles an SSPC-OTG device may disconnect and reconnect in [OTG&EH2.0] operation in order to use HNP. When it completes using the bus, it shall generate a disconnect again and then reconnect as **SS B-Peripheral**. Appendix A SSPC-OTG Device Operations provides more details on the expected behavior when attaching a SSPC-OTG device to a SSPC-OTG, SS-OTG or USB 2.0 OTG device.

2.4 Protocols

2.4.1 USB 3.0 based Role Swap Protocol (RSP)

RSP enables **SS-OTG** devices to swap roles using USB 3.0 protocols rather than HNP. **SS-OTG** devices shall use the OTG descriptor to communicate role swapping capabilities. Device Notification Transaction Packets shall be used by the peripheral to notify the host to prepare for a role swap. A SET_FEATURE mechanism is used by the **B-Host** to relinquish host role.

The details of this protocol are found in Section 5.4.

2.4.2 HNP, SRP and ADP

The ADP mechanism described in [OTG&EH2.0] may be employed by the **SS-OTG**, **SSPC-OTG**, **SS-PO** and **SS-EH** devices defined in this supplement to detect an attach event.

The SRP mechanism described in [OTG&EH2.0] may be employed by the **SS-OTG**, **SSPC-OTG** and **SS-PO** devices defined in this supplement. An **SS-EH A-Port** may detect and respond to a SRP event.

The HNP mechanism described in [OTG&EH2.0] may be employed by the **SS-OTG** and **SSPC-OTG** devices defined in this supplement when operating at High or Full Speed. HNP shall not apply to SuperSpeed operation where RSP may be used instead (see Section 5.4).

2.5 Capability limitation

Targeted Hosts shall be fully compliant with the relevant USB-IF specifications including [OTG&EH2.0], [USB2.0], [USB3.0] and [USBBattery1.2] where battery charging or ACA are supported. However a given Targeted Host may not support the full suite of functionality defined in these specifications. [OTG&EH2.0] defines the capability limitation requirements for Targeted Hosts with additional requirements for SuperSpeed capable products being listed below.

2.5.1 RSP Support

The Role Swap Protocol shall only apply to **SS-OTG** devices and shall be optional for such devices.

2.5.2 Operating speeds

A Targeted Host shall be able to support SuperSpeed and Full Speed. High Speed should be supported to prevent a gap in the operating speeds supported. Low Speed may be supported depending on the Targeted Hosts TPL.

An **SS-OTG**, or **SSPC-OTG** device shall be able to enumerate both as a SuperSpeed and Full Speed peripheral. An **SS-OTG**, or **SSPC-OTG** device should be able to enumerate as a High Speed peripheral (to prevent a gap in the operating speeds supported) and shall not be able to enumerate as a Low Speed peripheral.

2.5.3 Targeted Peripheral List

The provision for a Targeted Peripheral List as defined in [OTG&EH2.0] shall also apply to this supplement i.e. a Targeted Host is not required to support all types of USB peripherals but only a subset which is referred to as that Targeted Host's "Targeted Peripheral List". For example, an **SSPC-OTG** device will not include **SSPC-OTG**, **SS-PO** or **SS-OTG** devices on its Targeted Peripheral List because it does not support SuperSpeed host functionality.

2.6 No Silent Failures

The requirement to communicate messages to the user in the event of failures as defined in [OTG&EH2.0] shall also apply to this supplement. This supplement does not mandate the messages themselves or the user interface mechanism to be used but recommends that the messages should be self explanatory and not require the user to reference a manual or other additional material.

3 Electrical characteristics

All SuperSpeed capable EH and OTG products shall comply with both [OTG&EH2.0] and [USB3.0] electrical requirements. The electrical parameters referenced in this supplement are listed in Table 3-1.

Table 3-1: Electrical Parameters

| Parameter | Symbol | Reference |
|----------------------------------|----------------|-------------|
| OTG device or EH Leakage Voltage | VOTG_VBUS_LKG. | [OTG&EH2.0] |
| OTG device Session Valid | VOTG_SESS_VLD | [OTG&EH2.0] |
| ADP threshold capacitance | CADP_THR | [OTG&EH2.0] |

4 Signaling Characteristics

All SuperSpeed capable EH and OTG products shall comply with both [OTG&EH2.0] and [USB3.0] signaling and timing requirements. The relevant parameters referenced in this supplement are listed in Table 4-1.

Table 4-1: Signalling Timing Parameters

| Parameter | Symbol | Reference |
|--|-------------------------------|-------------|
| Wait for B-Connect | TA_WAIT_BCON | [OTG&EH2.0] |
| VBUS Rise Time | TA_VBUS_RISE | [OTG&EH2.0] |
| A-Idle to B-Disconnect | TA_AIDL_BDIS | [OTG&EH2.0] |
| Session end to VOTG_VBUS_LKG | TSEND_LKG | [OTG&EH2.0] |
| B-device ADP detach time, sensing mode | TB_ADP_DETACH | [OTG&EH2.0] |
| Session End to SRP Init | TB_SSEND_SRP | [OTG&EH2.0] |
| Time for Reset Error | tTimeForResetError | [USB3.0] |
| Timer in Polling.LFPS substate | tPollingLFPSTimeout | [USB3.0] |
| Timer in Polling.Active substate | tPollingActiveTimeout | [USB3.0] |
| Timer in Polling.Idle substate | tPollingIdleTimeout | [USB3.0] |
| Timer in Recovery.Active substate | tRecoveryActiveTimeout | [USB3.0] |
| Timer in Recovery.Configuration substate | tRecoveryConfigurationTimeout | [USB3.0] |
| Timer in Recovery.Idle substate | tRecoveryIdleTimeout | [USB3.0] |

5 Device Framework

SS-OTG and SSPC-OTG devices shall comply with the device framework requirements as described in [OTG&EH2.0]. Additional requirements are described in the following sections.

5.1 OTG descriptor

Any B-device that is compliant with this supplement shall respond to a GetDescriptor(OTG) request with an OTG descriptor as defined in Table 5-1. The B-device shall also return the OTG descriptor as part of a GetDescriptor(Configuration) request. **SS-PO** devices that are SRP-capable or ADP-capable shall also support the OTG descriptor. **B-Port** devices may support SRP and ADP mechanisms. The **B-Port** of a **SS-EH** shall also support the OTG descriptor if either SRP or ADP or both mechanisms are supported. The behavior of an **A-Peripheral** with respect to the OTG descriptor is undefined.

The format as defined in Table 5-1 is backwards compatible with the OTG descriptor defined in [OTG&EH2.0].

Table 5-1: OTG Descriptor

| Offset | Field | Size | Value | Description |
|--------|------------------------|------|----------|---|
| 0 | <i>bLength</i> | 1 | Number | Size of Descriptor = 5 |
| 1 | <i>bDescriptorType</i> | 1 | Constant | OTG type = 9 |
| 2 | <i>bmAttributes</i> | 1 | Bitmap | Attribute Fields D7...4: Reserved (reset to zero) D3: RSP support D2: ADP support D1: HNP support D0: SRP support |
| 3 | <i>bcdOTG</i> | 2 | BCD | This field contains a BCD version number that identifies the release of the OTG and EH supplement with which the device corresponds to. |

5.1.1 SRP, HNP and ADP support

These bit definitions as defined in Table 5-1 for indicating SRP, HNP and ADP support shall remain unchanged. For more details please refer to [OTG&EH2.0]

5.1.2 RSP support

This bit as defined in Table 5-1 shall be set to TRUE when a B-device is able to perform RSP. This bit enables an A-device to determine when a SET_FEATURE request to enable RSP in the B-device is necessary as described in Section 5.2.2.

5.1.3 OTG and EH supplement release number

This field as defined in Table 5-1 identifies the release of the OTG and EH supplement with which the device corresponds to. The format is a BCD number with a value of 0xMMNN (MM – major version number, NN – minor version number), e.g., version 3.0 is represented with the value 0300H.

SSPC-OTG, **SS-OTG** and SRP/ADP-capable **SS-PO** devices shall set this field to 0300H.

5.2 Standard Device Features

Table 5-2 shows the feature selectors which shall be supported by **SS-OTG** products with either HNP and/or RSP support. These are set with a SET_FEATURE request from an A-device.

Table 5-2: OTG Feature Selectors

| Feature Selector | Recipient | Value | Host Request | Feature Supported by | Ref |
|-------------------|-----------|-------|--------------|----------------------|------------------|
| b_hnp_enable | Device | 3 | SET_FEATURE | B-device | [OTG&EH2.0] |
| a_hnp_support | Device | 4 | SET_FEATURE | B-device | [OTG&EH2.0] |
| a_alt_hnp_support | Device | 5 | SET_FEATURE | B-device | [OTG&EH2.0] |
| NTF_HOST_REL | Device | 51 | SET_FEATURE | A-device & B-device | 5.2.1 & [USB3.0] |
| B3_RSP_ENABLE | Device | 52 | SET_FEATURE | B-device | 5.2.2 & [USB3.0] |

5.2.1 NTF_HOST_REL

The Feature Selector NTF_HOST_REL value is defined in [USB3.0] and is shown in Table 5-2.

A SS-OTG A-device or a B-device operating in host role shall use the SET_FEATURE command with this Feature Selector to notify the peripheral that a subsequent warm reset should be treated as a role swap request. This command is sent as part of the Role Swap protocol with specific timing constraints as detailed in Section 5.4.

The Request shall be issued only to a device that is in the Address or Configured State and only to the default control pipe. If an interface or an endpoint other than the Default Control Pipe is specified then the device shall respond with a Request Error.

5.2.2 B3_RSP_ENABLE

An A-device shall use the SET_FEATURE command to enable the B3_RSP_ENABLE feature in RSP-capable devices (see Section 5.4). Once an A-device that supports RSP determines that a B-device also supports RSP capability in its OTG descriptor (See Section 5.1.2), it shall enable the RSP capability within **TRSP_ENABLE** of configuring the B-device.

A B-device that is RSP capable shall accept the SET_FEATURE commands for this feature. If the device is not RSP capable, it shall return STALL if it receives a SET_FEATURE command for this feature. A B-device shall not issue HOST_ROLE_REQUEST Device Notification TP if its RSP capability is not enabled by the A-device.

The Request shall be issued only to a device that is in the Address or Configured State and only to the default control pipe. If an interface or an endpoint other than the Default Control Pipe is specified then the device shall respond with a Request Error.

Setting this feature when it is already set is not an error. The device receiving such a command shall acknowledge the command indicating successful completion.

5.3 Port capabilities for OTG devices operating at SuperSpeed

OTG devices operating at SuperSpeed shall set only one of the two Direction bits (1:16 or 1:17) of the Port Capability LMP [USB3.0] as follows:

- At the start of a session the OTG A-device shall default to host role and shall set the Downstream bit (1:16)
- At the start of a session the OTG B-device shall default to peripheral role and shall set the Upstream bit (1:17)
- At the end of a role swap the OTG device shall set either the Upstream or the Downstream bit depending on the role being transitioned to.

The above described behavior and the corresponding mapping to the OTG state of the device is defined in Table 5-3.

Table 5-3: Port Capability LMP – OTG State Mapping

| OTG state | Direction (D) (bits 1:16 to 1:17) ² | |
|-----------------------------------|---|---|
| | Downstream Capable (bit 1:16) ² | Upstream capable (bit 1:17) ² |
| a3_ds_host/b3_ds_host | 1 | 0 |
| a3_us_peripheral/b3_us_peripheral | 0 | 1 |

The Tiebreaker (bits 1:20 to 1:23) field of the Port Capability LMP are not used by OTG devices.

5.4 Role Swap Protocol (RSP)

SS-OTG devices when operating at SuperSpeed shall only use the RSP mechanism as defined in this section for swapping roles with other **SS-OTG** devices. **SS-OTG** or **SSPC-OTG** devices may use HNP as defined in [OTG&EH2.0] for swapping roles with other **SSPC-OTG** devices which support HNP.

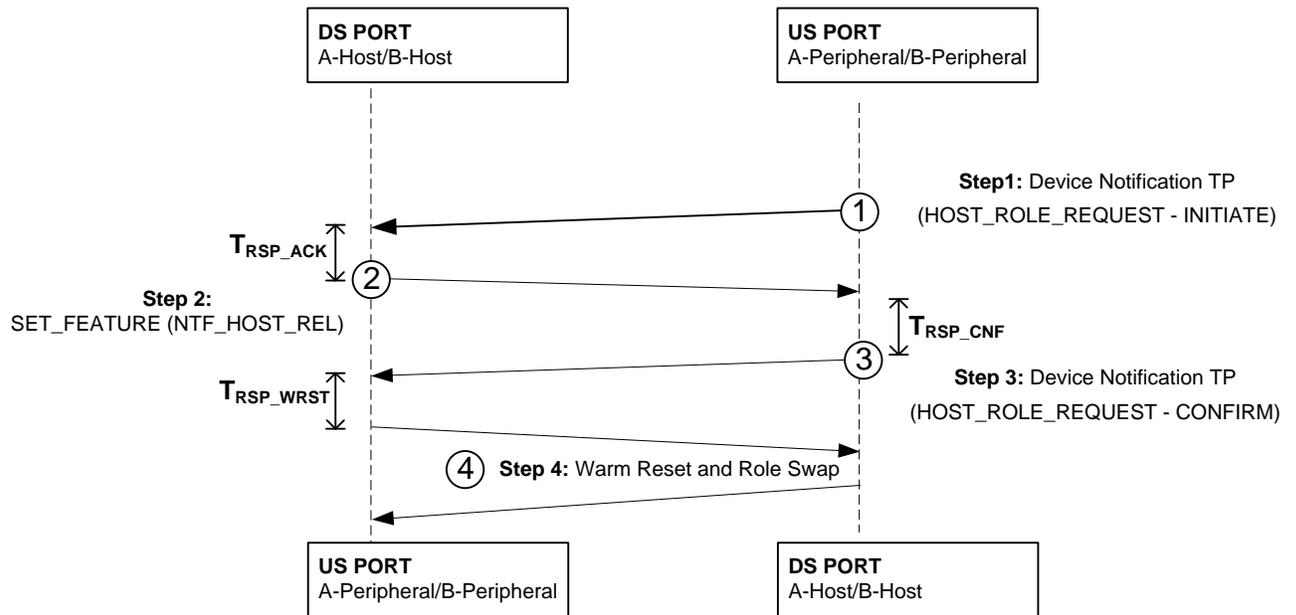
5.4.1 RSP Process

The Role Swapping process is used to swap host and peripheral roles between the A-device and the B-device and shall be initiated by:

- the B-Peripheral in order to assume host role functionality from an A-Host (RSP Step 1 below) or
- the A-Peripheral in order to assume host role functionality from a B-Host (RSP Step 1 below) or
- the B-Host in order to release host role functionality to an A-Peripheral (RSP Step 2 below).

² Offset (DW:Bit) in the Port Capability LMP Format

Figure 5-1: The Role Swap Protocol



The steps involved in the Role Swap Protocol are shown in Figure 5-1 and detailed below:

RSP Step 1:

- The US Port shall initiate the RSP process by requesting host role using a HOST_ROLE_REQUEST Device Notification TP.
- The RSP Phase of the Device Notification TP shall be set to INITIATE as detailed in Section 5.5.
- This step shall not take place when RSP is initiated by a B-Host.

RSP Step 2:

- The DS Port shall release host role using the SET_FEATURE command with the NTF_HOST_REL feature selector.
- A DS Port that has sent this SetFeature (NTF_HOST_REL) request shall not subsequently generate any warm resets on the link prior to the warm reset in RSP Step 4 that concludes the RSP process.
- A US Port that has not yet received this SetFeature (NTF_HOST_REL) request shall treat any warm reset signaled by the DS port as a standard warm reset.
- In the case of an RSP initiated by a US port:
 - The Downstream Port shall immediately send the SET_FEATURE command in this step if it is in a state where a role swap can be completed without undesirable side-effects.
 - If the Downstream Port is not ready for a role swap it shall perform a clean-up and then send the SET_FEATURE command within T_{RSP_ACK} of receiving the request from the peripheral in Step 1 above.
 - The US Port that does not receive the SET_FEATURE command within $T_{RSP_ACK_ERR}$ of requesting host role shall transition to an error state.

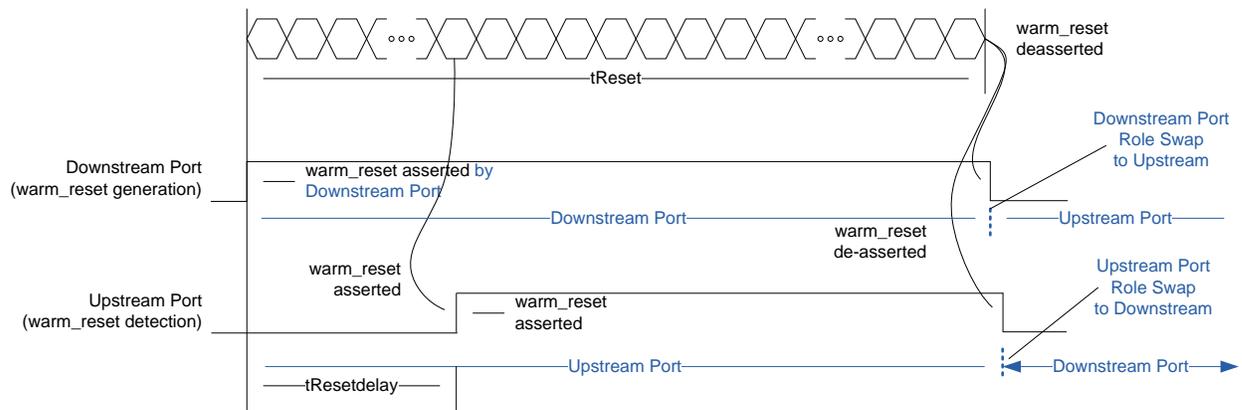
RSP Step 3:

- The US Port shall confirm that it is ready for the Warm Reset and Role Swap process by issuing a HOST_ROLE_REQUEST Device Notification TP.
- The RSP Phase field of the Device Notification TP shall be set to CONFIRM as detailed in Section 5.5.
- The Device Notification TP shall be sent within **TRSP_CNF** of receiving the SET_FEATURE command in RSP Step 2.
- If the DS Port does not receive this Device Notification TP within **TRSP_CNF_ERR** of issuing the SET_FEATURE command in Step 2 above, it shall transition to an error state.

RSP Step 4:

- The DS Port shall initiate the role swap by issuing a warm reset within **TRSP_WRST**.
- If the US Port does not receive the warm reset within **TRSP_WRST_ERR** of issuing the Device Notification TP in Step 3, it shall transition to an error state.
- Following the warm reset the A-device and B-device shall start up in the opposite role to the one they had prior to the reset as shown in Figure 5-2.

Figure 5-2: Warm Reset & Role Swap Protocol ³



Warm Reset shall be signaled as part of the role swapping process as defined below:

The host and peripheral port pairs shall exchange capabilities (either US or DS) using a LMP Port Capability packet with values set as defined in Section 5.3 and below:

- the OTG device which was acting as peripheral prior to the warm reset shall set the Downstream bit (1:16) in order to become the host (Downstream port).
- the OTG device which was acting as host prior to the warm reset shall set the Upstream bit (1:17) in order to become the peripheral (Upstream port).

³ Based on Fig 6-22 from the [USB3.0] specification (modifications from original are in blue)

5.4.2 RSP Boundary Case

The expected behavior and associated timing parameters for the RSP process are detailed in Section 5.4.1. However the asynchronous nature of the process creates a boundary case when RSP is initiated between a B-Host and an A-Peripheral as described in this section.

Figure 5-3: RSP Boundary Case

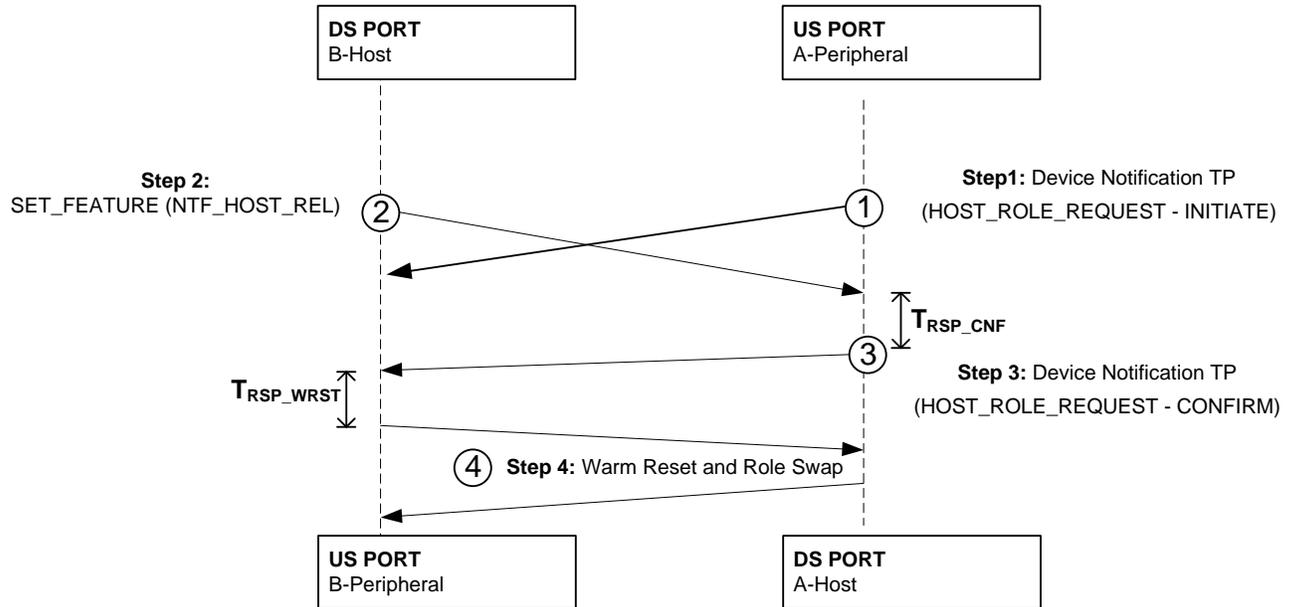


Figure 5-3 illustrates the boundary case when the B-Host simultaneously initiates RSP Step 1 along with an A-Peripheral that initiates RSP Step 2. The following is to be noted regarding the handling of this boundary case.

- A B-Host that has completed RSP Step 2 shall ignore any subsequent or concurrently received HOST_ROLE_REQUEST Device Notification TPs that have the RSP Phase set to INITIATE.
- An A-Peripheral that receives a SetFeature (NTF_HOST_REL) request shall directly proceed to complete RSP Step 3 irrespective of the state of any RSP Step 1 that may be in process.

5.4.3 RSP Timing Parameters

Table 5-4 documents the timing parameters associated with the Role Swap Protocol.

Table 5-4: RSP timing parameters

| Parameter | Symbol | Min | Max | Units |
|--|---------------|-----|-----|-------|
| Time from when the A-device selects a non-zero configuration until when the SET_FEATURE for enabling RSP is issued on the link | TRSP_ENABLE | | 2 | sec |
| Time spent by a DS device between the reception of an RSP Device Notification TP - INITIATE and the transmission of a SET_FEATURE (RSP Step 1 to RSP Step 2) | TRSP_ACK | | 2 | sec |
| Time spent by a US device waiting between the transmission of an RSP Device Notification TP – INITIATE and the transition to an Error State (on failure to detect a SET_FEATURE) (RSP Step 1 to Error State) | TRSP_ACK_ERR | 2.5 | 3 | sec |
| Time spent by a US device between the reception of a SET_FEATURE and the transmission of a Device Notification TP – CONFIRM to confirm the RSP process (RSP Step 2 to RSP Step 3) | TRSP_CNF | | 100 | ms |
| Time spent by a DS device between the transmission of a SET_FEATURE and the transition to an Error State (RSP Step 2 to Error State) | TRSP_CNF_ERR | 150 | 200 | ms |
| Time spent by a DS device between the reception of a Device Notification TP – CONFIRM and the generation of warm reset (RSP Step 3 to RSP Step 4) | TRSP_WRST | | 100 | ms |
| Time spent by a US device between the transmission of a Device Notification TP – CONFIRM and the transition to an error state (RSP Step 3 to RSP Step 4) | TRSP_WRST_ERR | 150 | 200 | ms |

5.5 Device Notification TP (HOST_ROLE_REQUEST)

SS-OTG devices shall issue a Device Notification Transaction Packet (HOST_ROLE_REQUEST) only if its RSP capability has been enabled as described in Section 5.2.2. The Device Notification TP shall be issued with the Notification Type (Offset 1:4) value set to HOST_ROLE_REQUEST and as defined in the

[USB3.0]. The “RSP Phase” field is set depending on the specific step in the RSP process that the Device Notification TP is sent as defined in Table 5-5.

Table 5-5: Device Notification TP – HOST_ROLE_REQUEST

| Width (bits) | Offset (DW:bit) | Description | | | | | | | | | | |
|--------------|--|---|--------------|------------------------------------|-------|-------------------|-----|--|-----|--|-----|----------|
| 4 | 1:0 | SubType The field shall be set to DEV_NOTIFICATION | | | | | | | | | | |
| 4 | 1:4 | <p>Notification Type The field identifies the type of device notification and shall be set to the following:</p> <table border="1"> <thead> <tr> <th><u>Value</u></th> <th><u>Type of Notification Packet</u></th> </tr> </thead> <tbody> <tr> <td>0100b</td> <td>HOST_ROLE_REQUEST</td> </tr> </tbody> </table> | <u>Value</u> | <u>Type of Notification Packet</u> | 0100b | HOST_ROLE_REQUEST | | | | | | |
| <u>Value</u> | <u>Type of Notification Packet</u> | | | | | | | | | | | |
| 0100b | HOST_ROLE_REQUEST | | | | | | | | | | | |
| 2 | 1:8 | <p>RSP Phase (Notification Type Specific)</p> <table border="1"> <thead> <tr> <th><u>Value</u></th> <th><u>Description</u></th> </tr> </thead> <tbody> <tr> <td>00b</td> <td>Reserved</td> </tr> <tr> <td>01b</td> <td>INITIATE : Set when initiating RSP in RSP Step 1</td> </tr> <tr> <td>10b</td> <td>CONFIRM: Set when confirming RSP in RSP Step 3</td> </tr> <tr> <td>11b</td> <td>Reserved</td> </tr> </tbody> </table> | <u>Value</u> | <u>Description</u> | 00b | Reserved | 01b | INITIATE : Set when initiating RSP in RSP Step 1 | 10b | CONFIRM: Set when confirming RSP in RSP Step 3 | 11b | Reserved |
| <u>Value</u> | <u>Description</u> | | | | | | | | | | | |
| 00b | Reserved | | | | | | | | | | | |
| 01b | INITIATE : Set when initiating RSP in RSP Step 1 | | | | | | | | | | | |
| 10b | CONFIRM: Set when confirming RSP in RSP Step 3 | | | | | | | | | | | |
| 11b | Reserved | | | | | | | | | | | |
| 22 | 1:10 | Reserved (Notification Type Specific) shall be set to zero | | | | | | | | | | |
| 32 | 2:0 | Reserved (Notification Type Specific) shall be set to zero | | | | | | | | | | |

5.6 Role Negotiation Consequences

A peripheral device should warn its user of the possible consequences before using RSP in situations where a badly timed role swap may cause data loss or corruption. For example, a forced role swap in the middle of a long-running low-level disk copy using the Mass Storage Class could result in a corrupted Mass Storage Device. The ability of a peripheral to request a role swap at any time may also cause thrashing with repeated role swaps taking place.

The peripheral device may choose to warn or not to warn the user based on knowledge of the current functions it is providing to the host, as some functions may be more robust to unexpected disconnections than others.

6 State Diagram

This section contains state diagrams provided for the reference of **SS-OTG**, **SSPC-OTG**, **SS-EH** and SRP/ADP-capable **SS-PO** implementers. In the case of any conflict between these diagrams and the behavior described in the rest of the document, the state machines shall take precedence.

Device capabilities are indicated by constants - **otg**, **eh**, **po** and **ss_host_support** – that are used to define which type of device is intended by a given set of values.

- **SS-OTG** (**otg** = TRUE, **eh** = FALSE, **po** = FALSE and **ss_host_support** = TRUE)
- **SSPC-OTG** (**otg** = TRUE, **eh** = FALSE, **po** = FALSE and **ss_host_support** = FALSE)
- **SS-PO** devices (**otg** = FALSE, **eh** = FALSE, **po** = TRUE and **ss_host_support** = FALSE)
- **SS-EH** (**otg** = FALSE, **eh** = TRUE, **po** = FALSE and **ss_host_support** = TRUE)

For each combination of constants it is therefore possible to determine, from the state diagrams in this section, a subset of states which must be supported.

The following state machines are described in this section:

- Section 6.1 documents the “Common State Diagram” that shall be followed by both A and B-devices when the session is not valid.
- Section 6.2 documents the “A-device USB3.0 State Diagram” that shall be followed by an A-device when it operates at [USB3.0] rates and the session is valid.
- Section 6.3 documents the “B-device USB3.0 State Diagram” that shall followed by a B-device when it operates at [USB3.0] rates and the session is valid.

A device compliant with this supplement shall follow the relevant state machines defined in [OTG&EH2.0] when it operates at [USB2.0] data rates (HS, FS or LS) and the session is valid. This supplement shall not apply to [OTG&EH2.0] devices that are not designed to operate at [USB3.0] rates and such devices shall be compliant with the state machines in the [OTG&EH2.0] specification.

6.1 Common State Diagram

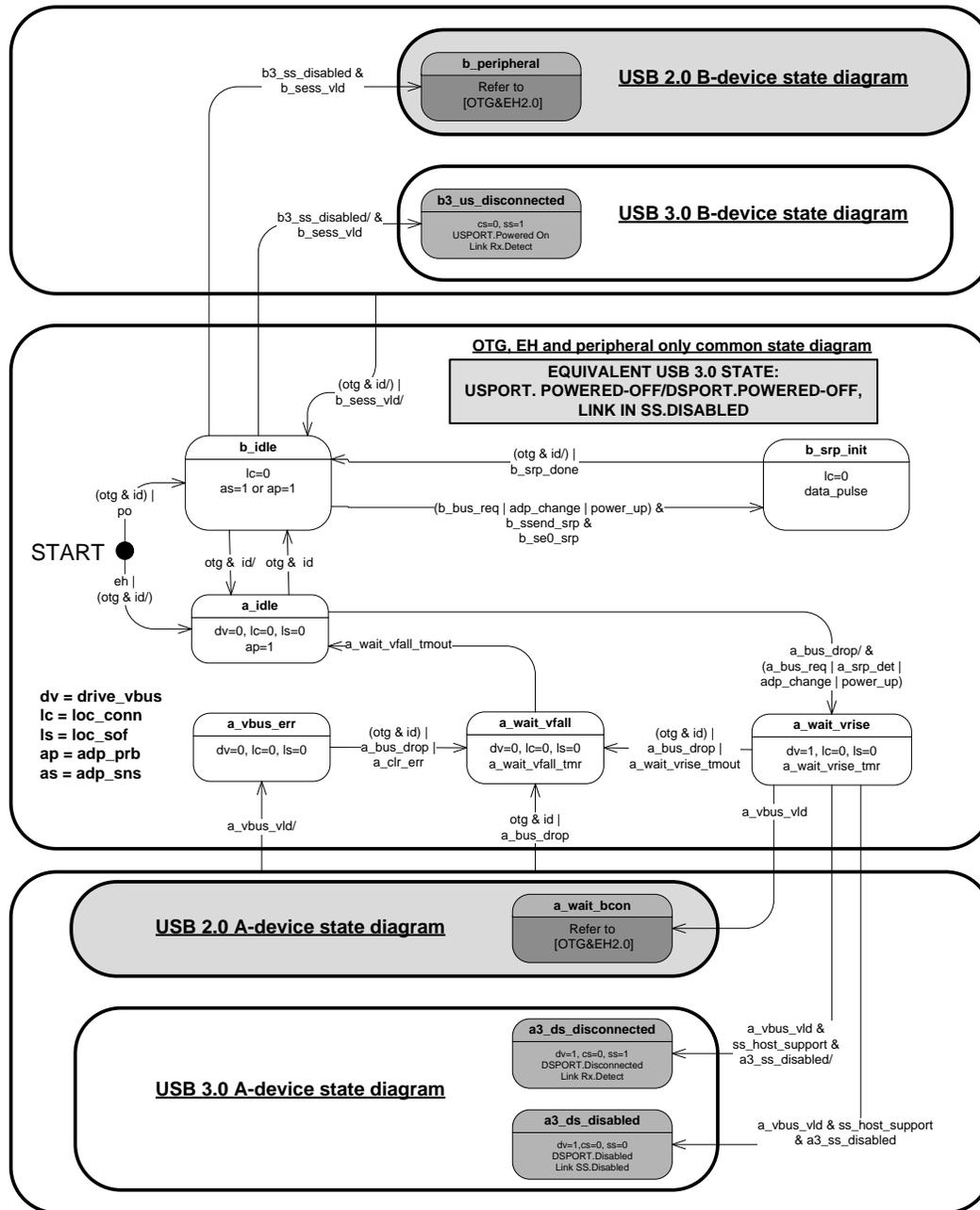
The common state diagram is equivalent to the [USB3.0] state **Powered-off** and shall apply when the session is not valid. This diagram covers state behavior common to all types of devices covered in this supplement:

A-device operation at [USB2.0] speeds is documented in [OTG&EH2.0] and is represented by the “USB2.0 A-device state diagram” bubble in Figure 6-1. For an A-device with SuperSpeed capability, it is possible to have a simultaneous transition, from the common state diagram, to both the [USB2.0] and [USB3.0] state diagrams since this is allowed by [USB3.0] and is necessary for SuperSpeed hub support. During an active SuperSpeed session, an A-device shall stay in the [USB2.0] state diagram in the **a_wait_bcon** state waiting for a [USB2.0] connect.

B-device operation at [USB2.0] speeds is documented in [OTG&EH2.0] and is represented by the “USB2.0 B-device state diagram” bubble in Figure 6-1. For a B-device with SuperSpeed capability [USB3.0] does not permit simultaneous operation as both [USB2.0] and [USB3.0]. For details please refer to [USB3.0].

If the cable is detached the state machine shall transition to the OTG B-device start state (**b_idle**). When the A-device is in any state except the **a_idle** state, the A-device transitions to the **a_wait_vfall** state before transitioning to the **a_idle** state and then to the **b_idle** state.

Figure 6-1: Common State Diagram⁴



⁴ Excludes timeout transitions from specific states (see following diagrams)

Table 6-1: Common state diagram states

| State | Description | Ref |
|------------------------------|---|-------------|
| Common States | | |
| a_idle | A-device starting state | 6.1.1 |
| a_vbus_err | A-device waits for recovery from over-current condition | 6.1.4 |
| a_wait_vfall | A-device waits for VBUS to drop to VOTG_VBUS_LKG | 6.1.3 |
| a_wait_vrise | A-device waits for VBUS to go into regulation | 6.1.2 |
| b_idle | B-device starting state | 6.1.5 |
| b_srp_init | B-device attempts to initiate SRP | 6.1.6 |
| USB 2.0 device states | | |
| a_wait_bcon | Wait for B-device to signal connection | [OTG&EH2.0] |
| b_peripheral | B-device acting as a peripheral | [OTG&EH2.0] |
| USB 3.0 device states | | |
| a3_ds_disabled | A-device [USB3.0] operation is disabled | 6.2.11 |
| a3_ds_disconnected | A-device is in downstream operation and is looking for [USB3.0] Rx terminations | 6.2.2 |
| b3_us_disconnected | B-device is in upstream operation and is looking for [USB3.0] Rx terminations | 6.3.2 |

Table 6-2: Common state machine parameters

| Parameter | Description | Ref |
|-------------------|---|-------------|
| Inputs | | |
| a_bus_drop | TRUE when the A-device application needs to power down the bus | [OTG&EH2.0] |
| a_bus_req | TRUE while the A-device application wants to use the bus | [OTG&EH2.0] |
| a_vbus_vld | TRUE when the A-device detects that the voltage on VBUS is above VOTG_SESS_VLD threshold. | [OTG&EH2.0] |
| a_srp_det | TRUE if the A-device detects SRP | [OTG&EH2.0] |
| adp_change | TRUE when two successive ADP measurement values are different by more than CADP_THR. | [OTG&EH2.0] |
| b_bus_req | TRUE during the time that the Application running on the B-device wants to use the bus. | [OTG&EH2.0] |

| Parameter | Description | Ref |
|---------------------------|---|-------------|
| b_se0_srp | TRUE when the line has been at SE0 for more than the minimum time before generating SRP | [OTG&EH2.0] |
| b_sess_vld | TRUE when the B-device detects that the voltage on VBUS is above VOTG_SESS_VLD threshold. | [OTG&EH2.0] |
| b_ssend_srp | TRUE when the VBUS has been below VOTG_SESS_VLD for more than the minimum time before generating SRP. | [OTG&EH2.0] |
| id | FALSE when a Micro-A plug is attached to the device's Micro-AB receptacle | [OTG&EH2.0] |
| power_up | TRUE when the device first powers up its USB system. | [OTG&EH2.0] |
| Internal constants | | |
| ss_host_support | TRUE when SuperSpeed is supported as a host. | 6.4.5.1 |
| eh | TRUE if this is an EH. | 6.4.5.2 |
| otg | TRUE if this device features a Micro-AB receptacle as defined in [USB3.0] or [Micro-USB1.01] | 6.4.5.3 |
| po | TRUE if this is a peripheral-only device. | 6.4.5.4 |
| Internal variables | | |
| a3_ss_disabled | TRUE when the A-device has disabled its SuperSpeed capability. | 6.4.2.12 |
| b3_ss_disabled | TRUE when the B-device has disabled its SuperSpeed capability. | 6.4.3.14 |
| b_srp_done | TRUE when the B-device has completed initiating SRP | [OTG&EH2.0] |
| Outputs | | |
| adp_prb (ap) | TRUE when the local device is in the process of carrying out ADP probing. | [OTG&EH2.0] |
| adp_sns (as) | TRUE when the B-device is in the process of carrying out ADP sensing. | [OTG&EH2.0] |
| data_pulse | TRUE when a B-device is performing data line pulsing | [OTG&EH2.0] |
| drv_vbus (dv) | TRUE when an A-device is driving VBUS. | [OTG&EH2.0] |
| loc_conn (lc) | TRUE when local device has signaled that it is connected to the bus. | [OTG&EH2.0] |
| loc_sof (ls) | TRUE when the local device is generating activity on the bus. | [OTG&EH2.0] |

| Parameter | Description | Ref |
|---|--|-------------|
| conn_stat (cs) | TRUE when a [USB3.0] connection has been established. | 6.4.4.1 |
| super_speed (ss) | TRUE when the device is operating at SuperSpeed. | 6.4.4.2 |
| Informative variables | | |
| a_clr_err | Asserted to clear a_vbus_err due to an overcurrent condition and causes the A-device to transition to a_wait_vfall . | [OTG&EH2.0] |
| Timers/Timeouts | | |
| a_wait_vfall_tmr/ a_wait_vfall_tmout | Used by an A-device to wait for VBUS to fall below VOTG_VBUS_LKG. | [OTG&EH2.0] |
| a_wait_vrise_tmr/ a_wait_vrise_tmout | Used by an A-device to wait for the voltage on VBUS to go into regulation. | [OTG&EH2.0] |

6.1.1 a_idle

This shall be the start state for A-devices that is when:

- if this is an Embedded Host (**eh** = TRUE),
- or
- if this is an [OTG&EH2.0] device or a **SS-OTG** device or a **SSPC-OTG** (**otg** = TRUE) and
- the Micro-A plug is attached (**id** = FALSE).

The A-device shall transition to the **a_wait_vrise** state:

- if the A-device application is not wanting to drop the bus (**a_bus_drop** = FALSE), and any of the following are true:
 - the A-device Application is requesting the bus (**a_bus_req** = TRUE), or
 - SRP is detected on the bus (**a_srp_det** = TRUE) or
 - an ADP change has been detected (**adp_change** = TRUE) or
 - the A-device has only just powered up its USB system (**power_up** = TRUE).

OTG devices (**otg** = TRUE) shall be configured such that a change in **id** from TRUE to FALSE shall cause **a_bus_req** to be asserted unless doing ADP probing (as defined in [OTG&EH2.0]) and that a change in **id** from FALSE to TRUE shall cause a transition to the **b_idle** state. This does not apply to an EH (**eh** = TRUE) since there is no ID pin in the Standard-A plug.

6.1.2 a_wait_vrise

In this state, the A-device shall wait for the voltage on VBUS to go into regulation (**a_vbus_vld** = TRUE). Upon entering this state, the A-device shall start a timer (**a_wait_vrise_tmr**).

The A-device shall transition to the **a_wait_bcon** state:

- if the voltage on VBUS is in regulation (**a_vbus_vld** = TRUE)

The A-device shall transition to **a3_ds_disconnected** (simultaneous to the transition to **a_wait_bcon** state):

- if the voltage on VBUS is in regulation (**a_vbus_vld** = TRUE) and
- operation as a SuperSpeed host is supported (**ss_host_support** = TRUE) and
- operation at SuperSpeed has not been disabled by the A-device (**a3_ss_disabled** = FALSE)

The A-device shall transition to **a3_ds_disabled** (simultaneous to the transition to **a_wait_bcon** state):

- if the voltage on VBUS is in regulation (**a_vbus_vld** = TRUE) and
- operation as a SuperSpeed host is supported (**ss_host_support** = TRUE) and
- operation at SuperSpeed has been disabled by the A-device (**a3_ss_disabled** = TRUE)

The A-device shall transition to the **a_wait_vfall** state:

- if this is an OTG A-device (**otg** = TRUE) and the Micro-A plug is detached (**id** = TRUE) or
- if the A-device application wants to drop the bus (**a_bus_drop** = TRUE) or
- if the **a_wait_vrise_tmr** times out (**a_wait_vrise_tmout** = TRUE)

6.1.3 a_wait_vfall

In this state the A-devices shall stop driving VBUS (**drv_vbus (dv)** = FALSE) and shall wait for VBUS to fall to VOTG_VBUS_LKG.

The A-device shall transition from the **a_wait_vfall** state to the **a_idle** state:

- if the **a_wait_vfall_tmr** expires (**a_wait_vfall_tmout** = TRUE)

6.1.4 a_vbus_err

In this state, the A-device shall wait for recovery of the overcurrent condition that caused it to enter this state.

The A-device shall transition to the **a_wait_vfall** state under the following conditions:

- if this is an OTG A-device (**otg** = TRUE) and the Micro-A plug is detached (**id** = TRUE), or
- if the A-device is no longer capable of powering VBUS (**a_bus_drop** = TRUE) or
- upon assertion of **a_clr_err** (nominally by system software),

To preserve the integrity of the circuitry supplying power to VBUS, on entering this state the A-device application should no longer drive VBUS (**a_bus_drop** = TRUE).

6.1.5 b_idle

This shall be the start state for B-devices that is when:

- this is either an [OTG&EH2.0] device or a **SS-OTG** or a **SSPC-OTG** device (**otg** = TRUE) and
- the micro-A plug is detached (**id** = TRUE)
- or
- this is a peripheral-only [USB2.0] device or a **SS-PO** device (**po** = TRUE)

The B-device shall transition to the **b_srp_init** state:

- If
 - the Application indicates that it wants to start a session (**b_bus_req** = TRUE), or
 - an ADP change has been detected (**adp_change** = TRUE) or
 - the B-device has only just powered up its USB system (**power_up** = TRUE).
- and
- if VBUS has been below the Session End threshold for at least TB_SSEND_SRP (**b_ssend_srp** = TRUE) and
- if the bus has been in the SE0 state for the minimum time before generating SRP (**b_se0_srp** = TRUE).

The B-device shall transition to the **a_idle** state and become an OTG A-device:

- If this is an OTG B-device (**otg** = TRUE) and
- the Micro-A plug is attached (**id** = FALSE)

The B-device shall transition to the **b_peripheral** state:

- if operation at SuperSpeed is disabled (**b3_ss_disabled** = TRUE), and
- VBUS rises above the Session Valid threshold (**b_sess_vld** = TRUE)

The B-device shall transition to the **b3_us_disconnected** state:

- if operation at SuperSpeed is not disabled (**b3_ss_disabled** = FALSE), and
- VBUS rises above the Session Valid threshold (**b_sess_vld** = TRUE)

6.1.6 b_srp_init

Upon entering this state, the SRP-capable B-device shall attempt to initiate a session via SRP.

The B-device shall transition to the **b_idle** state,

- if this is an OTG B-device (**otg** = TRUE) and the Micro-A plug is attached (**id** = FALSE) or
- SRP has been completed (**b_srp_done** = TRUE)

6.2 A-device USB 3.0 State Diagram

The state diagram shown in Figure 6-2 shall define the behavior of:

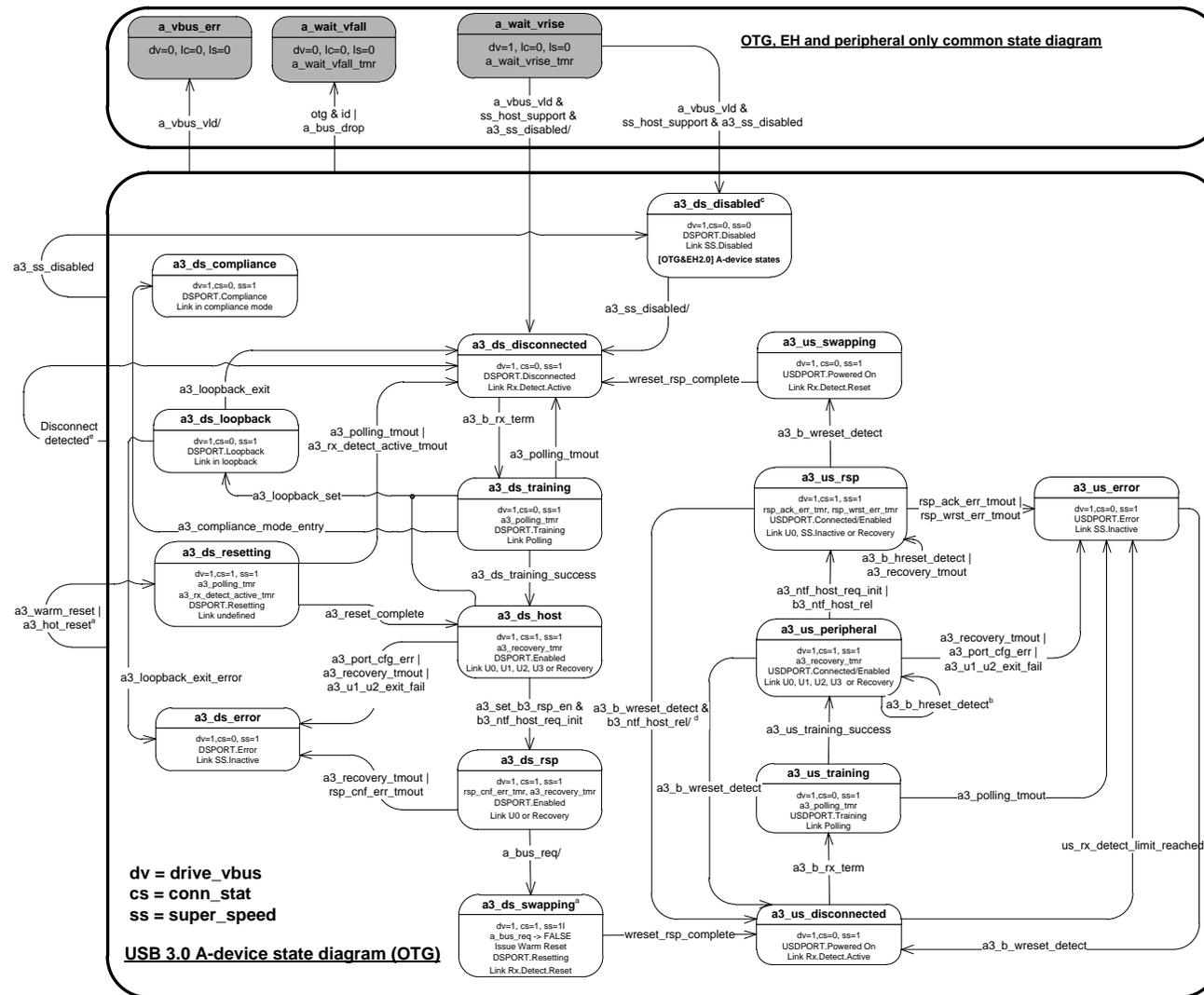
- **SS-EH** devices (**otg** = FALSE, **eh** = TRUE, **po** = FALSE and **ss_host_support** = TRUE) and
- **SS-OTG** A-devices (**otg** = TRUE, **eh** = TRUE, **po** = FALSE, **ss_host_support** = TRUE and **id** = FALSE).

Each state listed in Figure 6-2 also details the corresponding state in [USB3.0]. For each state the equivalent state in [USB3.0] Section 7.5 “Link Training and Status State Machine (LTSSM) is given. In addition for downstream ports the equivalent state in [USB3.0] Section 10.3 “Hub Downstream Facing Ports” is given. For upstream ports the equivalent state in [USB3.0] Section 10.16 “Peripheral Device Upstream Ports” is given. Any relevant LTSSM transitions defined in [USB3.0] that are not described in this section shall also apply.

Figure 6-2 shall define transitions to and from Figure 6-1.

For OTG A-devices Figure 6-2 shall define the role swapping behavior between upstream and downstream operation.

Figure 6-2: USB 3.0 A-device state diagram



^a Transition due to directed Resets (Hot & Warm) are possible only in ds states (except for a3_ds_swapping)

^b Hot Reset Transition possible only when link is in U0 or Recovery

^c Super-speed upstream ports are not allowed to communicate simultaneously at both [USB3.0] and [USB2.0] speeds. Details in a3_ds_disabled Section text.

^d US Port receives warm reset prior to receiving SetFeature (NTF_HOST_REL) . Refer to RSP Step 2 in Section 5.4.1

^e Transition due to failure to detect far-end Receiver Terminations.

Table 6-3: USB 3.0 A-device states

| State | Description | Ref |
|---------------------------|---|----------|
| Common states | | |
| a_vbus_err | A-device waits for recovery from over-current condition | 6.1.4 |
| a_wait_vfall | A-device waits for VBUS to drop to VOTG_VBUS_LKG | 6.1.3 |
| a_wait_vrise | A-device waits for VBUS to go into regulation | 6.1.2 |
| Downstream states | | |
| a3_ds_compliance | A-device is operating in [USB3.0] compliance mode | 6.2.7 |
| a3_ds_disabled | A-device [USB3.0] operation is disabled | 6.2.11 |
| a3_ds_disconnected | A-device is in downstream operation and is looking for [USB3.0] Rx terminations | 6.2.2 |
| a3_ds_error | A-device is in a [USB3.0] downstream error state | 6.2.10 |
| a3_ds_host | A-device is acting as a [USB3.0] host | 6.2.4 |
| a3_ds_rsp | A-device is in downstream operation and is executing the Role Swap Protocol with the B-device | 6.2.5 |
| a3_ds_loopback | A-device is operating in [USB3.0] loopback mode | 6.2.8 |
| a3_ds_resetting | A-device is resetting but not as part of a role swap | 6.2.9 |
| a3_ds_swapping | A-device is performing a directed warm reset as part of the role swapping process | 6.2.6 |
| a3_ds_training | A-device is in downstream operation and is performing [USB3.0] link training | 6.2.3 |
| Upstream states | | |
| a3_us_disconnected | A-device is in upstream operation and is looking for [USB3.0] Rx terminations | 6.2.12 |
| a3_us_error | A-device is in a [USB3.0] upstream error state | 6.2.16.1 |
| a3_us_peripheral | A-device is acting as a [USB3.0] peripheral. | 6.2.14 |
| a3_us_swapping | A-device is being warm reset by the B-device | 6.2.16 |
| a3_us_training | A-device is in upstream operation and is performing [USB3.0] link training. | 6.2.13 |
| a3_us_rsp | A-device is in upstream operation and is executing the Role Swap Protocol with the B-device | 6.2.15 |

Table 6-4: A-device state machine parameters

| Parameter | Description | Ref |
|---------------------------------|--|-------------|
| Inputs | | |
| a_bus_drop | TRUE when the A-device application needs to power down the bus | [OTG&EH2.0] |
| a_bus_req | TRUE while the A-device application wants to use the bus | [OTG&EH2.0] |
| a_vbus_vld | TRUE when the A-device detects that the voltage on VBUS is above VOTG_SESS_VLD threshold | [OTG&EH2.0] |
| a3_b_hreset_detect | TRUE when the A-device detects a hot reset generated by the B-device | 6.4.2.1 |
| a3_b_rx_term | TRUE when the A-device detects the B-device's [USB3.0] Rx terminations. | 6.4.2.2 |
| a3_b_wreset_detect | TRUE when the A-device detects a warm reset generated by the B-device | 6.4.2.3 |
| a3_compliance_mode_entry | TRUE when the link enters compliance mode | 6.4.2.4 |
| a3_ds_training_success | TRUE when the A-device [USB3.0] link training has succeeded | 6.4.2.5 |
| a3_hot_reset | TRUE when the A-device performs a [USB3.0] directed hot reset | 6.4.2.6 |
| a3_loopback_exit | TRUE when the port's link has performed a successful LFPS handshake in order to exit loopback. | 6.4.2.7 |
| a3_loopback_exit_error | TRUE when the port's link has failed to perform an LFPS handshake in order to exit loopback. | |
| a3_loopback_set | TRUE when the loopback bit is set in received TS2 ordered sets | 6.4.2.9 |
| a3_ntf_host_req_init | TRUE when the A-device has sent a host request device notification transaction packet with the RSP Phase set to INITIATE | 6.4.1.4 |
| a3_port_cfg_error | TRUE when the [USB3.0] port configuration fails | 6.4.2.10 |

| Parameter | Description | Ref |
|-----------------------------------|---|-------------|
| a3_reset_complete | TRUE when either a warm or hot reset process completes | 6.4.2.11 |
| a3_ss_disabled | TRUE when the A-device has disabled its SuperSpeed capability. | 6.4.2.12 |
| a3_u1_u2_exit_fail | TRUE when the A-device has failed to exit from the [USB3.0] U1 or U2 states | 6.4.2.13 |
| a3_us_training_success | TRUE when the A-device upstream link training has succeeded | 6.4.2.14 |
| a3_warm_reset | TRUE when the A-device performs a [USB3.0] directed warm reset | 6.4.2.15 |
| wreset_rsp_complete | TRUE when the warm reset handshake process completes successfully resulting in a role swap | 6.4.1.3 |
| b3_ntf_host_req_init | TRUE when the A-device receives a host request device notification transaction packet with the RSP Phase set to INITIATE. | 6.4.1.5 |
| b3_ntf_host_rel | TRUE when the A-device receives indication from the B-device that it wishes to release the host role and transition to peripheral mode. | 6.4.1.6 |
| a3_set_b3_rsp_en | TRUE when the A-device has successfully enabled the RSP feature in the B-device via the SET_FEATURE command. | 6.4.2.16 |
| id | FALSE when a Micro-A plug is attached to the device's Micro-AB receptacle | [OTG&EH2.0] |
| us_rx_detect_limit_reached | TRUE when the device (while in UpStream mode) has reached the Rx Termination detection limit defined in [USB3.0]. | 6.4.1.2 |
| Internal constants | | |
| ss_host_support | TRUE when SuperSpeed is supported as a host. | 6.4.5.1 |
| otg | TRUE if this device features a Micro-AB receptacle as defined in [USB3.0] or [Micro-USB1.01] | 6.4.5.3 |
| Outputs | | |

| Parameter | Description | Ref |
|---|--|-------------|
| conn_stat (cs) | TRUE when a [USB3.0] connection has been established | 6.4.4.1 |
| drv_vbus (dv) | TRUE when an A-device is driving VBUS. | [OTG&EH2.0] |
| super_speed (ss) | TRUE when the device is operating at SuperSpeed | 6.4.4.2 |
| Timers/Timeouts | | |
| a3_polling_tmr /a3_polling_tmout | Timer used by the A-device during [USB3.0] link polling process | 6.4.6.1 |
| a3_recovery_tmr /a3_recovery_tmout | Timer used by the A-device during link recovery | 6.4.6.6 |
| a3_rx_detect_active_tmr /a3_rx_detect_active_tmout | Timer used by the A-device during Rx termination detection | 6.4.6.5 |
| rsp_cnf_err_tmr/ rsp_cnf_err_tmout | Timer used in downstream mode, during role swapping, to ensure the process completes in a timely fashion | 6.4.6.2 |
| rsp_ack_err_tmr/ rsp_ack_err_tmout | Timer used in upstream mode, during role swapping, to ensure the process completes in a timely fashion | 6.4.6.3 |
| rsp_wrst_err_tmr/ rsp_wrst_err_tmout | Timer used in upstream mode, during role swapping, to ensure the process completes in a timely fashion | 6.4.6.4 |

6.2.1 All States

The following transitions apply to all states listed in the USB 3.0 A-device state diagram.

The A-device shall transition to the **a_wait_vfall** state

- if this is a **SS-OTG** or a **SSPC-OTG** device (**otg** = TRUE) and the Micro-A plug is detached (**id** = TRUE), or
- if the A-device wishes to stop powering VBUS (**a_bus_drop** = TRUE)

The A-device shall transition to the **a_vbus_err** state:

- If the attached device is unsupported due to an overcurrent condition (**a_vbus_vld** = FALSE as defined in [OTG&EH2.0])

The A-device shall transition to the **a3_ds_disabled** state:

- If the A-device disables its SuperSpeed capability (**a3_ss_disabled** = TRUE)

The A-device shall transition to the **a3_ds_resetting** state:

- If the A-device initiates a directed warm reset (**a3_warm_reset** = TRUE).
Note: This transition shall not apply to the **a3_ds_swapping** state where a warm reset is issued by the A-device in order to initiate role swapping. An A-device shall not issue a warm reset when operating as an upstream port.
- or if the A-device initiates a directed hot reset (**a3_hot_reset** = TRUE).
Note: An A-device shall not issue a hot reset when operating as an upstream port.

6.2.2 a3_ds_disconnected

This A-device state corresponds to the **DSPORT.Disconnected** state for a [USB3.0] hub port.

This A-device state corresponds to the **Rx.Detect** [USB3.0] LTSSM state and specifically the **Rx.Detect.Active** substate as documented below:

- When **a3_ds_disconnected** is entered from **a3_us_swapping**, the **Rx.Detect.Active** substate is entered as per [USB3.0] on the completion of a warm reset (**wreset_rsp_complete** = TRUE).
- When **a3_ds_disconnected** is entered from any other state, the **Rx.Detect.Active** substate is directly entered as per [USB3.0] since entry to Rx.Detect is not due to a warm reset.

The A-device is driving VBUS (**drv_vbus (dv)** = TRUE), is not connected (**conn_stat (cs)** = FALSE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE).

The A-device shall transition to the **a3_ds_training** state:

- if the B-device's [USB3.0] Rx Terminations are detected (**a3_b_rx_term** = TRUE)

6.2.3 a3_ds_training

This state corresponds to the **DSPORT.Training** state for a [USB3.0] hub port and the **Polling** state in the [USB3.0] LTSSM. The A-device is driving VBUS (**drv_vbus (dv)** = TRUE), is not connected (**conn_stat (cs)** = FALSE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE). The A-device uses the polling timer (**a3_polling_tmr**) to check for timeout of the link polling process.

The A-device shall transition to the **a3_ds_host** state:

- if link training was successful (**a3_ds_training_success** = TRUE)

The A-device shall transition to the **a3_ds_loopback** state:

- if the loopback bit is set in the received TS2 data sets (**a3_loopback_set** = TRUE)

The A-device shall transition to the **a3_ds_disconnected** state:

- if the link polling process times out (**a3_polling_tmout** = TRUE)

The A-device shall transition to the **a3_ds_compliance** state:

- if the link is configured to go into [USB3.0] compliance mode (**a3_compliance_mode_entry** = TRUE).

6.2.4 a3_ds_host

This state corresponds to the **DSPORT.Enabled** state for a [USB3.0] hub port and the **U0, U1, U2, U3** or **Recovery** states in the [USB3.0] LTSSM. The A-device is driving VBUS (**drv_vbus (dv)** = TRUE), is connected (**conn_stat (cs)** = TRUE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE). The A-device uses the Recovery timer (**a3_recovery_tmr**) to check for a timeout when the link is in the **Recovery** state.

The A-device shall transition to the **a3_ds_rsp** state:

- if the A-device has successfully set the B3_RSP_ENABLE feature in the B-device via the SET_FEATURE command (**a3_set_b3_rsp_en** = TRUE) and
- the OTG A-device has received a host role request Device Notification TP from B-device with the RSP Phase set to INITIATE (**b3_ntf_host_req_init** = TRUE).

Note: Above transition is valid only for OTG devices (**otg** = TRUE).

The A-device shall transition to the **a3_ds_error** state:

- if there is a port configuration error (**a3_port_cfg_error** = TRUE) or
- there is a timeout from the link **Recovery** state (**a3_recovery_tmout** = TRUE) or
- the exit from the U1 or U2 link states fails (**a3_u1_u2_exit_fail** = TRUE)

6.2.5 a3_ds_rsp

In this state the OTG A-device is executing the Role Swap Protocol (RSP) with the B-device as described in Section 5.4. As part of this process the A-device prepares for a role swap by shutting down any current host operations including for example ongoing file transfers. This ensures that there are no undesirable side-effects from the role swap.

This OTG A-device state corresponds to the **DSPORT.Enabled** state for a [USB3.0] hub port and the **U0** or **Recovery** states in the [USB3.0] LTSSM. The OTG A-device is driving VBUS (**drv_vbus (dv)** = TRUE), is connected (**conn_stat (cs)** = TRUE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE). The OTG A-device uses the RSP Confirm Error timer (**rsp_cnf_err_tmr**) to ensure that the role swapping occurs in a timely manner.

The OTG A-device shall transition to the **a3_ds_swapping** state:

- if the A-device releases host role as part of a successful completion of the RSP process (**a_bus_req** = FALSE)

The OTG A-device shall transition to the **a3_ds_error** state:

- if there is a timeout from the link **Recovery** state (**a3_recovery_tmout** = TRUE) or
- the "RSP Confirm Error timer" times-out during the RSP process (**rsp_cnf_err_tmout** = TRUE).

6.2.6 a3_ds_swapping

On entering this state the OTG A-device shall issue a warm reset leading to a role swap. This is distinct from the **a3_ds_resetting** state which applies to directed resets of the downstream port when not

swapping roles. The **a_bus_req** variable becomes false indicating that the OTG A-device is ready to hand-over the host role to the OTG B-device.

This OTG A-device state corresponds to the **DSPORT.Resetting** state for a [USB3.0] hub port.

This OTG A-device state corresponds to the **Rx.Detect.Reset** [USB3.0] LTSSM substate.

The parameter **a3_u1_u2_exit_fail** will not be set in this state because the associated LFPS signaling are only for the purposes of Warm Reset and do not have to be compliant with U1 or U2 exit criteria. The OTG A-device is driving VBUS (**drv_vbus (dv)** = TRUE), is connected (**conn_stat (cs)** = TRUE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE).

The OTG A-device shall transition to the **a3_us_disconnected** state:

- when the warm reset handshake, initiated by the A-device, completes resulting in a role swap (**wreset_rsp_complete** = TRUE)

6.2.7 a3_ds_compliance

This A-device state corresponds to the **DSPORT.Compliance** state for a [USB3.0] hub port and the **Compliance Mode** state in the [USB3.0] LTSSM. The A-device is driving VBUS (**drv_vbus (dv)** = TRUE), is not connected (**conn_stat (cs)** = FALSE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE).

6.2.8 a3_ds_loopback

This A-device state corresponds to the **DSPORT.Loopback** state for a [USB3.0] hub port and the **Loopback** state in the [USB3.0] LTSSM. The A-device is driving VBUS (**drv_vbus (dv)** = TRUE), is not connected (**conn_stat (cs)** = FALSE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE).

The A-device shall transition to **a3_ds_disconnected** state:

- if the A-device has performed a successful LFPS handshake in Loopback.Exit link state (**a3_loopback_exit** = TRUE).

The A-device shall transition to **a3_ds_error** state:

- if the A-device has failed to perform a successful LFPS handshake in Loopback.Exit link state (**a3_loopback_exit_error** = TRUE).

6.2.9 a3_ds_resetting

This shall be the state after an A-device directed reset. This state is distinct from the **a3_ds_swapping** state which applies only during a role swap.

This A-device state corresponds to the **DSPORT.Resetting** state for a [USB3.0] hub port and an undefined state in the [USB3.0] LTSSM. The A-device is driving VBUS (**drv_vbus (dv)** = TRUE), is not connected (**conn_stat (cs)** = FALSE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE). The A-device uses the polling timer (**a3_polling_tmr**) to check for timeout of the link polling process. The A-device uses the Rx detect active timer (**a3_rx_detect_active_tmr**) to check for timeout on detection of USB3.0] Rx Terminations from the B-device.

The A-device shall transition to the **a3_ds_disconnected** state:

- if the link polling process times out (**a3_polling_tmout** = TRUE) or
- the Rx detect active process times out (**a3_rx_detect_active_tmout** = TRUE)

The A-device shall transition to the **a3_ds_host** state:

- when the directed reset completes (**a3_reset_complete** = TRUE)

6.2.10 a3_ds_error

This shall be the error state for an A-device in downstream port operation.

This A-device state corresponds to the **DSPORT.Error** state for a [USB3.0] hub port and the **SS.Inactive** state in the [USB3.0] LTSSM. The A-device is driving VBUS (**drv_vbus (dv)** = TRUE), is not connected (**conn_stat (cs)** = FALSE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE).

The A-device shall issue a directed warm reset or a directed hot reset in order to transition out of this state. For details refer to Section 6.2.1.

6.2.11 a3_ds_disabled

In this state the A-device shall be operational at [USB2.0] data rates and comply with the [OTG&EH2.0] A-device state machine.

Super-speed upstream ports are not allowed to communicate simultaneously at both [USB3.0] and [USB2.0] speeds. When moving to operation as an upstream port after a [USB2.0] reset it is possible that there may be a residual [USB2.0] connection in this state due to the transition. Communication over [USB2.0] is only allowed in the **a3_ds_disabled** state.

This A-device state corresponds to the **DSPORT.Disabled** state for a [USB3.0] hub port and the **SS.Disabled** state in the [USB3.0] LTSSM. The A-device is driving VBUS (**drv_vbus (dv)** = TRUE), is not connected (**conn_stat (cs)** = FALSE) and is not operating at SuperSpeed (**super_speed (ss)** = FALSE). Note that an OTG A-device can enter this state from either downstream or upstream port operation.

The OTG A-device shall transition to the **a3_ds_disconnected** state:

- if operation at SuperSpeed has been enabled (**a3_ss_disabled** = FALSE).

6.2.12 a3_us_disconnected

This OTG A-device state corresponds to the **USPORT.Powered On** state for a [USB3.0] peripheral device upstream port and the **Rx.Detect** state in the [USB3.0] LTSSM.

This A-device state corresponds to the **Rx.Detect** [USB3.0] LTSSM state and specifically the **Rx.Detect.Active** substate as documented below:

- When **a3_us_disconnected** is entered from **a3_ds_swapping**, the **Rx.Detect.Active** substate is entered as per [USB3.0] on the completion of a warm reset (**wreset_rsp_complete** = TRUE).
- When **a3_us_disconnected** is entered from any other state, the **Rx.Detect.Active** substate is directly entered as per [USB3.0] since entry to Rx.Detect is not due to a warm reset.

The link sub-state for a downstream port is **Rx.Detect.Active** upon completion of Warm Reset Signaling [USB3.0] The OTG A-device is driving VBUS (**drv_vbus (dv)** = TRUE), is not connected (**conn_stat (cs)** = FALSE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE).

The OTG A-device shall transition to the **a3_us_training** state:

- if the OTG A-device detects the [USB3.0] Rx Terminations from the OTG B-device (**a3_b_rx_term** = TRUE)

The OTG A-device shall transition to the **a3_us_error** state:

- if the Rx detection limit is reached during the detection of the [USB3.0] Rx Terminations from the OTG B-device (**us_rx_detect_limit_reached** = TRUE)

6.2.13 a3_us_training

This OTG A-device state corresponds to the **USDPORT.Training** state for a [USB3.0] peripheral device upstream port and the **Polling** state in the [USB3.0] LTSSM. The OTG A-device is driving VBUS (**drv_vbus (dv)** = TRUE), is not connected (**conn_stat (cs)** = FALSE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE). The OTG A-device uses the polling timer (**a3_polling_tmr**) to check for timeout of the link polling process.

The OTG A-device shall transition to the **a3_us_peripheral** state:

- if the upstream link training process is successful (**a3_us_training_success** = TRUE)

The OTG A-device shall transition to the **a3_us_error** state:

- if the link polling process times out (**a3_polling_tmout** = TRUE)

6.2.14 a3_us_peripheral

In this state the OTG A-device shall operate as a SuperSpeed peripheral device.

This OTG A-device state corresponds to the **USDPORT.Connected/Enabled** states for a [USB3.0] peripheral device upstream port and the **U0, U1, U2, U3** or **Recovery** states in the [USB3.0] LTSSM. The OTG A-device is driving VBUS (**drv_vbus (dv)** = TRUE), is connected (**conn_stat (cs)** = TRUE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE). The OTG A-device uses the Recovery timer (**a3_recovery_tmr**) to check for a timeout when the link is in the **Recovery** state.

The OTG A-device shall transition to the **a3_us_rsp** state:

- if the OTG A-device has sent a host request device notification transaction packet with the RSP Phase set to INITIATE (**a3_ntf_host_req_init** = TRUE) or
- the OTG A-device receives a SET_FEATURE request from the B-device that initiates the RSP process (**b3_ntf_host_rel** = TRUE)

The OTG A-device shall transition to the **a3_us_error** state:

- if there is a timeout from the link **Recovery** state (**a3_recovery_tmout** = TRUE) or
- if there is a port configuration error (**a3_port_cfg_error** = TRUE) or
- the exit from the U1 or U2 link states fails (**a3_u1_u2_exit_fail** = TRUE)

The OTG A-device shall remain in the **a3_us_peripheral** state:

- if a hot reset is received from the OTG B-device (**a3_b_hreset_detect** = TRUE)

The OTG A-device shall transition to the **a3_us_disconnected** state:

- if a Warm reset is detected from the OTG B-device (**a3_b_wreset_detect** = TRUE)

6.2.15 a3_us_rsp

In this state the OTG A-device is in upstream operation and is executing the Role Swap Protocol (RSP) with the B-device as described in Section 5.4.

This OTG A-device state corresponds to the **USDPORT.Connected/Enabled** states for a [USB3.0] peripheral device upstream port and the **U0, SS.Inactive** or **Recovery** states in the [USB3.0] LTSSM. The OTG A-device is driving VBUS (**drv_vbus (dv) = TRUE**), is connected (**conn_stat (cs) = TRUE**) and is operating at SuperSpeed (**super_speed (ss) = TRUE**). The OTG A-device uses the recovery timer (**a3_recovery_tmr**) to check for a timeout when the link is in the **Recovery** state.

The OTG A-device uses the RSP Acknowledge Error timer (**rsp_ack_err_tmr**) and the RSP Warm Reset Error timer (**rsp_wrst_err_tmr**) to ensure that the role swapping occurs in a timely manner.

The OTG A-device shall transition to the **a3_us_error** state:

- the RSP Acknowledge Error timer times-out during the RSP process (**rsp_ack_err_tmout = TRUE**) or
- the RSP Warm Reset Error timer times-out during the RSP process (**rsp_wrst_err_tmout = TRUE**).

The OTG A-device shall remain in the **a3_us_rsp** state:

- if a hot reset is received from the OTG B-device (**a3_b_hreset_detect = TRUE**) or
- if there is a timeout from the link **Recovery** state (**a3_recovery_tmout = TRUE**).

The OTG A-device shall transition to the **a3_us_swapping** state:

- if a warm reset generated by the OTG B-device is detected (**a3_b_wreset_detect = TRUE**)
- (Note: This transition is when a warm reset is received at the end of a successful RSP process as described in Section 5.4.1)
- (Note: During this transition the corresponding LTSSM state shall either be **Recovery** or **SS.Inactive**)

The OTG A-device shall transition to the **a3_us_disconnected** state:

- if a Warm reset is detected from the OTG B-device (**a3_b_wreset_detect = TRUE**)
- and the notification from the OTG B-device to release host role has not been received **SET_FEATURE (b3_ntf_host_rel = FALSE)**.

6.2.16 a3_us_swapping

In this state the OTG A-device waits for completion of a warm reset, generated by the OTG B-device as part of a role swap.

This OTG A-device state corresponds to the **USDPORT.Powered On** state for a [USB3.0] peripheral device upstream port.

This OTG A-device state corresponds to the **Rx.Detect.Reset** [USB3.0] LTSSM substate.

The OTG A-device is driving VBUS (**drv_vbus (dv) = TRUE**), is not connected (**conn_stat (cs) = FALSE**) and is operating at SuperSpeed (**super_speed (ss) = TRUE**).

The OTG A-device shall transition to the **a3_ds_disconnected** state:

- if the warm reset handshake, initiated by the B-device, completes resulting in a role swap (**wreset_rsp_complete** = TRUE)

6.2.16.1 a3_us_error

This shall be the error state for OTG A-devices operating as an upstream port.

This OTG A-device state corresponds to the **USDPORT.Error** state for a [USB3.0] peripheral device upstream port and the **SS.Inactive** state in the [USB3.0] LTSSM. The OTG A-device is driving VBUS (**drv_vbus (dv)** = TRUE), is not connected (**conn_stat (cs)** = FALSE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE).

The A-device shall transition to the **a3_us_disconnected** state:

- if a Warm reset is detected from the OTG B-device (**a3_b_wreset_detect** = TRUE)

6.3 B-device USB 3.0 State Diagram

The state diagram shown in Figure 6-3 shall define the behavior of:

- **SS-OTG** B-devices (**otg** = TRUE, **eh** = FALSE, **po** = FALSE, **ss_host_support** = TRUE and **id** = TRUE)
- **SSPC-OTG** B-devices (**otg** = TRUE, **eh** = FALSE, **po** = FALSE, **ss_host_support** = FALSE and **id** = TRUE)
- **SS-PO** B-devices (**otg** = FALSE, **eh** = FALSE, **po** = TRUE and **ss_host_support** = FALSE)

Each state listed in Figure 6-3 also details the corresponding state in [USB3.0]. For each state the equivalent state in [USB3.0] Section 7.5 “Link Training and Status State Machine (LTSSM) is given. In addition for downstream ports the equivalent state in [USB3.0] Section 10.3 “Hub Downstream Facing Ports” is given. For upstream ports the equivalent state in [USB3.0] Section 10.16 “Peripheral Device Upstream Ports” is given. Any relevant LTSSM transitions defined in [USB3.0] that are not described in this section shall also apply.

Figure 6-3 defines transitions to and from Figure 6-1.

For SS-OTG B-devices Figure 6-3 defines the role swapping behavior between upstream and downstream operation.

Table 6-5: USB 3.0 B-device states

| State | Description | Ref |
|-----------------------------|---|------------|
| Common states | | |
| b_idle | B-device starting state | 6.1.5 |
| Downstream states | | |
| b3_ds_disconnected | B-device is in downstream operation and is looking for [USB3.0] Rx terminations | 6.3.11 |
| b3_ds_error | B-device is in a [USB3.0] downstream error state | 6.3.17 |
| b3_ds_host | B-device is acting as a [USB3.0] host | 6.3.13 |
| b3_ds_rsp | B-device is in downstream operation and is executing the Role Swap Protocol with the A-device | 6.3.14 |
| b3_ds_resetting | B-device is resetting but not as part of a role swap | 6.3.16 |
| b3_ds_swapping | B-device is performing a directed warm reset as part of the role swapping process | 6.3.15 |
| b3_ds_training | B-device is in downstream operation and is performing [USB3.0] link training | 6.3.12 |
| Upstream states | | |
| b3_us_disabled | B-device [USB3.0] operation is disabled | 6.3.8 |
| b3_us_disabled_error | B-device [USB3.0] is in an upstream error state and [USB3.0] operation is disabled. | 6.3.9 |
| b3_us_disconnected | B-device is in upstream operation and is looking for [USB3.0] Rx terminations | 6.3.2 |
| b3_us_error | B-device is in a [USB3.0] upstream error state | 6.3.10 |
| b3_us_peripheral | B-device is acting as a [USB3.0] peripheral. | 6.3.4 |
| b3_us_swapping | B-device is being warm reset by the A-device | 6.3.7 |
| b3_us_training | B-device is in upstream operation and is performing [USB3.0] link training. | 6.3.3 |
| b3_us_compliance | B-device is operating in [USB3.0] compliance mode | 6.3.4 |
| b3_us_rsp | B-device is in upstream operation and is executing the Role Swap Protocol with the A-device | 6.3.6 |

Table 6-6: USB3.0 B-device state machine parameters

| Parameter | Description | Ref |
|-------------------------------|--|-------------|
| Inputs | | |
| a3_ntf_host_req_init | TRUE when the B-device receives a host request device notification transaction packet with the RSP Phase set to INITIATE | 6.4.1.4 |
| b3_ntf_host_rel | TRUE when the B-device indicates that it wishes to release the host role and transition to peripheral mode. | 6.4.1.6 |
| b3_rsp_en | TRUE when the B-device has had its b3_rsp_en feature set by the A-device via the SET_FEATURE command | 6.4.3.6 |
| b_bus_req | TRUE during the time that the Application running on the B-device wants to use the bus | [OTG&EH2.0] |
| b_reset_detect | TRUE when the B-device detects a [USB2.0] reset | 6.4.3.13 |
| b_sess_vld | TRUE when the B-device detects that the voltage on VBUS is above VOTG_SESS_VLD | [OTG&EH2.0] |
| b3_a_hreset_detect | TRUE when the B-device detects a hot reset generated by the A-device | 6.4.3.1 |
| b3_a_rx_term | TRUE when the B-device detects the A-device's [USB3.0] Rx terminations. | 6.4.3.2 |
| b3_a_wreset_detect | TRUE when the B-device detects a warm reset generated by the A-device | 6.4.3.3 |
| b3_ds_training_success | TRUE when [USB3.0] link training has succeeded with the B-device in downstream mode | 6.4.3.4 |
| b3_hot_reset | TRUE when the B-device performs a [USB3.0] directed hot reset | 6.4.3.5 |
| b3_ntf_host_req_init | TRUE when the B-device sends a host request device notification transaction packet with the RSP Phase set to INITIATE. | 6.4.1.5 |
| b3_port_cfg_error | TRUE when the [USB3.0] port configuration fails | 6.4.3.7 |
| b3_reset_complete | TRUE when either a warm or hot reset process completes | 6.4.3.8 |

| Parameter | Description | Ref |
|---|---|----------|
| b3_u1_u2_exit_fail | TRUE when the B-device has failed to exit from the [USB3.0] U1 or U2 states | 6.4.3.9 |
| b3_us_training_success | TRUE when [USB3.0] link training has succeeded with the B-device in upstream mode | 6.4.3.10 |
| b3_warm_reset | TRUE when the B-device performs a [USB3.0] directed warm reset | 6.4.3.11 |
| wreset_rsp_complete | TRUE when the warm reset handshake process completes successfully resulting in a role swap | 6.4.1.3 |
| id | FALSE when a Micro-A plug is attached to the device's Micro-AB receptacle | 6.4.1.1 |
| us_rx_detect_limit_reached | TRUE when the device (while in UpStream mode) has reached the Rx Termination detection limit defined in [USB3.0]. | 6.4.1.2 |
| b3_compliance_mode_entry | TRUE when the link enters compliance mode | 6.4.3.12 |
| Internal constants | | |
| ss_host_support | TRUE when operation as a SuperSpeed host is supported. | 6.4.5.1 |
| otg | TRUE when the device features a Micro-AB receptacle as defined in [USB3.0] or [Micro-USB1.01] | 6.4.5.3 |
| Outputs | | |
| conn_stat (cs) | TRUE when a [USB3.0] connection has been established. | 6.4.4.1 |
| super_speed (ss) | TRUE when the device is operating at SuperSpeed. | 6.4.4.2 |
| Timers/Timeouts | | |
| b3_polling_tmr/ b3_polling_tmout | Timer used by the B-device during [USB3.0] link polling process. | 6.4.6.7 |
| b3_recovery_tmr/ b3_recovery_tmout | Timer used by the B-device during link recovery. | 6.4.6.9 |
| b3_rx_detect_active_tmr/ b3_rx_detect_active_tmout | Timer used by the B-device during Rx termination detection. | 7.4.6.8 |

| Parameter | Description | Ref |
|---|--|---------|
| rsp_cnf_err_tmr/ rsp_cnf_err_tmout | Timer used in downstream mode, during role swapping, to ensure the process completes in a timely fashion | 6.4.6.2 |
| rsp_ack_err_tmr/ rsp_ack_err_tmout | Timer used in upstream mode, during role swapping, to ensure the process completes in a timely fashion | 6.4.6.3 |
| rsp_wrst_err_tmr/ rsp_wrst_err_tmout | Timer used in upstream mode, during role swapping, to ensure the process completes in a timely fashion | 6.4.6.4 |

6.3.1 All States

The following transitions apply to all states listed in the USB 3.0 B-device state diagram.

The B-device shall transition to the **b_idle** state:

- if this is a **SS-OTG** or a **SSPC-OTG** device (**otg** = TRUE) and a Micro-A plug is attached (**id** = FALSE), or
- if the B-device detects that the voltage on VBUS is below VOTG_SESS_VLD threshold. (**b_sess_vld** = FALSE)

The B-device shall transition to the **b3_ds_resetting** state:

- If the B-device initiates a directed warm reset (**b3_warm_reset** = TRUE).
Note: This transition shall not apply to the **b3_ds_swapping** state where a warm reset is issued by the B-device in order to initiate role swapping. A B-device shall not issue a warm reset when operating as an upstream port.
- or if the B-device initiates a directed hot reset (**b3_hot_reset** = TRUE).
Note: A B-device shall not issue a hot reset when operating as an upstream port.

6.3.2 b3_us_disconnected

This is the entry state for the USB3 B-device state machine and corresponds to the **USDPORT.Powered On** state for a [USB3.0] peripheral device upstream port.

This B-device state corresponds to the **Rx.Detect** [USB3.0] LTSSM state and specifically the **Rx.Detect.Active** substate as documented below:

- When **b3_us_disconnected** is entered from **b3_ds_swapping**, the **Rx.Detect.Active** substate is entered as per [USB3.0] on the completion of a warm reset (**wreset_rsp_complete** = TRUE).
- When **b3_us_disconnected** is entered from any other state, the **Rx.Detect.Active** substate is directly entered as per [USB3.0] since entry to Rx.Detect is not due to a warm reset.

The B-device is not connected (**conn_stat (cs)** = FALSE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE).

In this state, the B-device shall wait for far-end SS Rx terminations to be asserted by the A-device. If this state was entered from the **b3_us_disabled** state, then the number of far-end receiver termination detection events required to set the **us_rx_detect_limit_reached** parameter to TRUE shall equal 1, otherwise the detection of 8 events is required.

The B-device shall transition to the **b3_us_training** state:

- if the B-device detects the [USB3.0] Rx Terminations from an A-device (**b3_a_rx_term** = TRUE)

The B-device shall transition to the **b3_us_disabled** state:

- if the Rx detection limit is reached during the detection of the [USB3.0] Rx Terminations from the OTG A-device (**us_rx_detect_limit_reached** = TRUE)

6.3.3 b3_us_training

This B-device state corresponds to the **USDPORT.Training** state for a [USB3.0] peripheral device upstream port and the **Polling** state in the [USB3.0] LTSSM. The B-device is not connected (**conn_stat (cs)** = FALSE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE). The B-device uses the polling timer (**b3_polling_tmr**) to check for timeout of the link polling process.

The B-device shall transition to the **b3_us_peripheral** state:

- if the upstream link training process is successful (**b3_us_training_success** = TRUE)

The B-device shall transition to the **b3_us_disabled** state:

- if the link polling process times out (**b3_polling_tmout** = TRUE)

The B-device shall transition to the **b3_us_compliance** state:

- if the link is configured to go into [USB3.0] compliance mode (**b3_compliance_mode_entry** = TRUE).

6.3.4 b3_us_compliance

This B-device state corresponds to the **USDPORT.Compliance** state for a [USB3.0] upstream port and the **Compliance Mode** state in the [USB3.0] LTSSM. The B-device is not connected (**conn_stat (cs)** = FALSE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE).

6.3.5 b3_us_peripheral

In this state the B-device shall operate as a SuperSpeed peripheral device.

This B-device state corresponds to the **USDPORT.Connected/Enabled** states for a [USB3.0] peripheral device upstream port and the **U0, U1, U2, U3** or **Recovery** states in the [USB3.0] LTSSM. The B-device is connected (**conn_stat (cs)** = TRUE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE). The B-device uses the recovery timer (**b3_recovery_tmr**) to check for a timeout when the link is in the **Recovery** state.

The B-device shall transition to the **b3_us_rsp** state:

- if the RSP capability has been enabled (**b3_rsp_en** = TRUE) and
- the B-device has sent a host role request Device Notification TP with the RSP Phase set to INITIATE (**b3_ntf_host_req_init** = TRUE).

The B-device shall transition to the **b3_us_disabled** state:

- if there is a port configuration error (**b3_port_cfg_error** = TRUE)

The B-device shall transition to the **b3_us_error** state:

- if there is a timeout from the link **Recovery** state (**b3_recovery_tmout** = TRUE) or
- if the exit from the U1 or U2 link states fails (**b3_u1_u2_exit_fail** = TRUE)

The B-device shall remain in the **b3_us_peripheral** state:

- if a hot reset is received from the OTG A-device (**b3_a_hreset_detect** = TRUE)

The B-device shall transition to the **b3_us_disconnected** state:

- if a warm reset is received from the OTG A-device (**b3_a_wreset_detect** = TRUE)

6.3.6 **b3_us_rsp**

In this state the OTG B-device is in upstream operation and is executing the Role Swap Protocol (RSP) with the A-device as described in Section 5.4.

This OTG B-device state corresponds to the **USDPORT.Connected/Enabled** states for a [USB3.0] peripheral device upstream port and the **U0**, **SS.Inactive** or **Recovery** states in the [USB3.0] LTSSM. The OTG B-device is connected (**conn_stat (cs)** = TRUE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE). The OTG B-device uses the recovery timer (**b3_recovery_tmr**) to check for a timeout when the link is in the **Recovery** state. The OTG B-device uses the RSP Acknowledge Error timer (**rsp_ack_err_tmr**) and the RSP Warm Reset Error timer (**rsp_wrst_err_tmr**) to ensure that the role swapping occurs in a timely manner.

The OTG B-device shall transition to the **b3_us_error** state:

- if the RSP Acknowledge Error timer times-out during the RSP process (**rsp_ack_err_tmout** = TRUE) or
- the RSP Warm Reset Error timer times-out during the RSP process (**rsp_wrst_err_tmout** = TRUE).

The OTG B-device shall remain in the **b3_us_rsp** state:

- if a hot reset is received from the OTG A-device (**b3_a_hreset_detect** = TRUE) or
- if there is a timeout from the link **Recovery** state (**b3_recovery_tmout** = TRUE).

The OTG B-device shall transition to the **b3_us_swapping** state:

- if a warm reset generated by the OTG A-device is detected (**b3_a_wreset_detect** = TRUE)
- (Note: During this transition the corresponding LTSSM state shall either be **U0** or **SS.Inactive**)

The OTG B-device shall transition to the **b3_us_disconnected** state:

- if a warm reset generated by the OTG A-device is detected (**b3_a_wreset_detect** = TRUE) prior to receiving SetFeature (NTF_HOST_REL). Refer to RSP Step 2 in Section 5.4.1.

6.3.7 b3_us_swapping

In this state the OTG B-device waits for completion of a warm reset, generated by the OTG A-device as part of a role swap.

This OTG B-device state corresponds to the **USDPORT.Powered On** state for a [USB3.0] peripheral device upstream port.

This OTG B-device state corresponds to the **Rx.Detect.Reset** [USB3.0] LTSSM substate.

The OTG B-device is not connected (**conn_stat (cs)** = FALSE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE).

The OTG B-device shall transition to the **b3_ds_disconnected** state:

- if the warm reset generated by the OTG A-device completes (**wreset_rsp_complete** = TRUE)

6.3.8 b3_us_disabled

In this state the B-device is unable to connect at SuperSpeed, either because no far-end SS Rx terminations were detected, or there was a problem with the link training or the Port Capability/Configuration LMP exchange. In either case, the USB 2.0 B-device shall be operational at [USB2.0] data rates and shall comply with the [OTG&EH2.0] B-device state machine.

A B-device operating as a peripheral in High Speed mode on receiving a [USB2.0] reset shall re-enable SS Terminations (see Section 6.3.8). However it should be noted that an A-device operating as a peripheral in High Speed mode on receiving a [USB2.0] reset shall NOT re-enable SS Terminations.

This B-device state corresponds to the **USDPORT.Disabled** state for a [USB3.0] peripheral device upstream port and the **SS.Disabled** state in the [USB3.0] LTSSM. The B-device is not connected (**conn_stat (cs)** = FALSE) and is not operating at SuperSpeed (**super_speed (ss)** = FALSE).

The B-device shall transition to **b3_us_disconnected** state:

- if a [USB2.0] reset is detected from the A-device (**b_reset_detect** = TRUE).

The B-device shall transition to the **b3_us_disabled_error** state:

- if the Disabled Counter as defined in Fig 10-25 in [USB3.0] reaches a value of 3.

6.3.9 b3_us_disabled_error

In this state the B-device is unable to connect at SuperSpeed, because no far-end SS Rx terminations were detected, there was a problem with the link training or the Port Capability/Configuration LMP exchange. In either case, the USB2 B-device shall be operational at [USB2.0] data rates and shall comply with the [OTG&EH2.0] B-device state machine.

This B-device state corresponds to the **USDPORT.Disabled_Error** state for a [USB3.0] peripheral device upstream port and the **SS.Disabled** state in the [USB3.0] LTSSM. The B-device is not connected (**conn_stat (cs)** = FALSE) and is not operating at SuperSpeed (**super_speed (ss)** = FALSE).

The B-device shall remain in this state:

- if a [USB2.0] reset is detected from the A-device (**b_reset_detect** = TRUE)

6.3.10 b3_us_error

This shall be the error state for B-devices operating as an upstream port.

This B-device state corresponds to the **USDPORT.Error** state for a [USB3.0] peripheral device upstream port and the **SS.Inactive** state in the [USB3.0] LTSSM. The B-device is not connected (**conn_stat (cs)** = FALSE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE).

The B-device shall transition to the **b3_us_disconnected** state:

- if the [USB3.0] Rx Terminations are removed (**b3_a_rx_term** = FALSE) or
- if a warm reset is received from the OTG A-device (**b3_a_wreset_detect** = TRUE)

6.3.11 b3_ds_disconnected

This OTG B-device state corresponds to the **DSPORT.Disconnected** state for a [USB3.0] hub port.

This B-device state corresponds to the **Rx.Detect** [USB3.0] LTSSM state and specifically the **Rx.Detect.Active** substate as documented below:

- When **b3_ds_disconnected** is entered from **b3_us_swapping**, the **Rx.Detect.Active** substate is entered as per [USB3.0] on the completion of a warm reset (**wreset_rsp_complete** = TRUE).
- When **b3_ds_disconnected** is entered from any other state, the **Rx.Detect.Active** substate is directly entered as per [USB3.0] since entry to Rx.Detect is not due to a warm reset

The OTG B-device is not connected (**conn_stat (cs)** = FALSE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE).

The OTG B-device uses the Rx detect active timer (**b3_rx_detect_active_tmr**) to check for timeout on detection of Far End Rx Terminations.

Expiration of the Rx detect active timer (**b3_rx_detect_active_tmout** = TRUE) is as an error condition because under no condition shall the remote A-device disable its Far End Rx Terminations after a role swap on SuperSpeed. Please note that if the A-device is detached after a role swap, Vbus will disappear (**b_sess_vld** = FALSE) and the state machine shall transition to **b_idle**.

The B-device shall transition to the **b3_ds_training** state:

- if the A-device's [USB3.0] Rx Terminations are detected (**b3_a_rx_term** = TRUE)

The OTG B-device shall transition to the **b3_ds_error** state:

- the Rx detect active process times out (**b3_rx_detect_active_tmout** = TRUE)

6.3.12 b3_ds_training

This state corresponds to the **DSPORT.Training** state for a [USB3.0] hub port and the **Polling** state in the [USB3.0] LTSSM. The OTG B-device is not connected (**conn_stat (cs)** = FALSE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE). The OTG B-device uses the polling timer (**b3_polling_tmr**) to check for timeout of the link polling process.

The OTG B-device shall transition to the **b3_ds_host** state:

- if link training was successful (**b3_ds_training_success** = TRUE)

The OTG B-device shall transition to the **b3_ds_disconnected** state:

- if the link polling process times out (**b3_polling_tmout** = TRUE)

6.3.13 b3_ds_host

This state corresponds to the **DSPORT.Enabled** state for a [USB3.0] hub port and the **U0**, **U1**, **U2**, **U3** or **Recovery** states in the [USB3.0] LTSSM. The OTG B-device is connected (**conn_stat (cs)** = TRUE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE). The OTG B-device uses the Recovery timer (**b3_recovery_tmr**) to check for a timeout when the link is in the **Recovery** state.

The OTG B-device shall transition to the **b3_ds_rsp** state:

- the OTG B-device application no longer wishes to take the host role and has notified the A-device via a SET_FEATURE (**b3_ntf_host_rel** = TRUE) or
- the OTG B-device receives a device notification TP from the A-device with the RSP Phase set to INITIATE (**a3_ntf_host_req_init** = TRUE)

The OTG B-device shall transition to the **b3_ds_error** state:

- if there is a port configuration error (**b3_port_cfg_error** = TRUE) or
- there is a timeout from the link **Recovery** state (**b3_recovery_tmout** = TRUE) or
- if the exit from the U1 or U2 link states fails (**b3_u1_u2_exit_fail** = TRUE)

6.3.14 b3_ds_rsp

In this state the OTG B-device is in downstream operation and is executing the Role Swap Protocol (RSP) with the A-device as described in Section 5.4. As part of this process the B-device prepares for a role swap by shutting down any current host operations including for example ongoing file transfers. This ensures that there are no undesirable side-effects from the role swap.

This OTG B-device state corresponds to the **DSPORT.Enabled** state for a [USB3.0] hub port and the **U0** or **Recovery** states in the [USB3.0] LTSSM. The OTG B-device is connected (**conn_stat (cs)** = TRUE) and is operating at SuperSpeed (**super_speed (ss)** = TRUE). The OTG B-device uses the RSP Confirm Error timer (**rsp_cnf_err_tmr**) to ensure that the role swapping occurs in a timely manner.

The OTG B-device shall transition to the **b3_ds_swapping** state:

- if the B-device releases host role as part of a successful completion of the RSP process (**b_bus_req** = FALSE)

The OTG B-device shall transition to the **b3_ds_error** state:

- if there is a timeout from the link **Recovery** state (**b3_recovery_tmout** = TRUE) or
- the “RSP Confirm Error timer” times-out during the RSP process (**rsp_cnf_err_tmout** = TRUE).

6.3.15 b3_ds_swapping

On entering this state the OTG B-device shall issue a warm reset leading to a role swap. This is distinct from the **b3_ds_resetting** state which applies to directed resets of the downstream port when not

swapping roles. The **b_bus_req** variable becomes false indicating that the OTG B-device is ready to hand-over the host role to the OTG A-device.

This OTG B-device state corresponds to the **DSPORT.Resetting** state for a [USB3.0] hub port. This OTG B-device state corresponds to the **Rx.Detect.Reset** [USB3.0] LTSSM substate.

The OTG B-device is connected (**conn_stat (cs) = TRUE**) and is operating at SuperSpeed (**super_speed (ss) = TRUE**).

The OTG B-device shall transition to the **b3_us_disconnected** state:

- if the warm reset handshake, initiated by the B-device, completes resulting in a role swap completes (**wreset_rsp_complete = TRUE**).

6.3.16 b3_ds_resetting

This shall be the state after an OTG B-device directed reset. This state is distinct from the **b3_ds_swapping** state which applies only during a role swap.

This OTG B-device state corresponds to the **DSPORT.Resetting** state for a [USB3.0] hub port and an undefined state in the [USB3.0] LTSSM. The OTG B-device is not connected (**conn_stat (cs) = FALSE**) and is operating at SuperSpeed (**super_speed (ss) = TRUE**).

The OTG B-device uses the polling timer (**b3_polling_tmr**) to check for timeout of the link polling process. The OTG B-device uses the Rx detect active timer (**b3_rx_detect_active_tmr**) to check for timeout on detection of Far End Rx Terminations.

Expiration of the Rx detect active timer (**b3_rx_detect_active_tmout = TRUE**) is as an error condition because under no condition shall the remote A-device disable its Far End Rx Terminations after a role swap on SuperSpeed. Please note that if the A-device is detached after a role swap, Vbus will disappear (**b_sess_vld = FALSE**) and the state machine shall transition to **b_idle**.

The OTG B-device shall transition to the **b3_ds_disconnected** state:

- if the link polling process times out (**b3_polling_tmout = TRUE**)

The OTG B-device shall transition to the **b3_ds_host** state:

- when the directed reset completes (**b3_reset_complete = TRUE**)

The OTG B-device shall transition to the **b3_ds_error** state:

- if the Rx detect active process times out (**b3_rx_detect_active_tmout = TRUE**)

6.3.17 b3_ds_error

This shall be the error state for an OTG B-device in downstream port operation.

This OTG B-device state corresponds to the **DSPORT.Error** state for a [USB3.0] hub port and the **SS.Inactive** state in the [USB3.0] LTSSM. The OTG B-device is not connected (**conn_stat (cs) = FALSE**) and is operating at SuperSpeed (**super_speed (ss) = TRUE**).

The B-device shall issue a directed warm reset or a directed hot reset in order to transition out of this state. For details refer to Section 6.3.1.

6.4 State Machine Parameters

This section describes the inputs, internal variables, timers, and outputs associated with the state machines.

6.4.1 Common Inputs

6.4.1.1 id

The identification (**id**) input is FALSE when a Micro-A plug is attached to the device's USB 3.0 Micro-AB receptacle. Otherwise, this input is TRUE.

6.4.1.2 us_rx_detect_limit_reached

The "USB 3.0 receiver detect limit" (**us_rx_detect_limit_reached**) input is TRUE when the A-device or the B-device, acting as an upstream port, has reached the receiver termination detection limit defined in [USB3.0].

6.4.1.3 wreset_rsp_complete

The "USB 3.0 warm reset and role swap complete" (**wreset_rsp_complete**) input is TRUE when the warm reset handshake completes resulting in a role swap.

6.4.1.4 a3_ntf_host_req_init

This state machine parameter is an input to both the USB3.0 A-device and the USB3.0 B-device state diagram and is set as defined below.

The "USB 3.0 A-device notify host request" (**a3_ntf_host_req_init**) input is TRUE in the USB3.0 A-device state diagram when a Device Notification TP with the RSP Phase set to INITIATE is sent by the A-device.

The "USB 3.0 A-device notify host request" (**a3_ntf_host_req_init**) input is TRUE in the USB3.0 B-device state diagram when a Device Notification TP with the RSP Phase set to INITIATE is received by the B-device.

6.4.1.5 b3_ntf_host_req_init

This state machine parameter is an input to both the USB3.0 A-device and the USB3.0 B-device state diagram and is set as defined below.

The "USB 3.0 B-device notify host request" (**b3_ntf_host_req_init**) input is TRUE in the USB3.0 A-device state diagram when a HOST_ROLE_REQUEST Device Notification TP with the RSP Phase set to INITIATE is received by the A-device.

The "USB 3.0 B-device notify host request" (**b3_ntf_host_req_init**) input is TRUE in the USB3.0 B-device state diagram when a HOST_ROLE_REQUEST Device Notification TP with the RSP Phase set to INITIATE is sent by the B-device.

6.4.1.6 b3_ntf_host_rel

The "USB 3.0 B-device notify host release" (**b3_ntf_host_rel**) input is TRUE when the A-device has received a SET_FEATURE request from the B-device (see Section 5.2.1).

6.4.2 USB 3.0 A-device Inputs

6.4.2.1 a3_b_hreset_detect

The "USB 3.0 A-device hot reset from the B-device detect" (**a3_b_hreset_detect**) input is TRUE when the A-device detects that the B-device is performing a directed [USB3.0] hot reset.

6.4.2.2 a3_b_rx_term

The “USB 3.0 A-device receiver terminations from the B-device” (**a3_b_rx_term**) input is TRUE when the A-device detects the B-device’s [USB3.0] receiver terminations.

6.4.2.3 a3_b_wreset_detect

The “USB 3.0 A-device warm reset from the B-device detect” (**a3_b_wreset_detect**) input is TRUE when the A-device detects a [USB3.0] warm reset which is being generated by the B-device.

6.4.2.4 a3_compliance_mode_entry

The “USB 3.0 A-device compliance mode entry” (**a3_compliance_mode_entry**) input is TRUE when the A-device is configured to go into [USB3.0] compliance mode. The compliance mode entry criteria are defined in [USB3.0] (Section 7.5.4.3).

6.4.2.5 a3_ds_training_success

The “USB 3.0 A-device downstream port training success” (**a3_ds_training_success**) input is TRUE when the A-device, acting as a downstream port, successfully completes [USB3.0] link training.

6.4.2.6 a3_hot_reset

The “USB 3.0 A-device hot reset” (**a3_hot_reset**) input is TRUE when the A-device initiates a [USB3.0] directed hot reset.

6.4.2.7 a3_loopback_exit

The “USB 3.0 A-device loopback exit” (**a3_loopback_exit**) input is TRUE when the A-device has successfully performed a [USB3.0] LFPS handshake in order to exit [USB3.0] loopback mode.

6.4.2.8 a3_loopback_exit_error

The “USB 3.0 A-device loopback exit” (**a3_loopback_exit_error**) input is TRUE when the A-device has not been successful in performing a [USB3.0] LFPS handshake in order to exit [USB3.0] loopback mode.

6.4.2.9 a3_loopback_set

The “USB 3.0 A-device loopback set” (**a3_loopback_set**) input is TRUE when the A-device receives [USB3.0] TS2 ordered sets with the loopback bit set.

6.4.2.10 a3_port_cfg_error

The “USB 3.0 A-device port configuration error” (**a3_port_cfg_error**) input is TRUE when the A-device detects that the [USB3.0] port configuration process has failed.

6.4.2.11 a3_reset_complete

The “USB 3.0 A-device reset complete” (**a3_reset_complete**) input is TRUE when the A-device has completed either a directed [USB3.0] warm or [USB3.0] hot reset.

6.4.2.12 a3_ss_disabled

The “USB 3.0 A-device SuperSpeed disabled” (**a3_ss_disabled**) input is TRUE when the A-device has disabled its SuperSpeed capability.

6.4.2.13 a3_u1_u2_exit_fail

The “USB 3.0 A-device U1, U” exit fail” (**a3_u1_u2_exit_fail**) input is TRUE when the A-device LTSSM fails to exit from either the U1 or U2 state.

6.4.2.14 a3_us_training_success

The “USB 3.0 A-device upstream training success” (**a3_us_training_success**) input is TRUE when the A-device, acting as a upstream port, successfully completes link training.

6.4.2.15 a3_warm_reset

The “USB 3.0 A-device warm reset” (**a3_warm_reset**) input is TRUE when the A-device, acting as a downstream port, initiates a [USB3.0] directed warm reset.

6.4.2.16 a3_set_b3_rsp_en

The “USB 3.0 A-device Set B3_RSP_ENABLE” (**a3_set_b3_rsp_en**) input is TRUE when the A-device has successfully enabled the B3_RSP_ENABLE feature via the SET_FEATURE command (see Section 5.2.2).

6.4.3 USB 3.0 B-device Inputs

6.4.3.1 b3_a_hreset_detect

The “USB 3.0 B-device hot reset from the A-device detect” (**b3_a_hreset_detect**) input is TRUE when the B-device detects that the A-device is performing a directed [USB3.0] hot reset.

6.4.3.2 b3_a_rx_term

The “USB 3.0 B-device receiver terminations from the A-device” (**b3_a_rx_term**) input is TRUE when the B-device detects the A-device’s [USB3.0] receiver terminations.

6.4.3.3 b3_a_wreset_detect

The “USB 3.0 B-device warm reset from the A-device detect” (**b3_a_wreset_detect**) input is TRUE when the B-device detects a [USB3.0] warm reset which is being generated by the A-device.

6.4.3.4 b3_ds_training_success

The “USB 3.0 B-device downstream port training success” (**b3_ds_training_success**) input is TRUE when the B-device, acting as a downstream port, successfully completes [USB3.0] link training.

6.4.3.5 b3_hot_reset

The “USB 3.0 B-device hot reset” (**b3_hot_reset**) input is TRUE when the B-device initiates a [USB3.0] directed hot reset.

6.4.3.6 b3_rsp_en

The “USB 3.0 B-device RSP enable” (**b3_rsp_en**) input is TRUE when the B-device has had its B3_RSP_ENABLE capability set by the SET_FEATURE command (see Section 5.2.2).

6.4.3.7 b3_port_cfg_error

The “USB 3.0 B-device port configuration error” (**b3_port_cfg_error**) input is TRUE when the B-device detects that the [USB3.0] port configuration process has failed.

6.4.3.8 b3_reset_complete

The “USB 3.0 B-device reset complete” (**b3_reset_complete**) input is TRUE when the B-device has completed either a directed [USB3.0] warm or [USB3.0] hot reset.

6.4.3.9 b3_u1_u2_exit_fail

The “USB 3.0 B-device U1, U2” exit fail” (**b3_u1_u2_exit_fail**) input is TRUE when the B-device LTSSM fails to exit from either the U1 or U2 state.

6.4.3.10 b3_us_training_success

The “USB 3.0 B-device upstream training success” (**b3_us_training_success**) input is TRUE when the B-device, acting as a upstream port, successfully completes link training.

6.4.3.11 b3_warm_reset

The “USB 3.0 B-device warm reset” (**b3_warm_reset**) input is TRUE when the B-device, acting as a downstream port, initiates a [USB3.0] directed warm reset.

6.4.3.12 b3_compliance_mode_entry

The “USB 3.0 B-device compliance mode entry” (**b3_compliance_mode_entry**) input is TRUE when the B-device is configured to go into [USB3.0] compliance mode. The compliance mode entry criteria are defined in [USB3.0] (Section 7.5.4.3).

6.4.3.13 b_reset_detect

The “B-device Reset Detect” (**b_reset_detect**) input is TRUE when a [USB2.0] reset is received.

6.4.3.14 b3_ss_disabled

The “USB 3.0 B-device SuperSpeed disabled” (**b3_ss_disabled**) input is TRUE when the B-device has disabled its SuperSpeed capability.

This parameter is used by **SSPC-OTG** B-devices that wish to support a switch to host role when attached to **SS-OTG** A-devices. The scenario of events in this case is described in Figure A-3.

6.4.4 Outputs

6.4.4.1 conn_stat

The “connection state” (**conn_stat (cs)**) bit is TRUE when the local device has established a SuperSpeed connection with the remote device.

6.4.4.2 super_speed

The “SuperSpeed” (**super_speed (ss)**) bit is TRUE when the local device is operating at SuperSpeed.

6.4.5 Internal Constants

6.4.5.1 ss_host_support

The “USB 3.0 SuperSpeed host support” (**ss_host_support**) internal constant is TRUE when the A-device supports SuperSpeed capability as a host.

6.4.5.2 eh

The “Embedded Host” (**eh**) internal constant is TRUE when the local device is an Embedded Host.

6.4.5.3 otg

The “On-The-Go” (**otg**) internal constant is TRUE when the device features a Micro-AB receptacle as defined in [USB3.0] or [Micro-USB1.01].

6.4.5.4 po

The “Peripheral-only” (**po**) internal constant is TRUE when the local device is a peripheral-only B-device.

6.4.6 Timers

The state machines specified in this supplement make use of the timers in Table 6-7. All timers are started on entry to and reset on exit from their associated states.

Table 6-7: OTG Device Timers

| Timer | Timeout Time | Timeout Indication | Associated State |
|--------------------------------|---|----------------------------------|---|
| a3_polling_tmr | tPollingLFPSTimeout tPollingActiveTimeout tPollingIdleTimeout | a3_polling_tmout | a3_ds_training, a3_ds_resetting, a3_us_training |
| rsp_cnf_err_tmr | TRSP_CNF_ERR | rsp_cnf_err_tmout | a3_ds_rsp, b3_ds_rsp |
| rsp_ack_err_tmr | TRSP_ACK_ERR | rsp_ack_err_tmout | a3_us_rsp, b3_us_rsp |
| rsp_wrst_err_tmr | TRSP_WRST_ERR | rsp_wrst_err_tmout | a3_us_rsp, b3_us_rsp |
| a3_rx_detect_active_tmr | tTimeForResetError | a3_rx_detect_active_tmout | a3_ds_resetting |
| a3_recovery_tmr | tRecoveryActiveTimeout tRecoveryConfigurationTimeout tRecoveryIdleTimeout | a3_recovery_tmout | a3_ds_host, a3_ds_rsp, a3_us_peripheral, a3_us_rsp |
| b3_polling_tmr | tPollingLFPSTimeout tPollingActiveTimeout tPollingIdleTimeout | b3_polling_tmout | b3_ds_training, b3_ds_resetting, b3_us_training |
| b3_rx_detect_active_tmr | tTimeForResetError | b3_rx_detect_active_tmout | b3_ds_resetting, b3_ds_disconnected |
| b3_recovery_tmr | tRecoveryActiveTimeout tRecoveryConfigurationTimeout tRecoveryIdleTimeout | b3_recovery_tmout | b3_ds_host, b3_ds_rsp, b3_us_peripheral, b3_us_rsp |

6.4.6.1 a3_polling_tmr

This timer is used in the **a3_ds_training**, **a3_ds_resetting**, and **a3_us_training** states. The “USB 3.0 A-device polling timeout” (**a3_polling_tmout**) variable is TRUE when the A-device times out of the [USB3.0] LTSSM **Polling** state while in SuperSpeed operation.

The associated parameters **a3_polling_tmout** and **a3_compliance_mode_entry** are set to TRUE when one of the following timers expires:

- tPollingLFPSTimeout timer started in the **Polling.LFPS** substate.

- **a3_polling_tmout** is set to TRUE on the expiration of this timer only if training has previously been successful on the port since power up.
- **a3_compliance_mode_entry** is set to TRUE on the expiration of this timer only if training has not previously been successful on the port since power up and the condition to transition to **Polling.RxEq** substate is not met.
- tPollingActiveTimeout timer started in **Polling.Active** substate.
 - **a3_polling_tmout** is set to TRUE on the expiration of this timer and the conditions to transition to **Polling.Configuration** substate are not met.
- tPollingIdleTimeout timer started in **Polling.Idle** substate.
 - **a3_polling_tmout** is set to TRUE on the expiration of this timer and the conditions to transition to **U0** state are not met.

Please refer to [USB3.0] for more details regarding these timeouts.

6.4.6.2 rsp_cnf_err_tmr

This timer is used in the **a3_ds_rsp** and **b3_ds_rsp** states and is started on entry to these states. The “RSP Confirm Error Timer” is used to ensure that a RSP confirmation is received from the peripheral in a timely manner. If the confirmation is not received after **TRSP_CNF_ERR**, **rsp_cnf_err_tmout** is set to TRUE at which point a transition is made to an error state (**a3_ds_error** or **b3_ds_error**).

6.4.6.3 rsp_ack_err_tmr

This timer is used in the **a3_us_rsp** and **b3_us_rsp** states and is started on entry to these states. The “RSP Acknowledge Error Timer” is used to ensure that a RSP acknowledgement is received from the host in a timely manner. If the acknowledgement is not received after **TRSP_ACK_ERR**, **rsp_ack_err_tmout** is set to TRUE at which point a transition is made to an error state (**a3_us_error** or **b3_us_error**).

6.4.6.4 rsp_wrst_err_tmr

This timer is used in the **a3_us_rsp** and **b3_us_rsp** states. The “RSP Warm Reset Error Timer” is used to ensure that a Warm Reset is received from the host in a timely manner. If the Warm Reset is not received after **TRSP_WRST_ERR**, **rsp_wrst_err_tmout** is set to TRUE at which point a transition is made to an error state (**a3_us_error** or **b3_us_error**).

6.4.6.5 a3_rx_detect_active_tmr

This timer is used by the A-device in the **a3_ds_resetting** state. The “A-device Rx Detect Active Timeout” (**a3_rx_detect_active_tmout**) variable is TRUE when the Rx terminations are not detected for a period of time of tTimeForResetError as described in [USB3.0].

6.4.6.6 a3_recovery_tmr

This timer is used in the **a3_ds_host**, **a3_ds_rsp**, **a3_us_peripheral**, and **a3_us_rsp** states. The “USB 3.0 A-device recovery timeout” (**a3_recovery_tmout**) variable is TRUE when the A-device times out of the [USB3.0] LTSSM **Recovery** state while in SuperSpeed operation.

The parameter **a3_recovery_tmout** is set to TRUE when one of the following timers expires:

- tRecoveryActiveTimeout timer started in **Recovery.Active** substate
- tRecoveryConfigurationTimeout timer started in **Recovery.Configuration** substate
- tRecoveryIdleTimeout timer started in **Recovery.Idle** substate

Please refer to [USB3.0] for more details regarding these timeouts.

6.4.6.7 b3_polling_tmr

This timer is used in the **b3_ds_training**, **b3_ds_resetting**, and **b3_us_training** states. The “USB 3.0 B-device polling timeout” (**b3_polling_tmout**) variable is TRUE when the B-device times out of the [USB3.0] LTSSM **Polling** state while in SuperSpeed operation.

The associated parameters **b3_polling_tmout** and **b3_compliance_mode_entry** are set to TRUE when one of the following timers expires:

- tPollingLFPSTimeout timer started in the **Polling.LFPS** substate.
 - **b3_polling_tmout** is set to TRUE on the expiration of this timer only if training has previously been successful on the port since power up.
 - **b3_compliance_mode_entry** is set to TRUE on the expiration of this timer only if training has not previously been successful on the port since power up and the condition to transition to **Polling.RxEq** substate is not met.
- tPollingActiveTimeout timer started in **Polling.Active** substate.
 - **b3_polling_tmout** is set to TRUE on the expiration of this timer and the conditions to transition to **Polling.Configuration** substate are not met.
- tPollingIdleTimeout timer started in **Polling.Idle** substate.
 - **b3_polling_tmout** is set to TRUE on the expiration of this timer and the conditions to transition to **U0** state are not met.

Please refer to [USB3.0] for more details regarding these timeouts.

6.4.6.8 b3_rx_detect_active_tmr

This timer is used by the B-device in the **b3_ds_resetting** and **b3_ds_disconnected** states. The “B-device Rx Detect Active Timeout” (**b3_rx_detect_active_tmout**) variable is TRUE when the Rx terminations are not detected for a period of time of tTimeForResetError as described in [USB3.0]. Please note that while the [USB3.0] specifies the use of this timer for a standard Downstream port only in the DSPORT.Resetting state, a B-device Downstream port shall use this timer in both the **b3_ds_resetting** and **b3_ds_disconnected** states.

6.4.6.9 b3_recovery_tmr

This timer is used in the **b3_ds_host**, **b3_ds_rsp**, **b3_us_peripheral**, and **b3_us_rsp** states. The “USB 3.0 A-device recovery timeout” (**b3_recovery_tmout**) variable is TRUE when the B-device times out of the [USB3.0] LTSSM **Recovery** state while in SuperSpeed operation. Recovery timeouts are detailed in [USB3.0] section 7.5.10.

b3_recovery_tmout is set to TRUE when one of the following timers expires:

- tRecoveryActiveTimeout timer started in **Recovery.Active** substate
- tRecoveryConfigurationTimeout timer started in **Recovery.Configuration** substate
- tRecoveryIdleTimeout timer started in **Recovery.Idle** substate

Please refer to [USB3.0] for more details regarding these timeouts.

Appendix A SSPC-OTG Device Operations

This appendix provides additional details regarding examples of expected behavior when attaching a SSPC-OTG device to a SSPC-OTG, SS-OTG or USB 2.0 OTG device. The scenario of attaching a SSPC-OTG device to an EH is excluded.

Table A-1: SSPC-OTG Device Operations

| | A-Device | B-Device | Behavior |
|-----|----------|----------|--|
| A.1 | SSPC-OTG | SSPC-OTG | <p>There is no SuperSpeed Host in this connection so the USB cannot operate in SuperSpeed mode. The SSPC-OTG A-Device starts as HS A-Host and the SSPC-OTG B-Device connects as HS B-Peripheral.</p> <p>Through the OTG descriptor of the SSPC-OTG B-Device, the software on A-Device detects there is also no SS Host capability on the B-Device and can prompt the user “The connected OTG devices do not support SuperSpeed Host function so it will be operating in USB 2.0 High Speed rate only.” or similar user messaging. This is to avoid confusing the user who might be expecting two SuperSpeed-capable devices to operate at SS data rate. Please refer to Section 3.3 for more details.</p> <p>The SSPC-OTG B-Device can use HNP to request Host role if needed. After HNP, the B-Device becomes HS B-Host, while the A-Device becomes HS A-Peripheral.</p> <p>Refer to Figure A.1 example below for more details.</p> |
| A.2 | SSPC-OTG | SS-OTG | <p>The SSPC-OTG A-Device starts as HS A-Host and the SS-OTG B-Device connects as HS B-Peripheral. The SS-OTG B-Device in HS B-Peripheral role may request a role swap through HNP, but the SSPC-OTG A-Device in HS A-Host role can only swap to HS A-Peripheral role and not to SS A-Peripheral so the connection between the two devices remains at HS only.</p> <p>Through the OTG Descriptor of the SS-OTG B-Device, the SSPC-OTG A-Device knows the B-Device supports SS Host capability and can prompt the user “You can run at USB 3.0 SuperSpeed rate if you reverse the ends of the cable between the two devices.” or similar user messaging. Please refer to Section 3.3 for more details.</p> <p>Refer to Figure A.2 example below for more details.</p> |

| | | | |
|-----|-------------|-------------|---|
| A.3 | SS-OTG | SSPC-OTG | <p>The SS-OTG A-Device starts as SS A-Host and the SSPC-OTG B-Device connects as SS B-Peripheral.</p> <p>SSPC-OTG Device in SS B-Peripheral role cannot request a role swap via RSP. In order to swap roles an SSPC-OTG device can disconnect and reconnect in [OTG&EH2.0] operation in order to use HNP, but only if the SS-OTG A-device supports HNP while operating in [OTG&EH2.0] speeds. When it completes using the bus, it can generate a disconnect again and then reconnect as SS B-Peripheral.</p> <p>Refer to Figure A.3 example below for more details.</p> |
| A.4 | SSPC-OTG | USB 2.0 OTG | <p>The SSPC-OTG A-Device starts as HS A-Host and the USB 2.0 OTG B-Device connects as HS B-Peripheral. No SS operation can be supported. All normal USB 2.0 OTG HNP role swap operations will be supported per specification if both devices support HNP.</p> |
| A.5 | USB 2.0 OTG | SSPC-OTG | <p>The USB 2.0-OTG A-Device will start as HS A-Host and the SSPC-OTG B-Device will connect as HS B-Peripheral. No SS operation can be supported. All normal USB 2.0 OTG HNP role swap operations will be supported per specification if both devices support HNP.</p> |

Figures A-1 to A-3 illustrates the scenarios A.1, A.2 and A.3 described in Table A-1 respectively and it is assumed both A-Device and B-Device support HNP functionalities.

Figure A-1: SSPC-OTG A-Device connected to SSPC-OTG B-Device

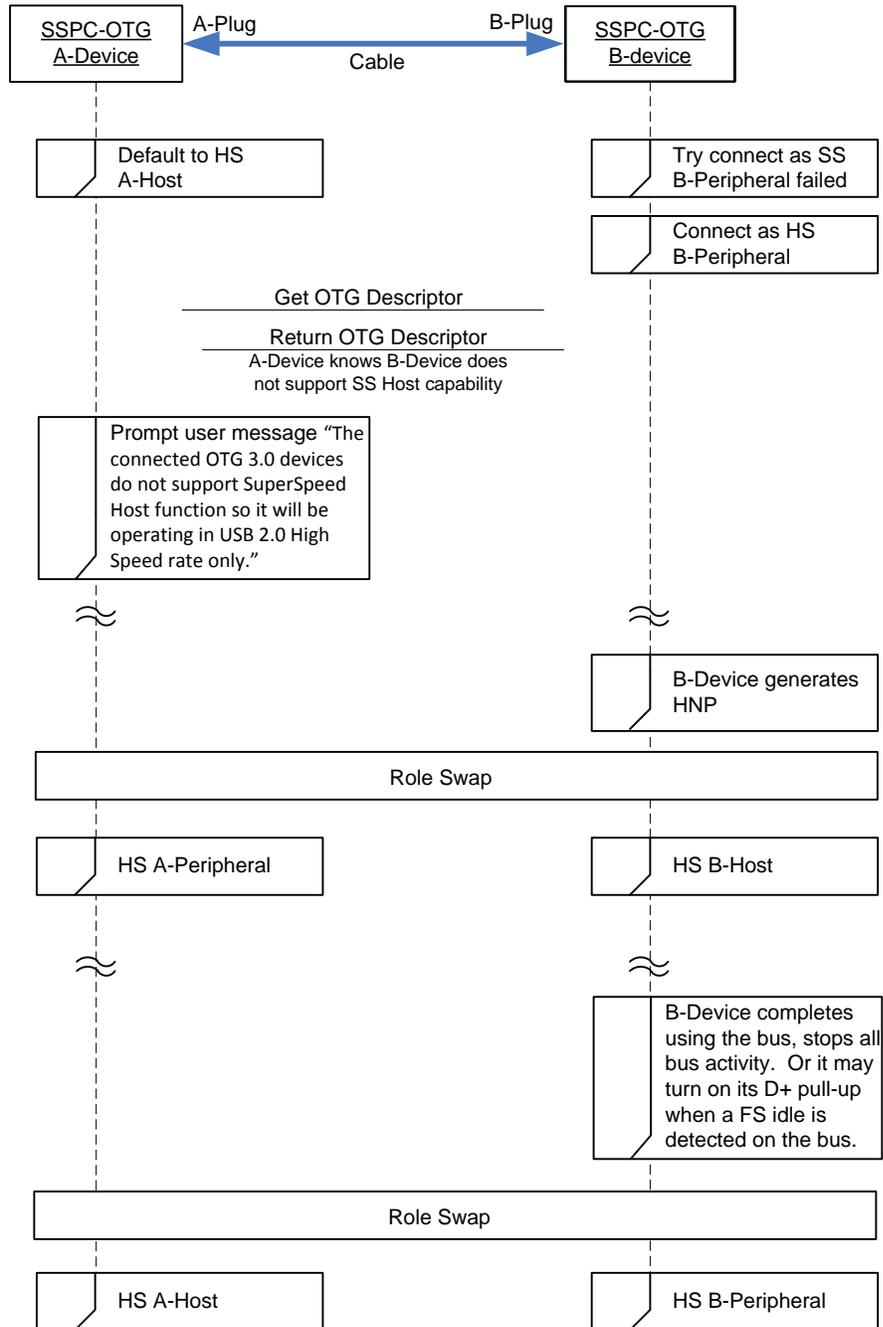


Figure A-2: SSPC-OTG A-Device connected to SS-OTG B-Device

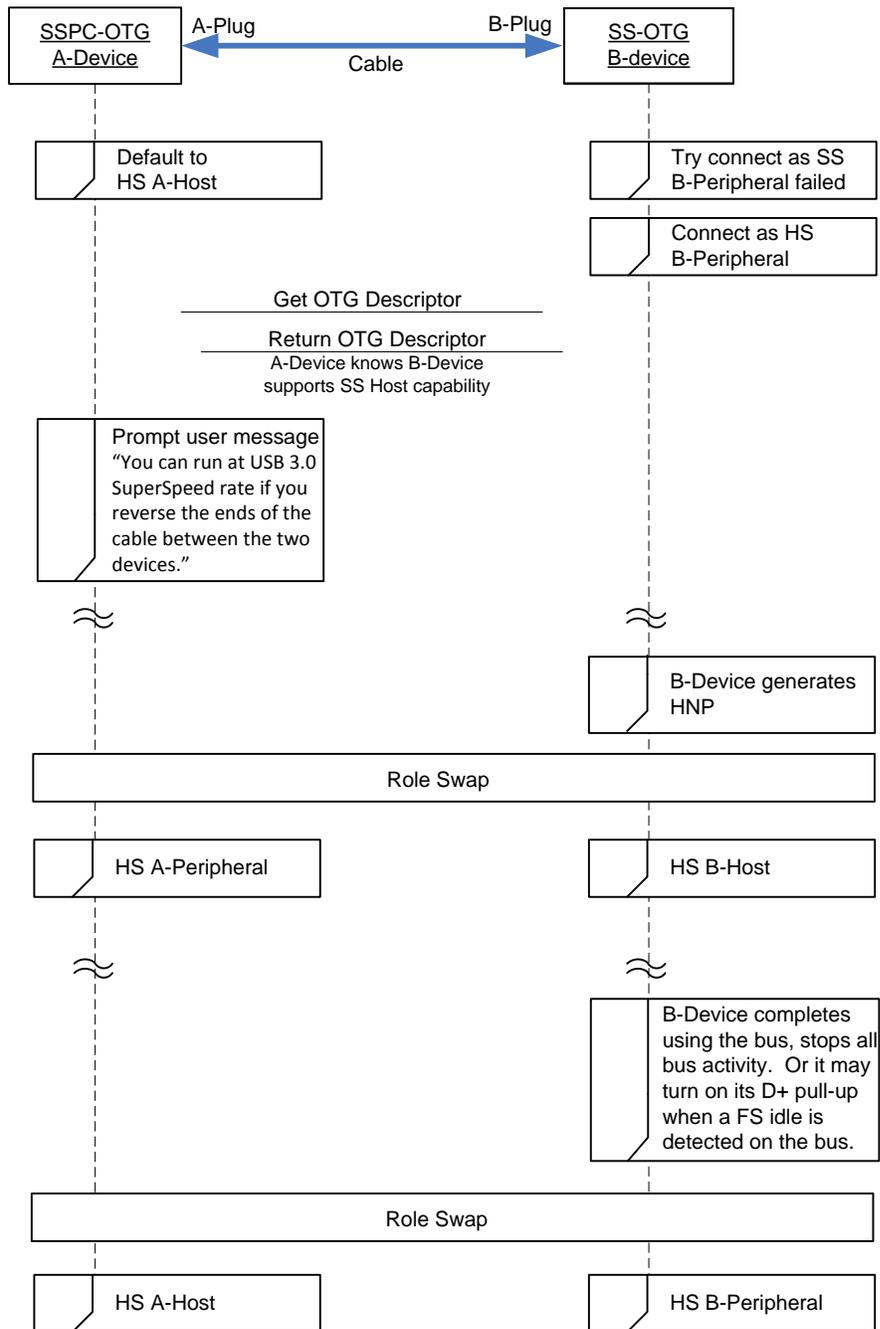


Figure A-3: SS-OTG A-Device connected to SSPC-OTG B-Device

