OMAP4 Standard USB Usage

Version A

Application Report

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ABSTRACT

This application note describes the architecture and use of the host and on-the-go (OTG) USB controllers in the OMAP4 product family. Software developers can use the provided images to improve their understanding of USB usage in OMAP4 devices.

NOTE: **OMAP44xx Disclaimer:** All programming models and use cases presented in this document are provided for educative purposes only and may differ from or be optimized for your applications. All OMAP peripheral devices presented in this document are provided for illustration purposes and may be different from those in your system.

1 Introduction

OMAP4 high-performance multimedia application devices are based on enhanced OMAP™ architecture. OMAP4 devices include one high-speed (HS) USB OTG controller module and one HS multiport USB host module. Both modules comply with USB2.0 standards for HS function (480 Mbps). (OMAP4 devices also embed a legacy FS USB host module, which is beyond the scope of this document.)

NOTE: To avoid confusion, the following terminology is defined:

- Device: Any device that can be a host or peripheral, such as a PC, smartphone, tablet, or USB stick
- Host or host device: A USB host device, such as a PC or the device embedding the OMAP4 device
- Peripheral or peripheral device: A USB peripheral device, such as a USB stick, mouse, or the device embedding the OMAP4 device

The Mentor HS USB OTG IP only has one interface (USBA), providing DP/DM pins directly at the OMAP boundary.

The Synopsys HS USB Host IP is divided into 2 blocks: Enhanced host controller interface (EHCI) and open host controller interface (OHCI).

The EHCI block allows HS-only transfers on 2 physical ports: USBB1 and USBB2. Each port can be configured in UTMI+ low pin interface (ULPI), transceiver-less link logic (TLL), or high-speed inter-chip (HSIC) mode.

The OHCI block allows FS/LS transfers on 2 physical ports: USBB1 and USBB2. Each port can be configured in 3/4/5/6 pin FS serial mode.

Depending on the OMAP44xx version (4430/4460/4470) and revision (ESx.y), some combinations might not be functional (for example, TLL on USBB1 and HSIC on USBB2). Please see the latest errata available.

Figure 1 shows a global overview of USB architecture in OMAP4 devices.

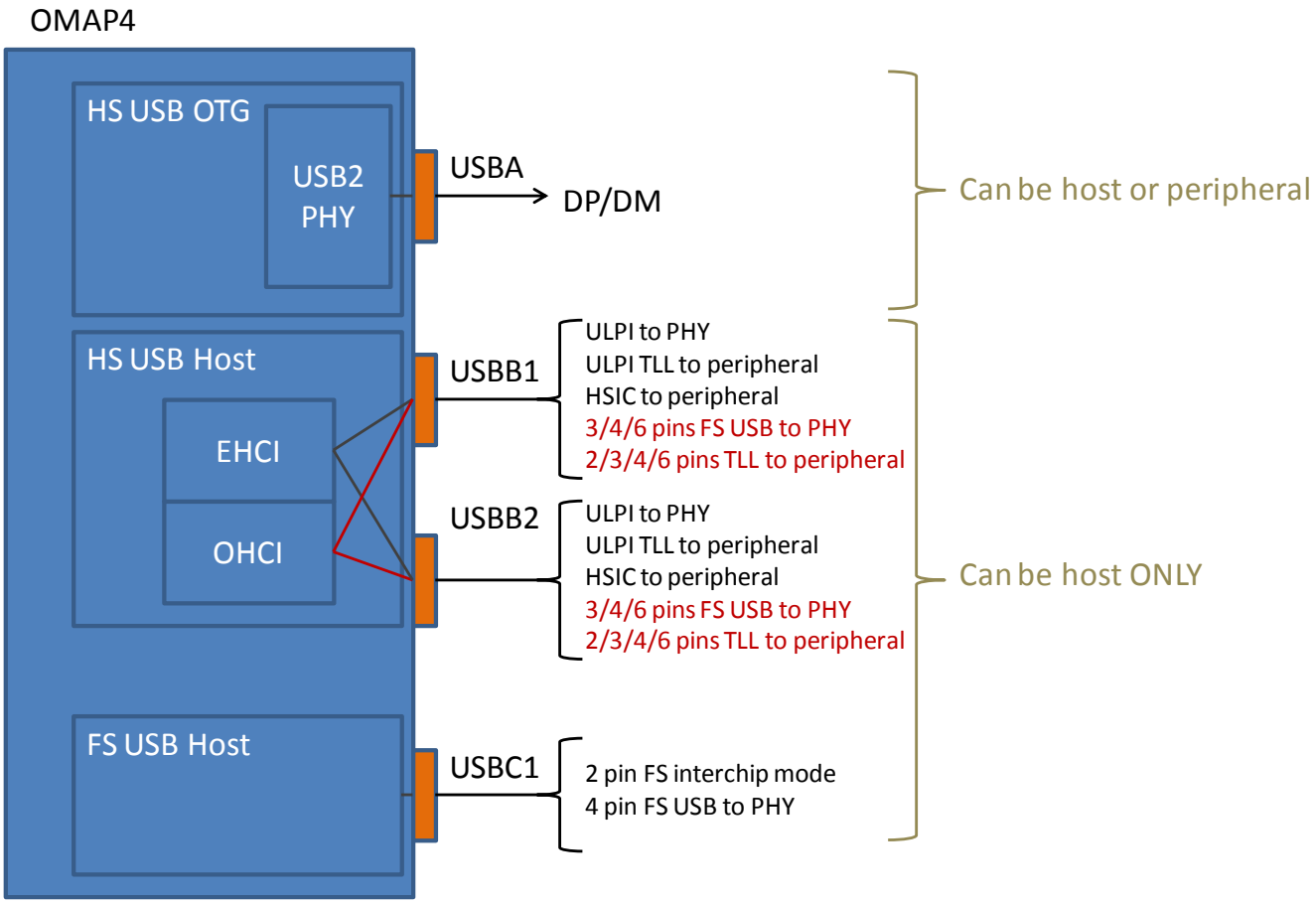

Figure 1. OMAP4 Global USB Architecture

2 OMAP4 USB OTG

The OMAP4 USB OTG controller can be used as a peripheral connected to a host or as a host connected to a peripheral.

2.1 USB OTG as a Peripheral Device

Figure 2 shows two examples of OMAP4 USB OTG devices (in this case, smart phones) connected as peripherals to other USB host devices.

Figure 2. Smart Phone With OMAP4 USB OTG Used as Peripheral

2.1.1 Connecting to a Host PC

Figure 3 shows the connection between a PC and OMAP USB OTG device in peripheral mode.

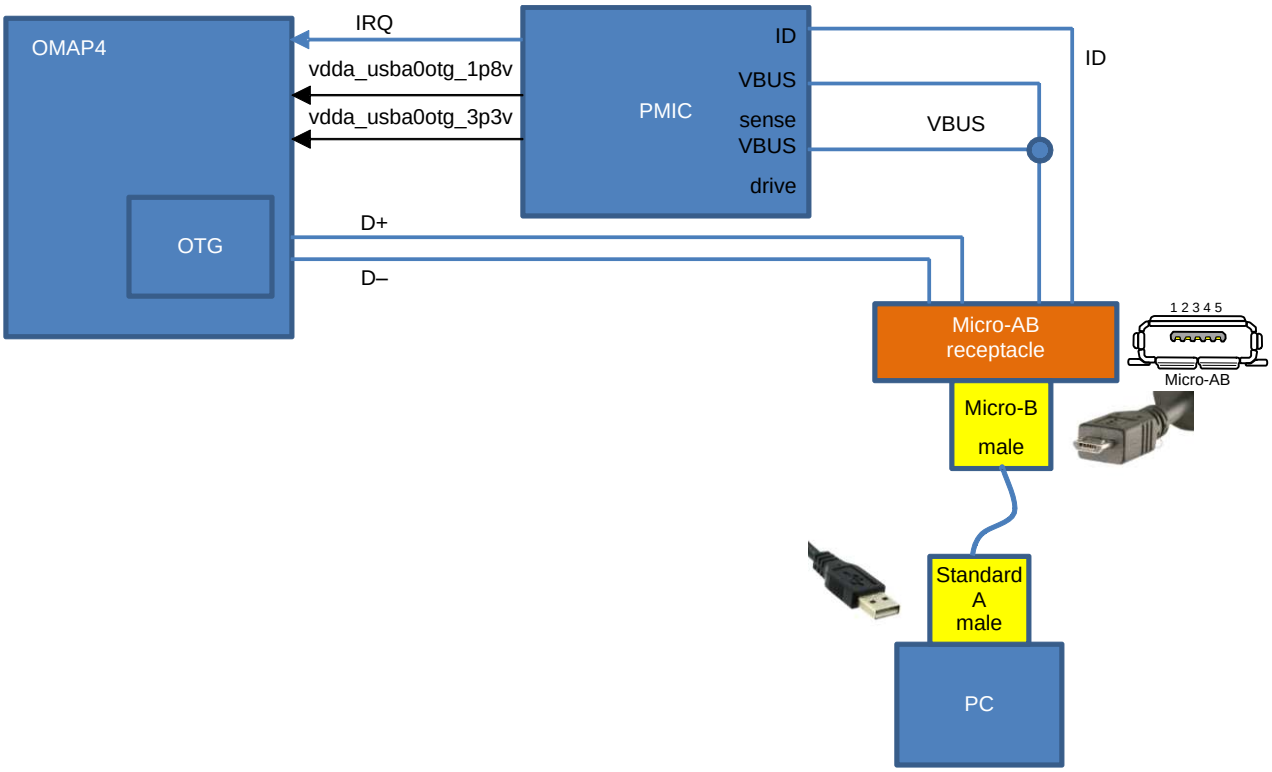

Figure 3. PC Connected to OMAP4 USB OTG in Peripheral Mode

In the scenario shown in Figure 3, when the USB cable is connected:

- A micro-B male is plugged into a micro-AB receptacle.
- VBUS is provided by the PC.
- VBUS rise is detected by the power management multichannel IC (PMIC).
- The PMIC sends an IRQ to the OMAP device.
- The OMAP device loads the OTG driver.

When VBUS IRQ is provided, the OMAP device enters peripheral mode and recognizes the PC as host. The OMAP device sets the pull-up on D+, and the PC performs a USB reset and enumerates.

In the scenario shown in Figure 3, when the USB cable is removed:

- VBUS drops.
- The PMIC sends an IRQ to the OMAP device.
- The OTG device detects a disconnection through D+/D–.

2.1.2 Connecting to Another OTG Device in Host Mode

Figure 4 shows the connection between an OTG device acting as a host and an OMAP USB OTG device in peripheral mode.

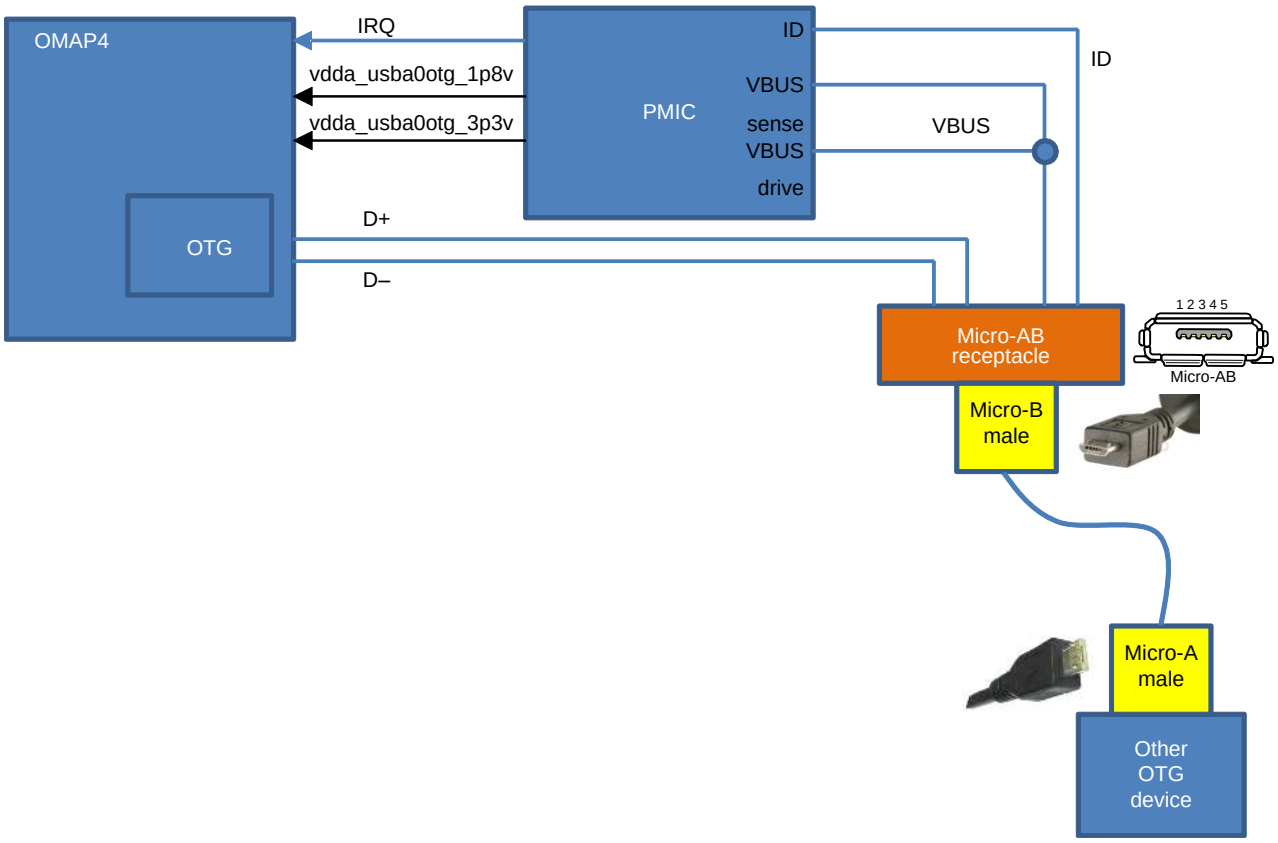

Figure 4. OTG Device Connected an to OMAP4 USB OTG in Peripheral Mode

In the scenario shown in Figure 4, the OMAP USB OTG device determines its role based on the type of plug connected (micro-B = peripheral, micro-A = host). When the USB cable is connected:

- A micro-B male is plugged into a micro-AB receptacle.
- VBUS is provided by the host OTG device.
- VBUS rise is detected by the PMIC.
- The PMIC sends an IRQ to the OMAP device.
- The OMAP device loads the OTG driver.
- When VBUS IRQ is provided, the OMAP device enters peripheral mode and recognizes the other OTG device as host.
- The OMAP device sets the pull-up on D+, and the host device performs USB reset and enumerates.

When the USB cable is removed:

- VBUS drops.
- The PMIC sends an IRQ to the OMAP device.
- The OTG device detects a disconnection through D+/D–.

2.2 USB OTG as Host Device

Figure 5 shows examples of OMAP4 USB OTG devices (in this case, smart phones) connected as hosts to other peripheral devices.

Figure 5. Smart Phone With the OMAP4 USB OTG Device Used as Host

2.2.1 Connecting to an HS/FS/LS Peripheral Device

Figure 6 shows the connection between an HS/FS/LS peripheral device and OMAP USB OTG device in host mode.

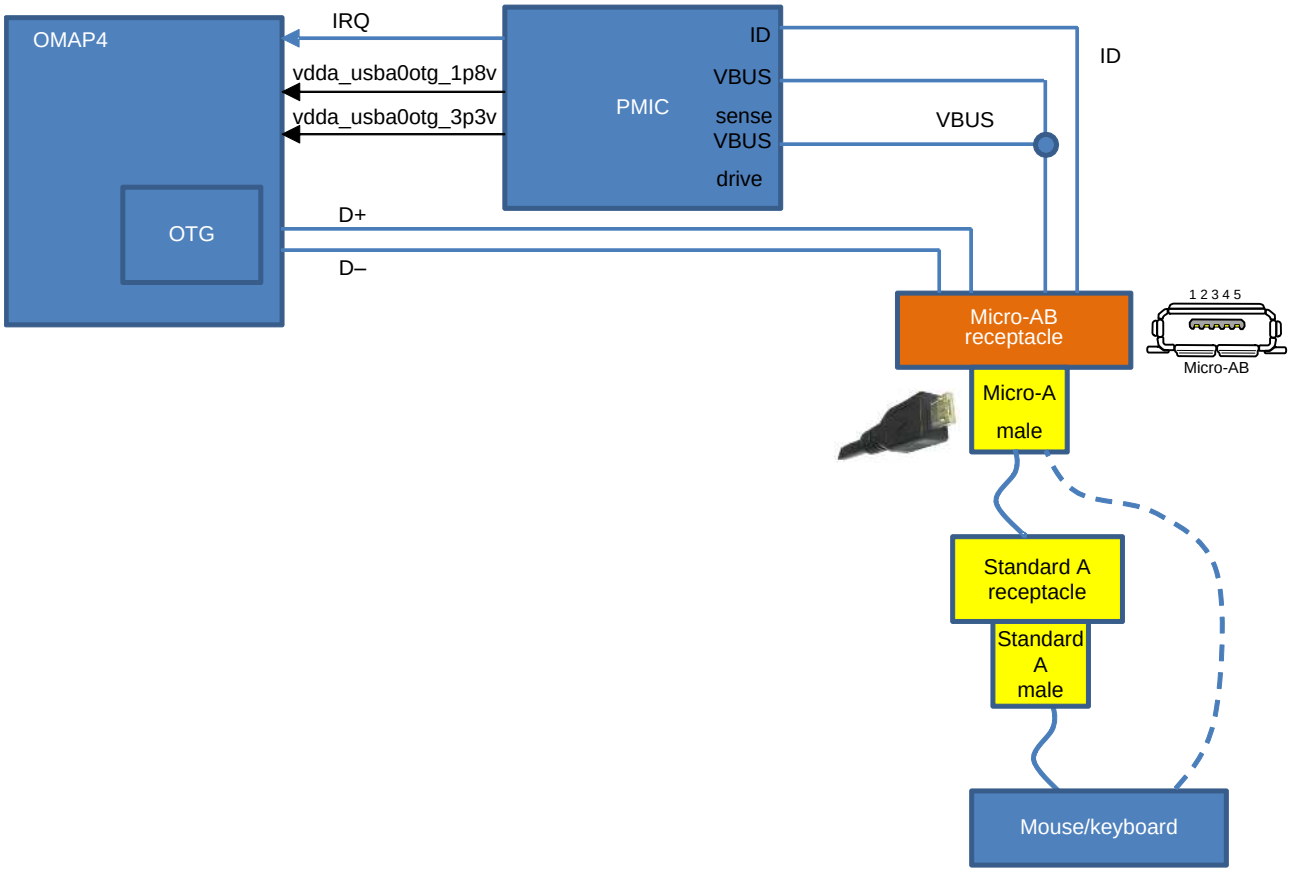

Figure 6. OMAP4 USB OTG Device as Host for HS/FS/LS Peripheral Device

In the scenario shown in Figure 6, when the USB cable is connected:

- A micro-A male is plugged into a micro-AB receptacle.
- ID-grounded is detected by the PMIC.
- The PMIC sends an IRQ to the OMAP device.
- The OMAP device loads the OTG driver.
- If ID-grounded IRQ is present, the OMAP device enters host mode.
- The OMAP device requests that the PMIC drive VBUS (that is, the PMIC does not start VBUS on its own).
- The peripheral device sets pull-up on D+ (if HS/FS) or D– (if LS).
- The OMAP device performs USB reset and enumerates the peripheral device.

In the scenario shown in Figure 6, when the USB cable is removed:

- ID is set back to 1 because of the PMIC internal pull-up.
- The PMIC sends an IRQ to the OMAP device.
- The OMAP device requests that the PMIC stop VBUS.
- The OTG device detects a disconnection through D+/D–.

2.2.2 Connecting to Another OTG Device in Peripheral Mode

Figure 7 shows the connection between the OMAP4 USB OTG device configured in host mode and another OTG device configured in peripheral mode.

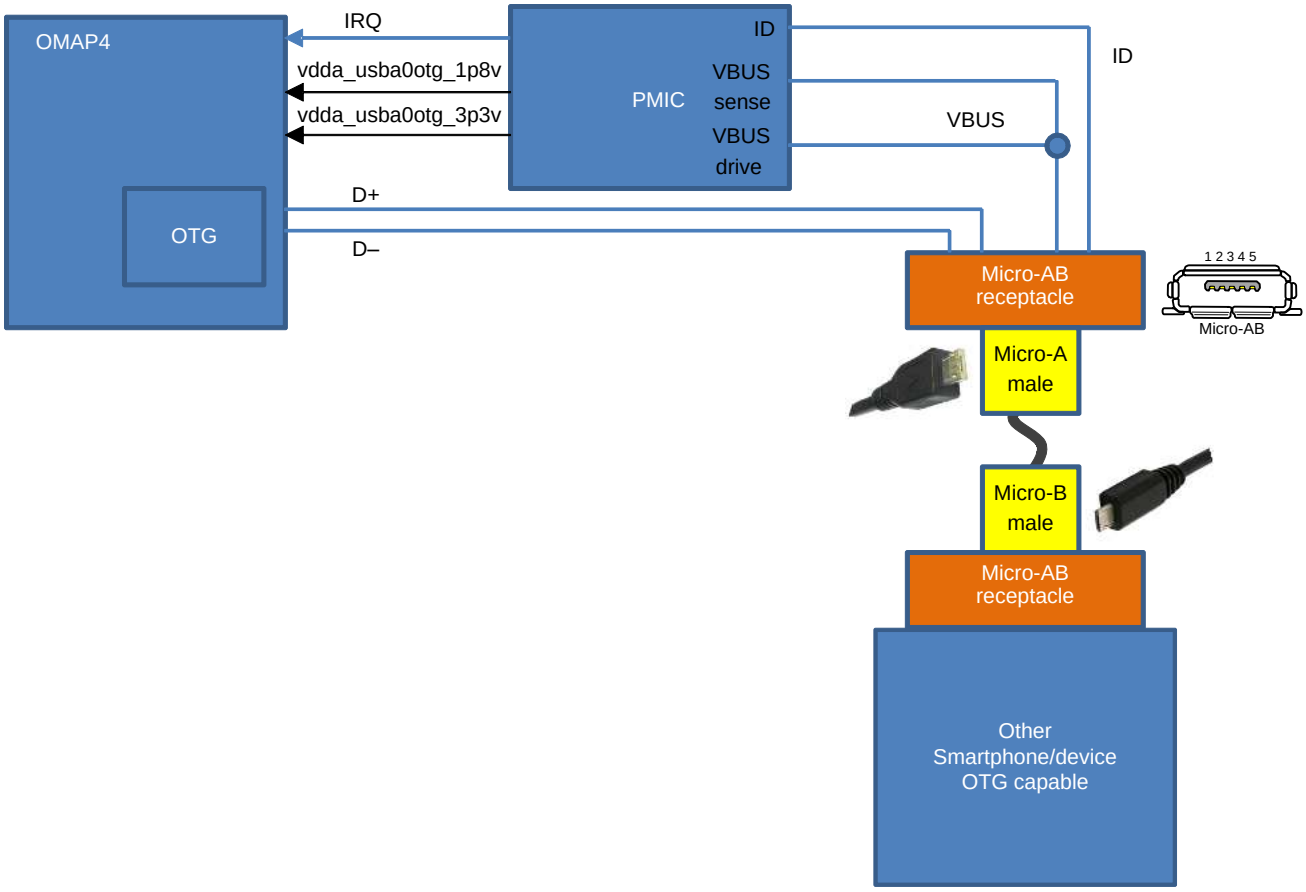

Figure 7. OMAP4 USB OTG Device as Host for Another OTG Device

In the scenario shown in Figure 7, the OMAP USB OTG device determines its role based on the type of plug connected (micro-B = peripheral, micro-A = host). When the USB cable is connected:

- A micro-A male plugs into a micro-AB receptacle.
- ID-grounded is detected by the PMIC.
- The PMIC sends an IRQ to the OMAP device.
- The OMAP device loads the OTG driver.
- If an ID-grounded IRQ is present, the OMAP device enters host mode.
- The OMAP device requests that the PMIC drive VBUS (that is, the PMIC does not start VBUS on its own).
- The peripheral sets a pull-up on D+ (if HS/FS) or D– (if LS).
- The OMAP device performs a USB reset and enumerates the peripheral.

NOTE: The OMAP USB OTG device and the connected peripheral device can exchange host or device roles by host negotiation protocol (HNP).

When the USB cable is removed:

- The ID is set to 1 because of the PMIC internal pullup.
- The PMIC sends an IRQ to the OMAP device.
- The OMAP device requests that the PMIC stop VBUS.
- The OTG device detects a disconnection through D+/D–.

3 OMAP4 HS USB Host

The OMAP4 HS USB host module allows communication with USB peripherals using physical (PHY), TLL, and HSIC connections.

The HS USB host controller supports the following connection types:

- EHCI + ULPI PHY to connect an HS peripheral device only on one physical port
- OHCI + Serial PHY to connect an FS peripheral device only on one physical port
- EHCI + ULPI PHY + HUB to connect an HS/FS/LS peripheral on several physical ports
- EHCI + TLL link to connect on board HS modem
- OHCI + TLL link to connect on board LS/FS modem
- EHCI + HSIC to connect to an HS on board peripheral
- EHCI + HSIC + HUB to connect to an HS/FS/LS on several physical ports

3.1 External PHY Mode

Figure 8 shows an example of an OMAP4 device (in this case, a tablet computer) as a USB host for multiple peripheral devices.

Figure 8. Tablet With Host Port

3.1.1 EHCI + ULPI PHY

Figure 9 shows the connection between an HS peripheral device and the OMAP4 HS USB Host EHCI interface through an external ULPI PHY.

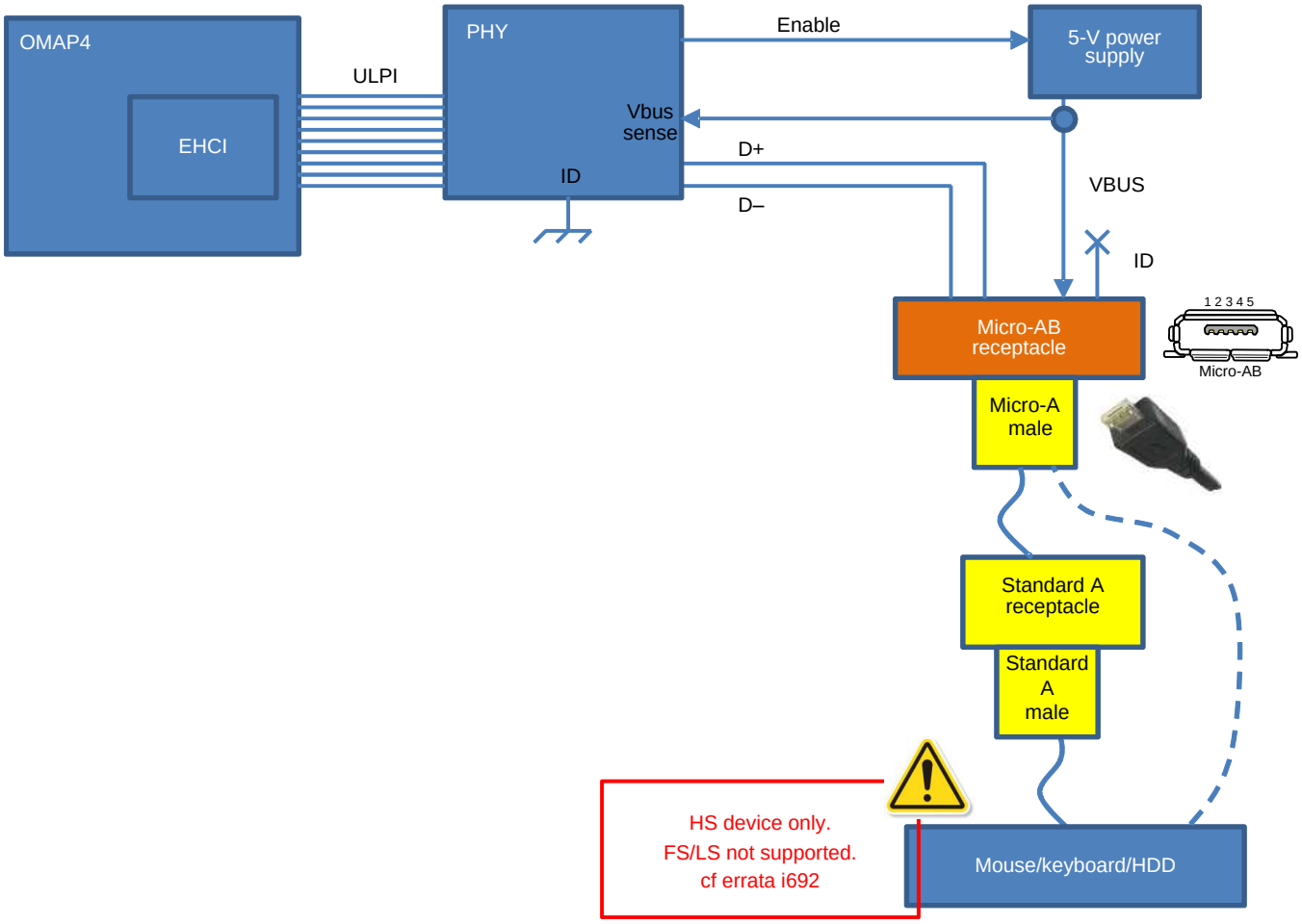

Figure 9. HS Peripheral Device Connection on One EHCI + ULPI PHY Port

In the scenario shown in Figure 9:

- VBUS must always be on, provided by a dedicated LDO.
- EHCI is always host (that is, the micro-AB receptacle ID pin is not checked).
- The PHY ID pin must be grounded.

When the USB cable is connected:

- A micro-A male is plugged into a micro-AB receptacle.
- The device sets a pull-up on D+ when VBUS is received (HS peripheral only because of errata i692).
- PHY detects a linestate change and sends ULPI RXCMD to the OMAP device.
- The OMAP device resets the peripheral, detects peripheral speed, and enumerates.

When the USB cable is removed:

- PHY detects a disconnection through D+/D– and warns OMAP through:
  - ULPI RXCMD, if the PHY is awake
  - D+/D– state copied on ULPI_DAT0/1, if the PHY is in low-power mode (for example, during suspend)

NOTE: A standard A receptacle and a peripheral device with a standard A plug can also be used. In this case, the ID pin is not available.

3.1.2 OHCI + Serial PHY

Figure 10 shows the connection between an HS device and the OMAP4 host over one OHCI + serial PHY port.

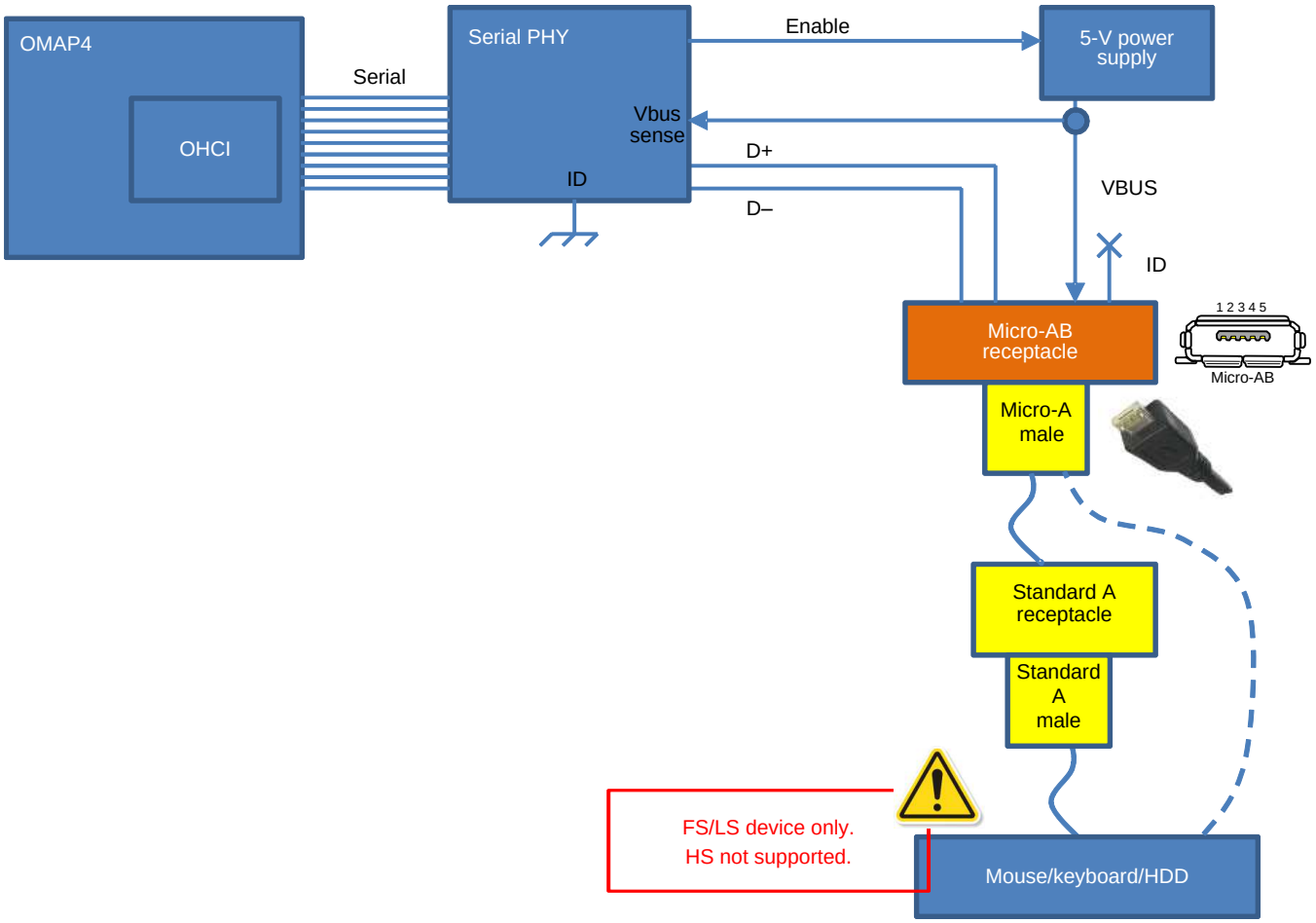

Figure 10. HS Device Connection on One OHCI + Serial PHY Port

In the scenario shown in Figure 10:

- VBUS must always be on, provided by a dedicated LDO.
- OHCI is always host (that is, the micro-AB receptacle ID pin is not checked).
- The PHY ID pin must be grounded.

When the USB cable is connected:

- A micro-A male is plugged into a micro-AB receptacle.
- The device sets a pull-up on D+ or D– when VBUS is received.
- PHY detects a linestate change and informs the OMAP device.
- The OMAP device resets the peripheral and enumerates.

When the USB cable is removed:

- PHY detects disconnection and informs the OMAP device.

NOTE: A standard A receptacle and a device with a standard A plug can also be used. In this case, the ID pin is not available.

3.1.3 EHCI + ULPI PHY + External HUB

Figure 11 shows the connection between several USB devices and OMAP4 EHCI + ULPI PHY ports using a hub.

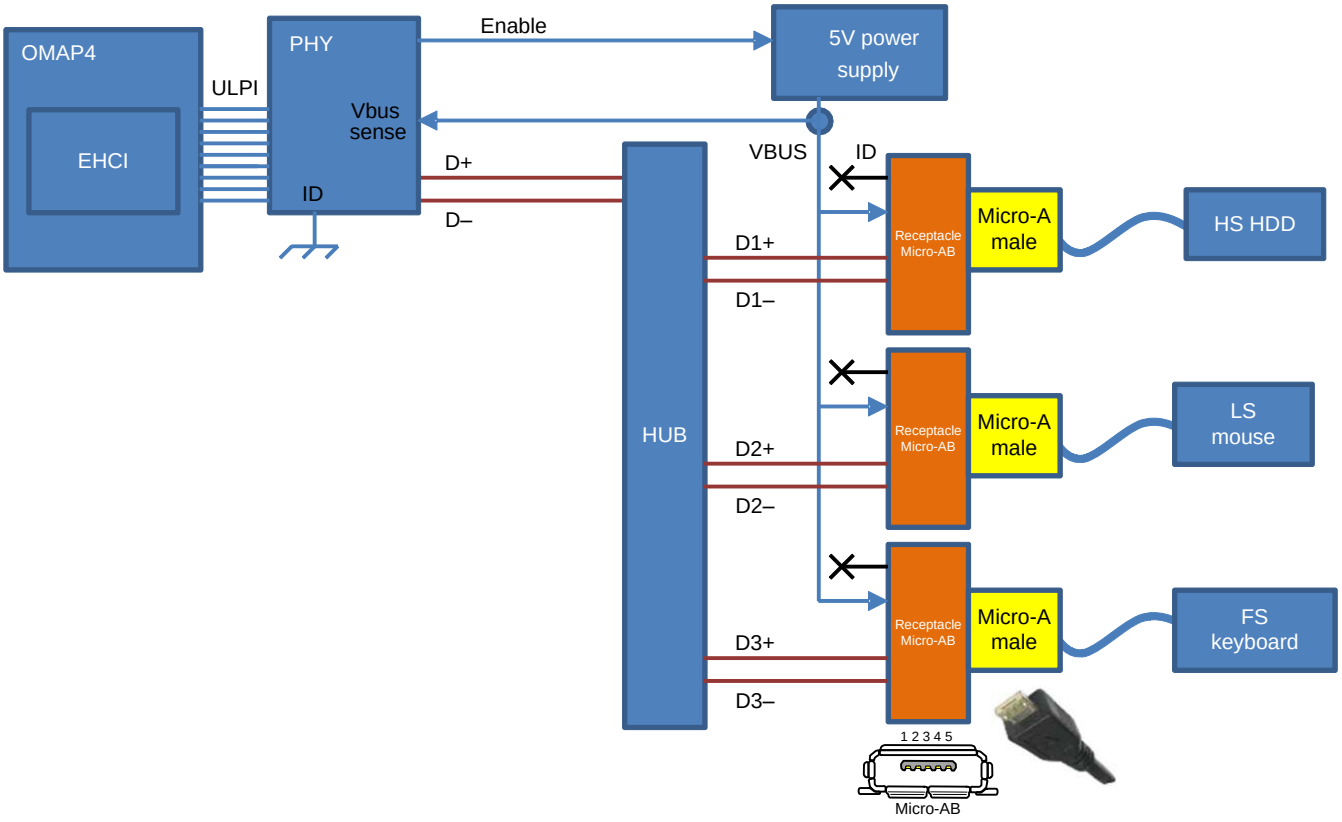

Figure 11. HS Device Multiple Connections on EHCI + ULPI PHY Hub

The scenario shown in Figure 11 is the typical use for OMAP4 EHCI. When used this way, several physical ports can support all USB speeds (HS, FS, and LS).

In this scenario, the OMAP4 host sees the hub as the only peripheral. The OMAP4 host detects peripheral device insertion in the following ways:

- Remote wakeup from hub to OMAP: If the hub and already-connected peripherals are all suspended.
- Polling the hub (getportstatus)

NOTE: A standard A receptacle and a device with a standard A plug can also be used. In this case, the ID pin is not available.

3.2 TLL Mode

Figure 12 shows an example of an OMAP4 device (in this case, a smart phone) as a TLL host for USB peripheral devices, which removes the requirement for host and peripheral PHYs.

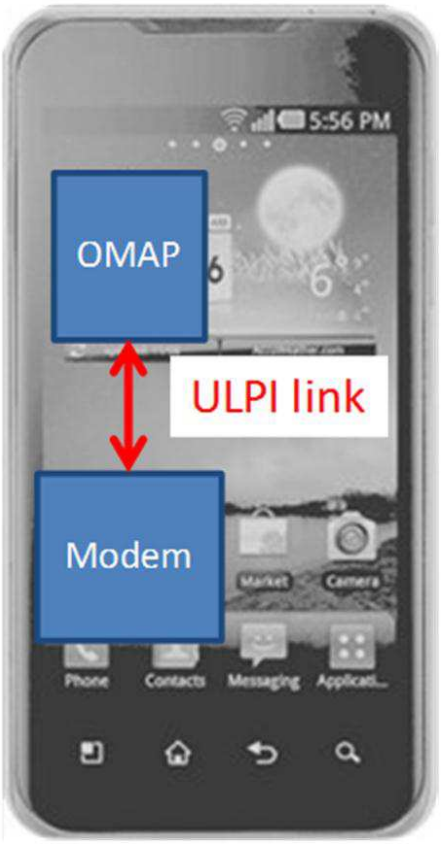

Figure 12. USB Host With Onboard Modem

3.2.1 EHCI + TLL

Figure 13 shows the EHCI TLL connection over the onboard HS modem.

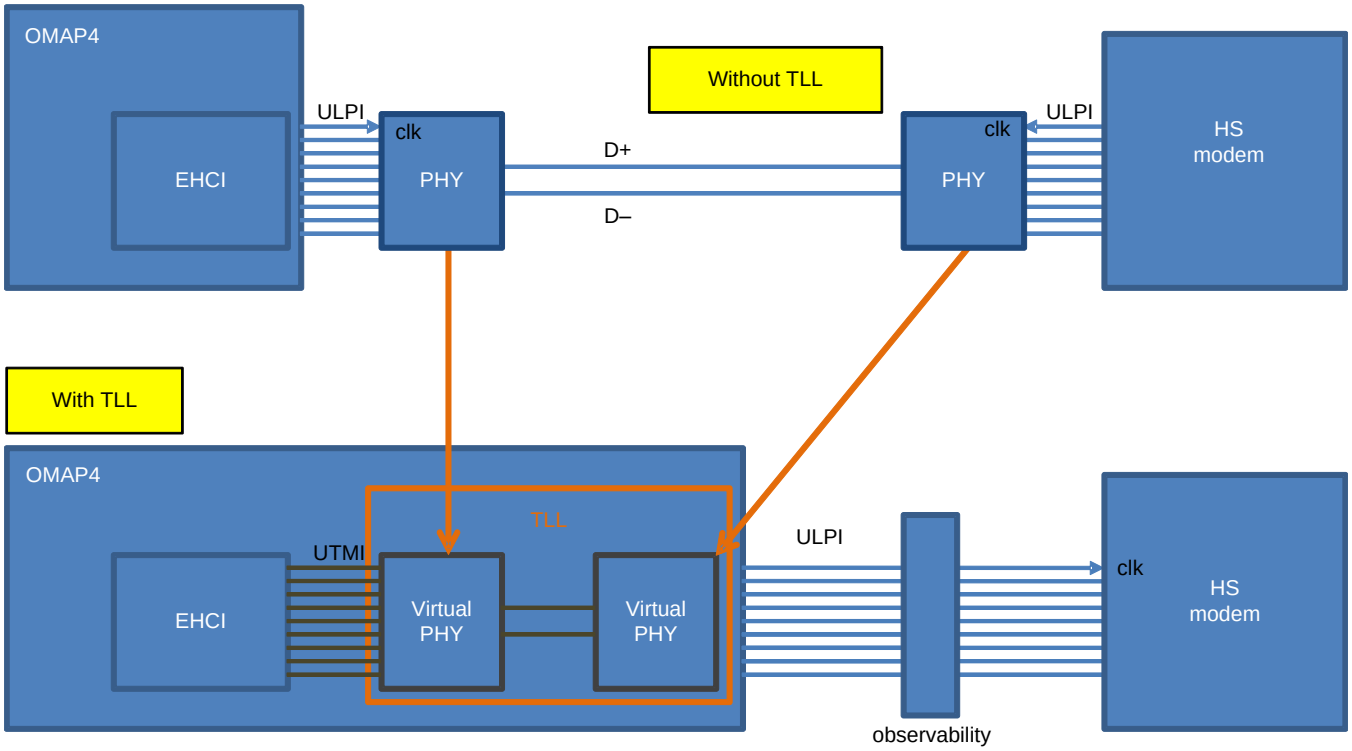

Figure 13. Host Connection on EHCI + TLL with Onboard HS Modem

When the modem is onboard (as shown in Figure 13), TLL removes the need for two external PHYs. Test points and observability are recommended for debug purposes.

3.2.2 OHCI + TLL

Figure 14 shows the OHCI TLL connection over the onboard modem.

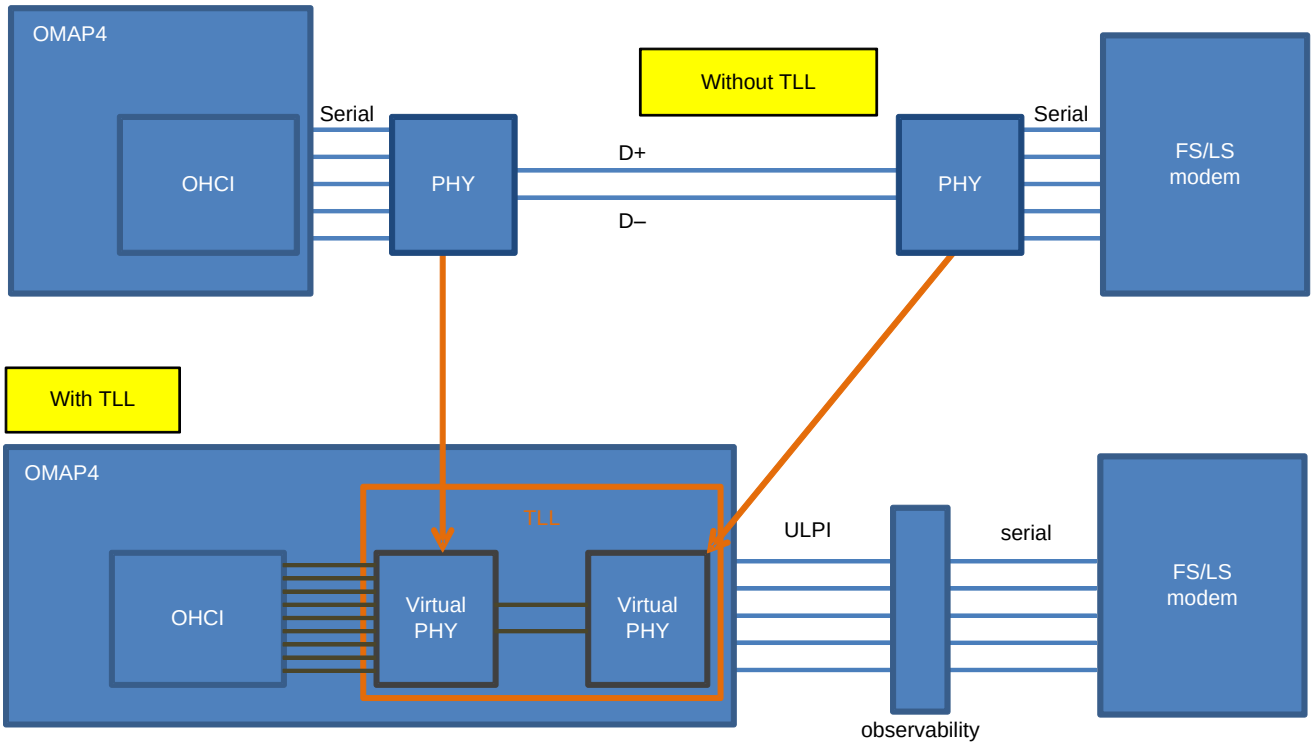

Figure 14. Host Connection on OHCI + TLL With Onboard Modem

When the modem is onboard (as shown in Figure 14), TLL removes the need for two external PHYs. Test points and observability are recommended for debug purposes.

3.3 HSIC Mode

Figure 15 shows an example of an OMAP4 device in which an HSIC link connects between the OMAP HS USB host and an onboard modem, or between the OMAP HS USB host and an onboard HUB offering two physical standard A ports to connect any kind of peripheral device.

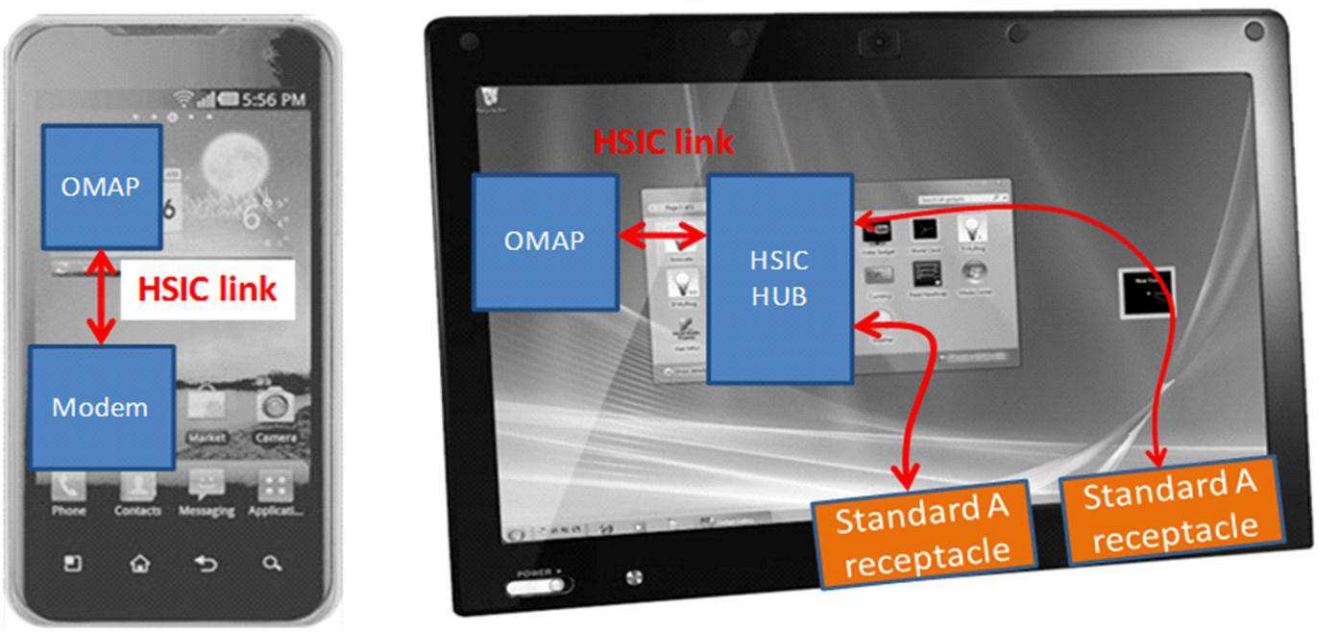

Figure 15. USB Host With Onboard HSIC Modem or HSIC HUB

3.3.1 EHCI + HSIC

Figure 16 shows the EHCI HSIC connection with an onboard HS modem, requiring only 2 signals (data and strobe).

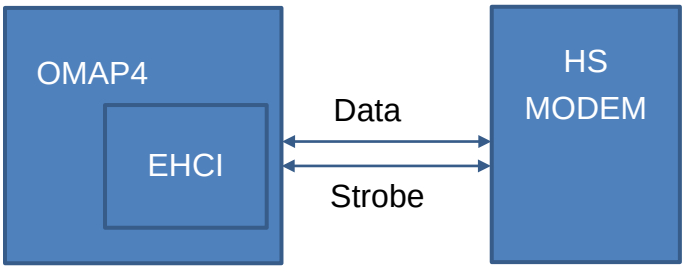

Figure 16. HSIC Modem Connection With EHCI HSIC Interface

3.3.2 EHCI + HSIC + HUB

Figure 17 shows the EHCI HSIC connection with an onboard HSIC HUB, allowing the connection of several USB peripheral devices on external ports.

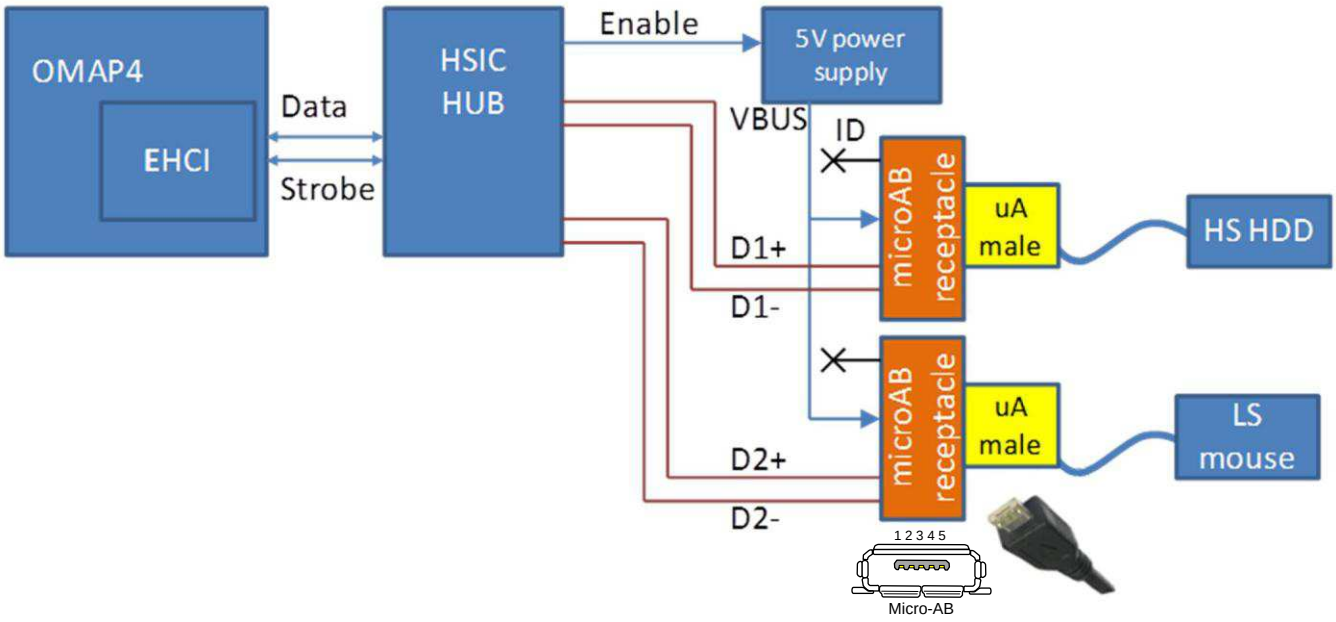

Figure 17. HSIC HUB Connection With EHCI HSIC Interface

A separate LDO controlled by the HUB handles the 5-V power supply.

NOTE: A standard A receptacle and a device with a standard A plug can also be used. In this case, the ID pin is not available.

4 USB2 Cables and Plugs

Figure 18 shows the male-to-male plugs available on USB1.x and USB2.0 cables.

Cable plugs (USB 1.x/2.0)

Cables exist with pairs of plugs:

Plug	Plug: Micro-B	Plug: Micro-A	Plug: Mini-B	Plug: Type B	Plug: Type A
Type A	Yes	NS	Yes	Yes	NS
Type B	No	NS	No	No	
Mini-B	No	NS	No		
Micro-A	NS	No			
Micro-B	No				

Yes means existing standard cable.
NS means existing but non-standard cable.
No means that these cable should not exist.

Figure 18. Official USB2 Cables—Male to Male

5 Which Plug for Which Receptacle

Figure 19 shows the types of USB plugs that fit the available types of USB receptacles.

Host interface receptacles

The following receptacles accept the following plugs:

Receptacle	Plug: Type A	Plug: Type B	Plug: Mini-B	Plug: Micro-A	Plug: Micro-B
Type A	Yes	No	No	No	No
Type B	No	Yes	No	No	No
Mini-B	No	No	Yes	No	No
Micro-AB	No	No	No	Yes	Yes
Micro-B	No	No	No	No	Yes

Figure 19. USB Plugs and Receptacles

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