

Hardware Configurations for the i.MX Family USB Modules

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1 Introduction

The i.MX family multimedia application processors, such as i.MX31 and i.MX27, contain three separate USB 2.0 compliant modules—two dedicated USB host modules and one dual-role On-The-Go (OTG) module. The i.MX25 and i.MX35 processors contain one integrated host and one OTG port each. The dual-role OTG module can be used as a USB host, device, or an OTG port.

The host and OTG modules can be interfaced with serial transceivers for Full-Speed (FS) connection, or optional UTMI+ Low Pin Interface (ULPI) transceivers to provide High-Speed (HS) connectivity. The flexibility provided by the modules imply that there are a number of possible hardware configurations that allow different functionalities.

This application note shows block diagrams for possible configurations, and also discusses some hardware implementation issues. This application note does not discuss about the software development for USB.

Contents

1. Introduction	1
2. USB Host Hardware Configuration	2
3. USB OTG Connections	4
4. USB Layout Considerations	5
5. Revision History	7

2 USB Host Hardware Configuration

The i.MX27 and i.MX31 processors have two dedicated USB host modules—one is Full-Speed (FS)/Low-Speed (LS) only, which is interfaced with an external serial transceiver, and the other is High-Speed (HS capable, also compatible with FS/LS), which is interfaced with an optional ULPI or serial transceiver.

Figure 1 shows a hardware setup of the FS/LS USB host module.

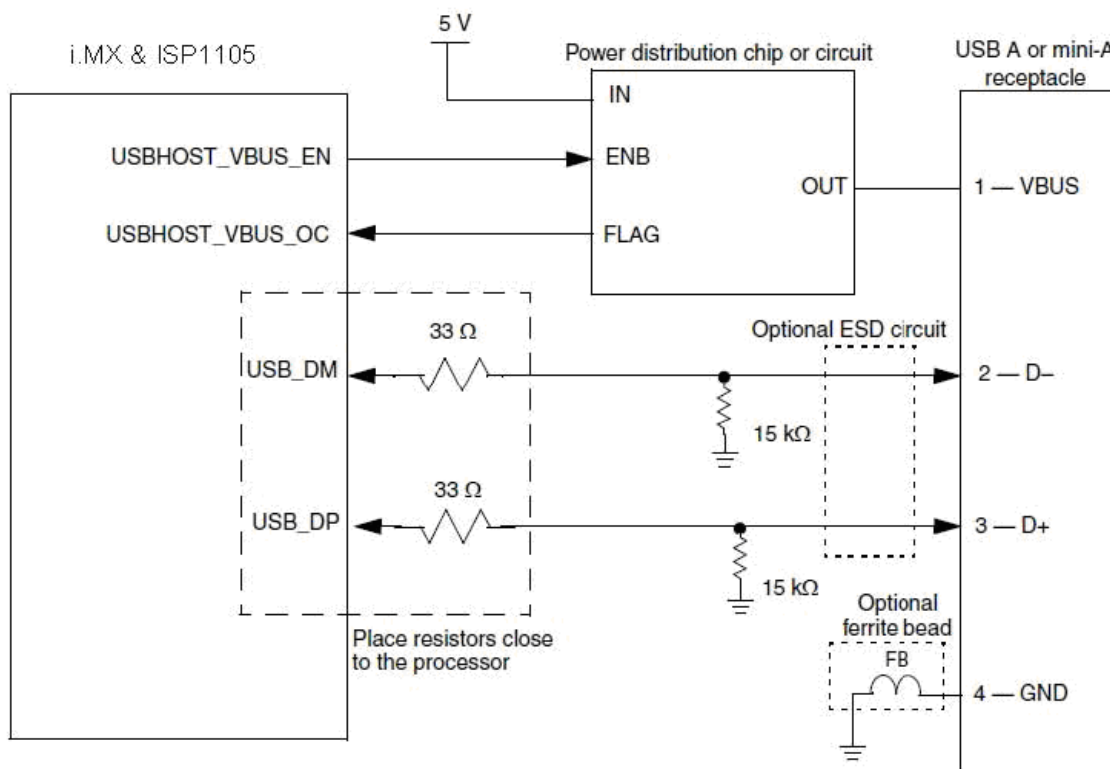


Figure 1. FS/LS USB Host Module

Figure 2 shows the connections for HS Host/OTG with ULPI transceiver.

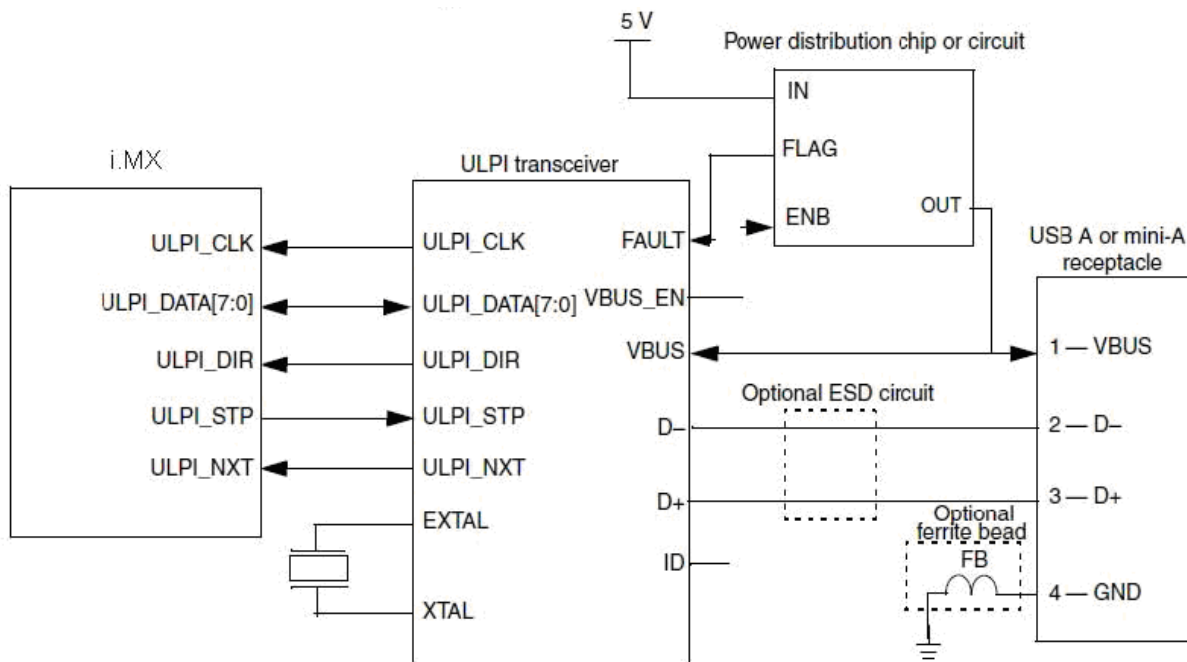


Figure 2. HS Host/OTG with ULPI Transceiver

2.1 Resistors

The $33\ \Omega$ series termination resistors are recommended for the FS/LS USB transceiver. These series termination resistors must be placed as close as possible to the transceiver to maximize the eye diagram for the data lines.

For the HS ULPI USB transceiver (that is, ISP1504 from NXP and USB3317 from SMSC), the D+/D- lines of the transceiver must be connected to the USB receptacle directly, without any series termination resistors. Optional Electro Static Discharge (ESD) circuit is recommended on the D+/D- lines for both FS and HS transceivers to improve safety and reliability.

The FS/LS USB host operation also requires $15\ \text{k}\Omega$ pull-down resistors on both the D+ and D- lines, but the HS USB host does not require external pull-down resistors on the D+/D- lines. Refer to *USB 2.0 specifications* and Section 4, “USB Layout Considerations,” for more information.

2.2 USB Connectors

A USB host uses a type-A connector. There are two different versions of A receptacle—a typical standard-size A receptacle, and a mini-A (usually combined with mini-B and mini-AB receptacle) or a micro-A receptacle. The USB 2.0 standard supports only the standard A receptacle, while the OTG supplement adds support to the mini-A receptacle too. A mini-A to standard-A receptacle adapter is commonly available if mini-A receptacle is used.

The impact of cabling costs, board costs, and form factor must be considered when selecting which USB connector to use in a design.

2.3 VBUS

The i.MX processor does not include a signal for supplying the 5 V VBUS power for USB. An external power management chip or discrete logic for enabling VBUS is required for the host operation. The power distribution circuit must have over-current detection capability to be compliant with the USB standard.

For FS transceiver, using General Purpose Input/Output (GPIO) pads of the i.MX processor as OE (USBHOST_VBUS_EN) and OC (USBHOST_VBUS_OC) for the VBUS power distribution circuit is recommended (Figure 1). Most ULPI transceivers have a pair of VBUS_EN (Output) and FAULT (Input) pins (Figure 2). Some ULPI PHY even have a built-in charge pump to drive the VBUS. Refer to the specification of the particular ULPI transceiver for more information.

A switch designed specifically for USB power, such as the Maxim MAX1931, or a general purpose power-distribution chip, such as Micrel's MIC2026, can be used.

3 USB OTG Connections

The i.MX OTG controller can be used either as a USB host or as a USB device (also known as a USB peripheral or function).

Figure 3 shows a typical hardware setup for the OTG controller that acts as a dual-role USB device with external ULPI transceiver.

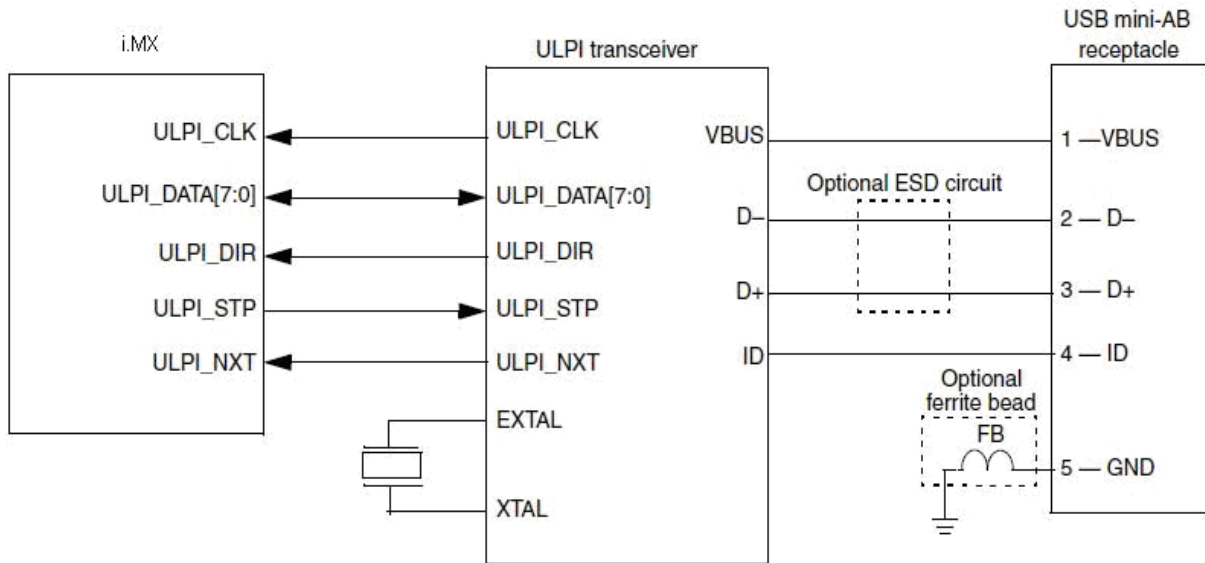


Figure 3. OTG with ULPI Transceiver

3.1 Resistors

The ULPI transceiver includes on-chip series termination resistors and programmable pull-up/pull-down resistors for the D+ and D- lines. This implies that the D+/D- lines from the ULPI transceiver must be connected to the receptacle directly, and optional ESD circuit is recommended for the ULPI transceiver.

3.2 VBUS

Some ULPI PHY (that is, ISP1504 from NXP) can source a VBUS supply, when acting as a host. However, there are certain limitations when using the charge pump on the PHY (refer to the specification of the particular PHY for more information). For applications where large current is needed on the VBUS supply, an external VBUS power switch can be used.

Some ULPI PHY (that is, USB3317 from SMSC) do not provide the charge pump for VBUS supply. An external power switch is necessary in this case if OTG controller acts as a host. [Figure 2](#) shows a HS capable host implementation that uses a ULPI PHY, with an external 5 V VBUS source supply.

3.3 USB Connectors

Because a ULPI PHY can support all the host, device, and OTG operations, it can be connected to any USB receptacle according to the usage, and the required functionality determines the choice of receptacle. If OTG or dual-role functionality is required, then a mini-AB or micro-AB connector must be used (as shown in [Figure 4](#)). For host only operations, a standard-A or mini-A or micro-A connector can be used (as shown in [Figure 2](#)). If only the device functionality is required, then a standard-B or mini-B or micro-B receptacle can be used in place of the mini-AB receptacle.

4 USB Layout Considerations

This section describes the series termination resistor values and placement and provides the general USB layout suggestions.

4.1 Series Termination Resistor Values and Placement

While using the FS/LS serial transceiver, the 33 Ω series termination resistors on the D+ and D- lines are recommended. To obtain the optimal eye diagram, these series resistors must be placed as close as possible to the transceiver. No termination resistors must be used for the HS ULPI transceiver on the D+ and D- lines.

Optional ESD circuit with low parasitic capacitance is recommended to protect the serial and ULPI transceivers.

4.2 General USB Layout Suggestions

The general USB layout suggestions are as follows:

- Route the USB D+ and D- signals as parallel 90 Ω differential pairs.
- Match the trace lengths as closely as possible. Matching within 150 mils is a good guideline.
- Try to maintain short trace lengths, not longer than 15 cm.

- Avoid placing USB differential pairs near signals, such as clocks, periodic signals, and I/O connectors, that might cause interference.
- Minimize vias and corners.
- Route differential pairs on a signal layer, next to the ground plane.
- Avoid signal stubs.

Figure 4 shows the USB routing example.

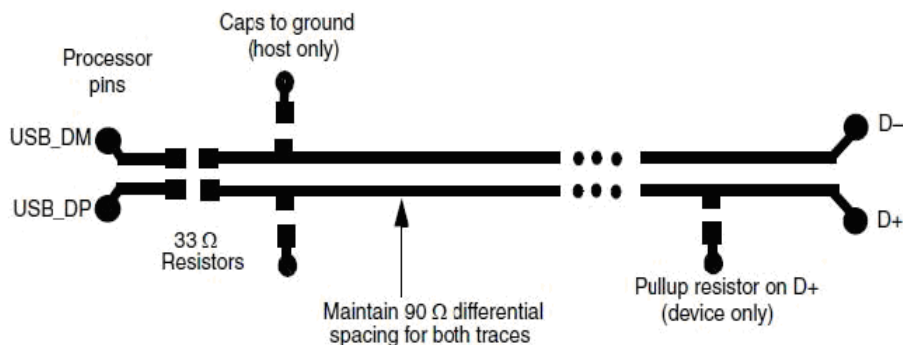


Figure 4. USB Routing Example

NOTE

USB connection is recommended for i.MX25 and i.MX35 processors.

Figure 5 shows the recommended USB connections for both the i.MX25 and i.MX35 processors.

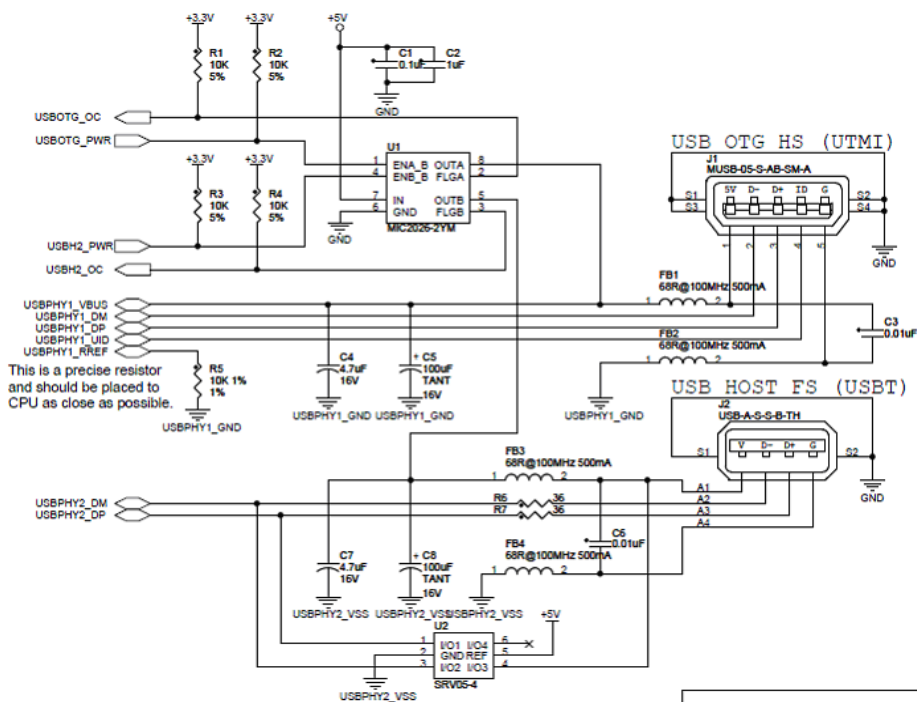


Figure 5. USB Connections for i.MX25 and i.MX35 Processors

5 Revision History

Table 1 provides the revision history for this application note.

Table 1. Document Revision History

Rev. Number	Date	Substantive Change(s)
0	06/2010	Initial release

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