Freescale Semiconductor
Application Note

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Hardware Configurations for the MCF532x Family USB Modules

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1 Introduction

The ColdFire™ MCF532x family devices contain two separate USB modules — a dedicated USB host module and a dual-role module. The dual-role module can be used as a USB host, device, or an On-The-Go (OTG) port. Both modules are also integrated with an on-chip full-speed (FS) and low-speed (LS) capable USB transceiver. The dual-role module can be used with an optional UTMI+ low pin interface (ULPI) transceiver to provide high-speed (HS) functionality.

The flexibility provided by the modules means that there are a number of possible hardware configurations that allow different functionalities. This application note shows block diagrams for possible configurations and discusses some hardware implementation issues. The intended audience is hardware engineers who are working on schematics or layout using the MCF532x USB module. This application note does not discuss software development for USB.

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2 USB Host Hardware Configuration

The MCF532x has a dedicated USB host module. The host module is interfaced to an on-chip, full-speed (FS)/low-speed (LS) transceiver. Figure 1 shows a typical hardware setup for the dedicated USB host module. Similar connections would be used for the dual-role controller acting as a FS/LS host only.

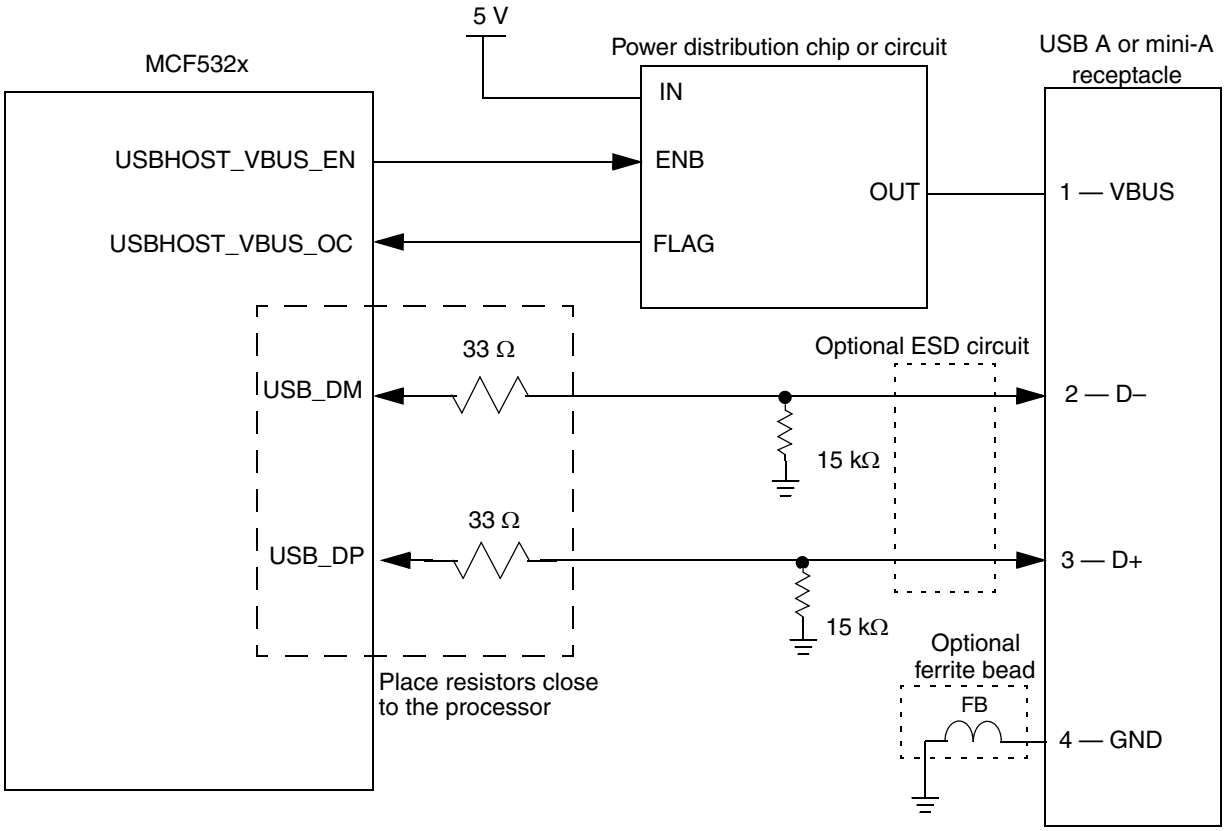

Figure 1. Typical Hardware Configuration Using the USB Host Module

2.1 Resistors

For the on-chip USB transceiver, using 33 Ω series termination resistors is recommended. These series termination resistors must be placed as close to the processor as possible. This helps maximize the eye diagram for the data lines. See Section 6, “USB Layout Considerations,” for more information.

USB host operation also requires pulldown resistors on both the D+ and D– lines.

2.2 USB Connector

A USB host uses a type-A connector. There are two different versions of A receptacle: a standard-size A receptacle and a mini-A. The USB standard supports only the standard A receptacle, while the OTG supplement adds support for the mini-A receptacle. If a mini-A receptacle is used, then a mini-A to standard-A receptacle adapter is needed. When selecting which USB connector to use in a design, take into account the impact of cabling costs, board costs, and form factors.

2.3 VBUS

The MCF532x does not include a signal for supplying the 5 V VBUS power for the USB. An external power distribution chip or discrete logic for enabling VBUS is required for host operation. The power distribution circuit must have over-current detection capability to be compliant with the USB standard. 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.

2.3.1 USBHOST_VBUS_EN and USBHOST_VBUS_OC

The MCF532x provides two signals on the USB host controller designed to aid in interfacing to an external power distribution chip.

The USBHOST_VBUS_EN signal is an active high output intended to be tied to the enable signal on a power-distribution chip. The state of the PORTSC[PP] field controls the USBHOST_VBUS_EN signal. When PORTSC[PP] = 1 (port power applied), the USBHOST_VBUS_EN signal is driven high. When PORTSC[PP] = 0 (port power off), then USBHOST_VBUS_EN signal goes low.

The USBHOST_VBUS_OC signal is a programmable polarity input to the MCF532x. The polarity of the signal is programmed using the system control module's BCR[VBUS_OC_POL] bit. The signal is intended to be tied to the FLAG output of a VBUS supply chip. When the USBHOST_VBUS_OC signal is asserted, this indicates an over-current condition on the VBUS supply to the USB host controller. When USBHOST_VBUS_OC asserts, the PORTSC[OCA] bit is set to indicate an over-current condition has been detected. Software is responsible for clearing the PORTSC[PP] bit to remove power from the malfunctioning port. The port change interrupt USBINTR[PCE] can alert software to the over-current condition (along with other port events).

NOTE

Section 2.3.1, "USBHOST_VBUS_EN and USBHOST_VBUS_OC," describes the operation of the USBHOST_VBUS_OC signal on the revision two silicon. On previous MCF532x silicon the USBHOST_VBUS_OC signal is always an active high input. The programmable polarity for this signal is added to allow for compatibility with more power distribution chips and/or more flexibility in discrete power distribution circuits.

The CIR[PRN] field or the processor markings can distinguish between the revisions. If the CIR[PRN] field is less than two, the USB_VBUS_OC signal is active high only. If the processor is marked as M29B, the USB_VBUS_OC is active high only; if the processor is marked as 3M29B or 4M29B, the polarity of the USB_VBUS_OC signal is programmable.

2.3.2 Using the USB Dual-Role Module in Host Mode

The circuit shown in Figure 1 can also be used with the MCF532x's dual-role USB module when FS/LS host-only operation is desired. The MCF532x does not supply a VBUS enable or VBUS over-current signal for the dual-role controller; these signals are available only for the dedicated host port. A GPIO signal can create a software-controlled VBUS enable signal for the dual-role module. An external interrupt

signal can be used for over-current detection. A GPIO could also be used for over-current detection, but this requires software polling of the signal state on a periodic basis to ensure the over-current condition is detected in a timely manner. Therefore, an external interrupt line is preferred for an over-current signal since less software overhead is required.

3 USB Device-Only Connections

The MCF532x dual-role controller can be used as an FS device. Figure 2 shows a typical hardware setup for the dual-role controller acting as an FS device. For HS operation an external transceiver must be used. See Section 5, "ULPI Connections," for more information on HS implementations.

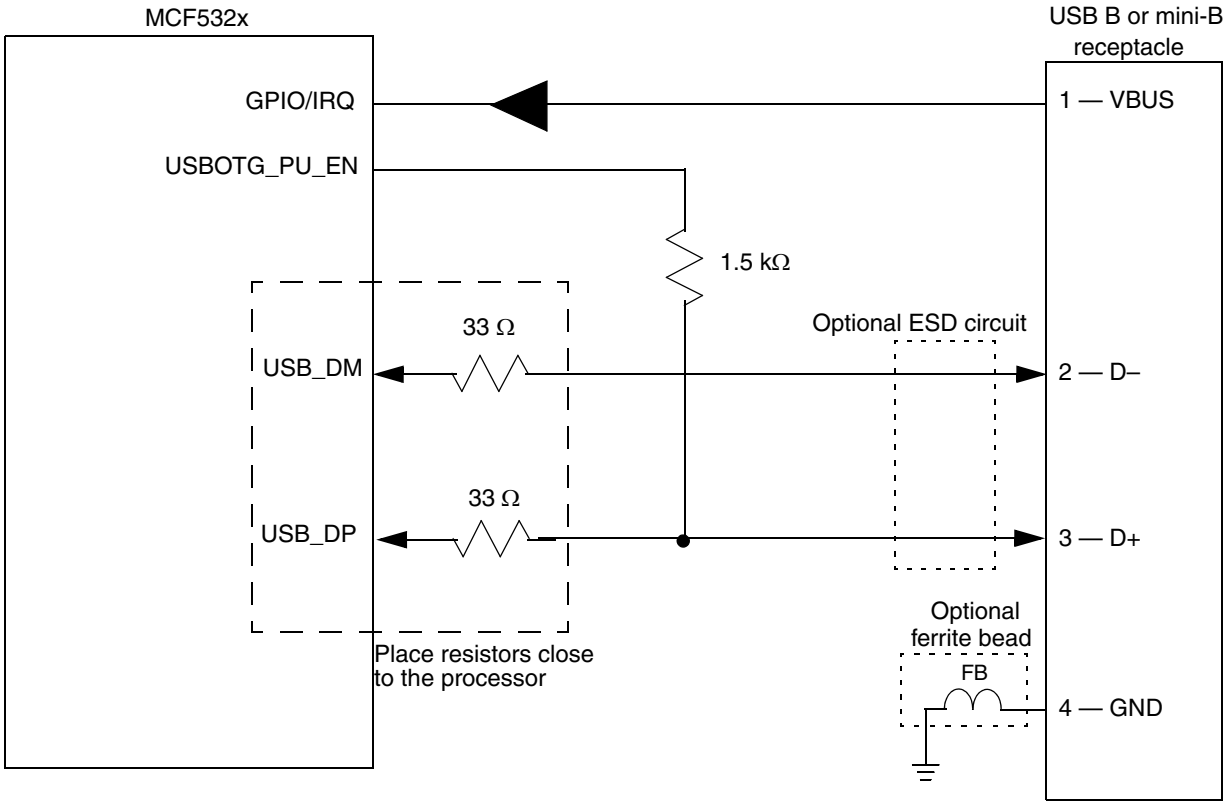

Figure 2. Typical Hardware Configuration for FS Device-Only Operation

3.1 Resistors

In device mode, the on-chip transceiver should be used with the same 33 Ω series termination resistors as those used in host mode. Again, the resistors should be placed as close to the processor as possible to maximize the eye diagram for the data lines.

A USB device uses a pullup on one of the data lines to indicate its speed to the host and also allow the host to detect when the device is connected. For full-speed operation, a 1.5 kΩ pullup on the D+ line is used.

The MCF532x provides a signal for enabling the pullup when the USB module is initialized. The USBOTG_PU_EN signal is controlled by the chip configuration module's USB OTG controller status

register (UOCSR) BVLD field. When UOCSR[BVLD] is cleared USBOTG_PU_EN is driven low, and when UOCSR[BVLD] is set, USBOTG_PU_EN is driven high.

However, the USBOTG_PU_EN signal must not be used alone to control the external pullup resistor. USB specification requires that when VBUS is removed the pullup becomes inactive. This uses one of the MCF532x GPIO or IRQ pins as a VBUS detect. Since the MCF532x inputs are not 5 V tolerant, a buffer or current limiting resistor is needed to prevent damage to the MCF532x input. When the GPIO or IRQ is detected high, the USB module is initialized and the UOCSR[BVLD] bit is set to drive the USBOTG_PU_EN signal high.

3.2 USB Connectors

A USB device uses a type-B connector. As with the A receptacles used for host, there are two different versions of B receptacle: a standard size B receptacle and a mini-B. Both the standard-B and mini-B connector are part of the original USB 2.0 specification (they are supported by standard USB, not just OTG), so either receptacle can be used. Since many consumer devices (such as digital cameras) use a mini-B receptacle, A to mini-B cables are fairly easy to source. However, the full-size A to B cables are more common and usually less expensive.

4 FS/LS USB OTG Connections

Figure 3 shows a typical hardware setup for the dual-role controller acting as a true USB OTG device. This configuration allows for FS/LS USB OTG functionality.

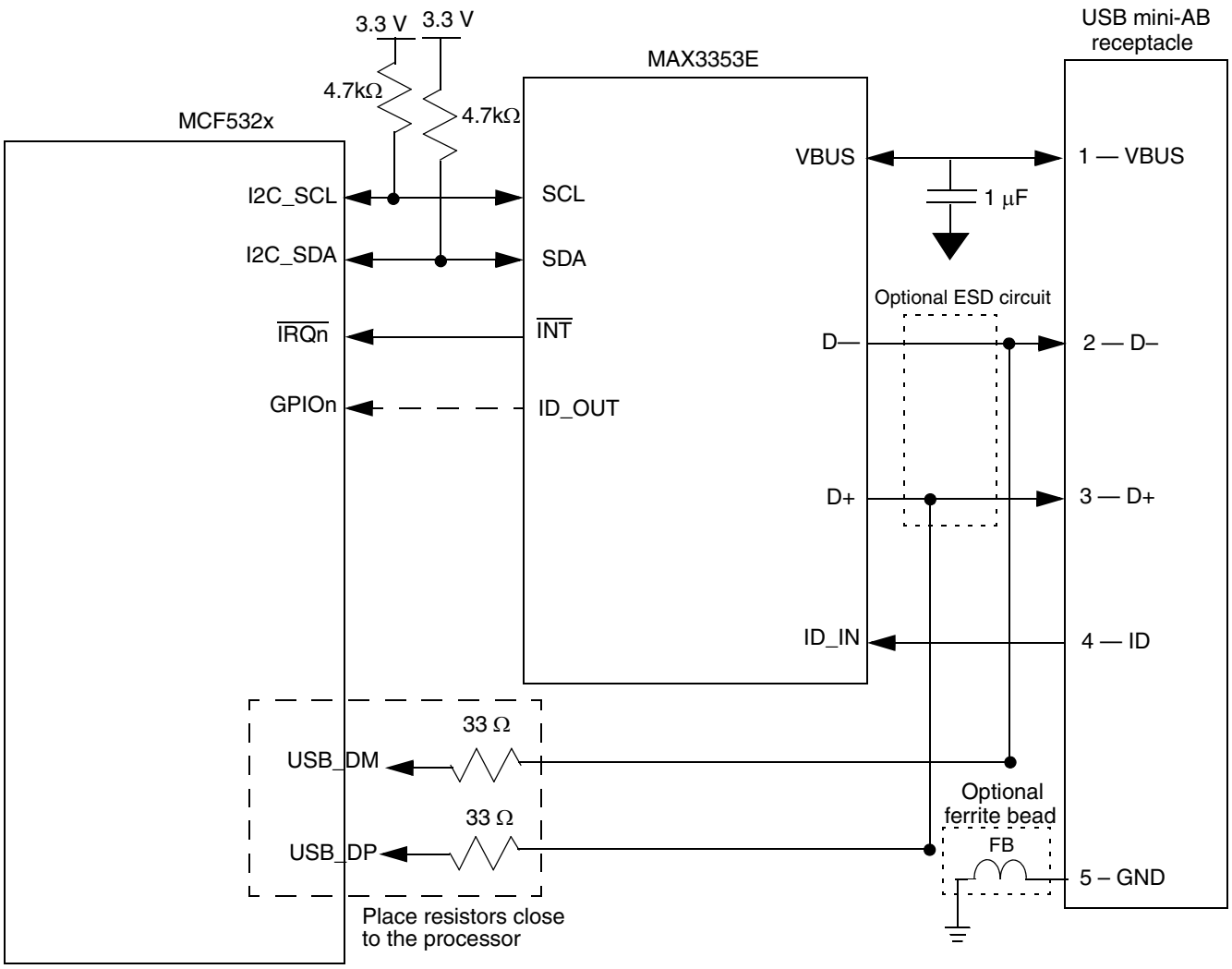

Figure 3. Typical Hardware Configuration for FS/LS OTG Operation

4.1 Resistors

The D+ and D– lines for the on-chip transceiver should be used with the same 33 Ω series termination resistors used in host mode. Again, the resistors should be placed as close to the processor as possible to maximize the eye diagram for the data lines.

For OTG operation, the configuration of pullup/pulldown resistors can change depending on the mode used, so switchable resistors are needed. The MAX3353E provides this functionality, therefore eliminating the need for discrete pullup/pulldown resistors that are GPIO controllable.

4.2 MAX3353E/VBUS

The MAX3353E is a USB OTG charge pump with switchable pullup/pulldown resistors device. It uses an I^2C interface to communicate with the MCF532x. The MAX3353E also has an active low-interrupt line

used to alert the MCF532x to conditions that require service. The actual conditions that trigger the MAX3353E's interrupt are programmable.

The ID_OUT signal could optionally be connected to a GPIO or interrupt line on the MCF532x so that software can monitor the state of the ID signal on the USB connector. The status of the ID pin can also be read using the MAX3353E's internal registers so the use of this signal is optional.

Along with supplying programmable pullup/pulldown resistors for the D+ and D– lines, the MAX3353E can also supply the 5 V VBUS supply for the USB bus and supports the VBUS pulsing needed to implement the OTG session request protocol (SRP).

NOTE

The OTG standard requires the host must source at least 8 mA on VBUS. However, for standard USB a single unit load is 100mA (although devices request current in 2 mA increments). Due to the discrepancy in current supply requirements an external VBUS source that can supply more current might be required when interfacing to some non-OTG devices.

4.3 USB Connectors

The USB OTG specification defines a mini-AB receptacle. Both a mini-A and mini-B plug could be plugged into a mini-AB receptacle. This allows a dual-role device to support either host (A) or device (B) functionality depending on which plug end is connected to the receptacle. The fifth pin on the connector, ID, allows for the hardware to determine which end of the cable (A or B) is connected.

5 ULPI Connections

The dual-role USB module allows for using an optional external ULPI USB PHY instead of the on-chip FS/LS transceiver. An external ULPI transceiver can be used to provide HS device, host, or OTG functionality. Figure 4 shows the connections used to interface the MCF532x to an external ULPI transceiver.

NOTE

The USB host module can be used only with one of the on-chip FS/LS transceivers. Only the dual-role controller can be used with an external ULPI PHY.

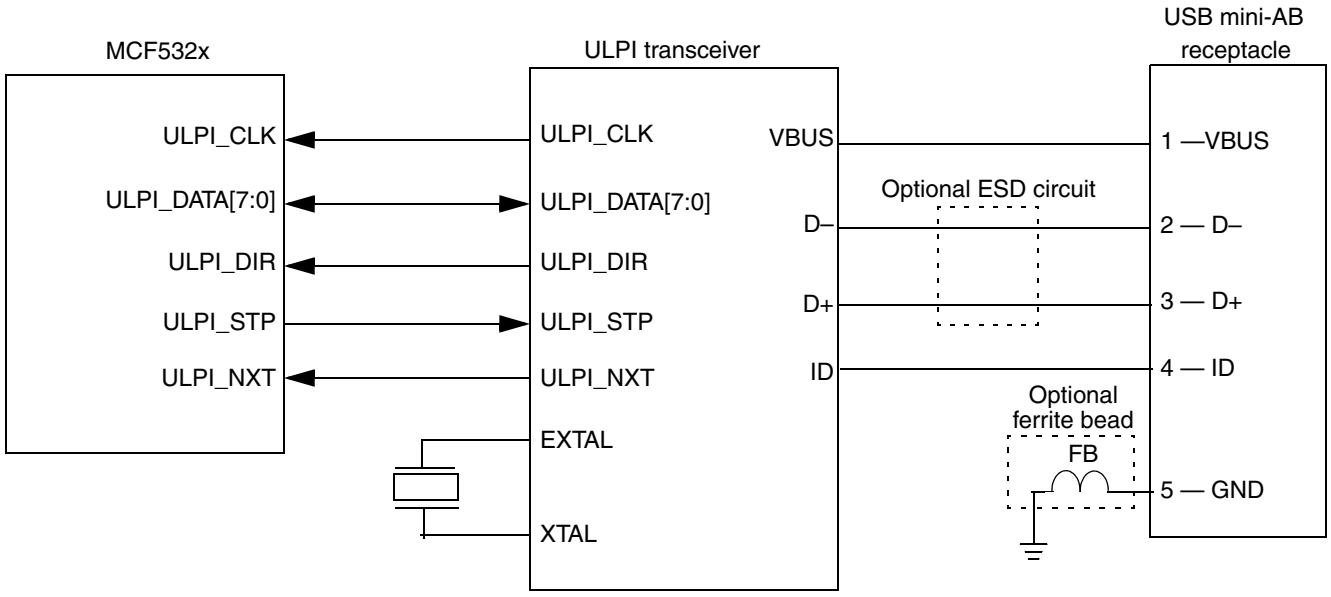

Figure 4. Connections for Using the Dual-Role Controller with a ULPI Transceiver

5.1 Resistors

The ULPI PHYs include on-chip series termination resistors and programmable pullup/pulldown resistors for the D+ and D– lines.

5.2 VBUS

The ULPI PHY can source a VBUS supply when acting as a host; however, there are current limitations when using the charge pumps on the PHY (see the specification for the particular PHY for more information). For applications where more current is needed on the VBUS supply, an external VBUS power switch can be used. Figure 5 shows a HS capable host implementation using a ULPI PHY with an external 5 V VBUS source supply.

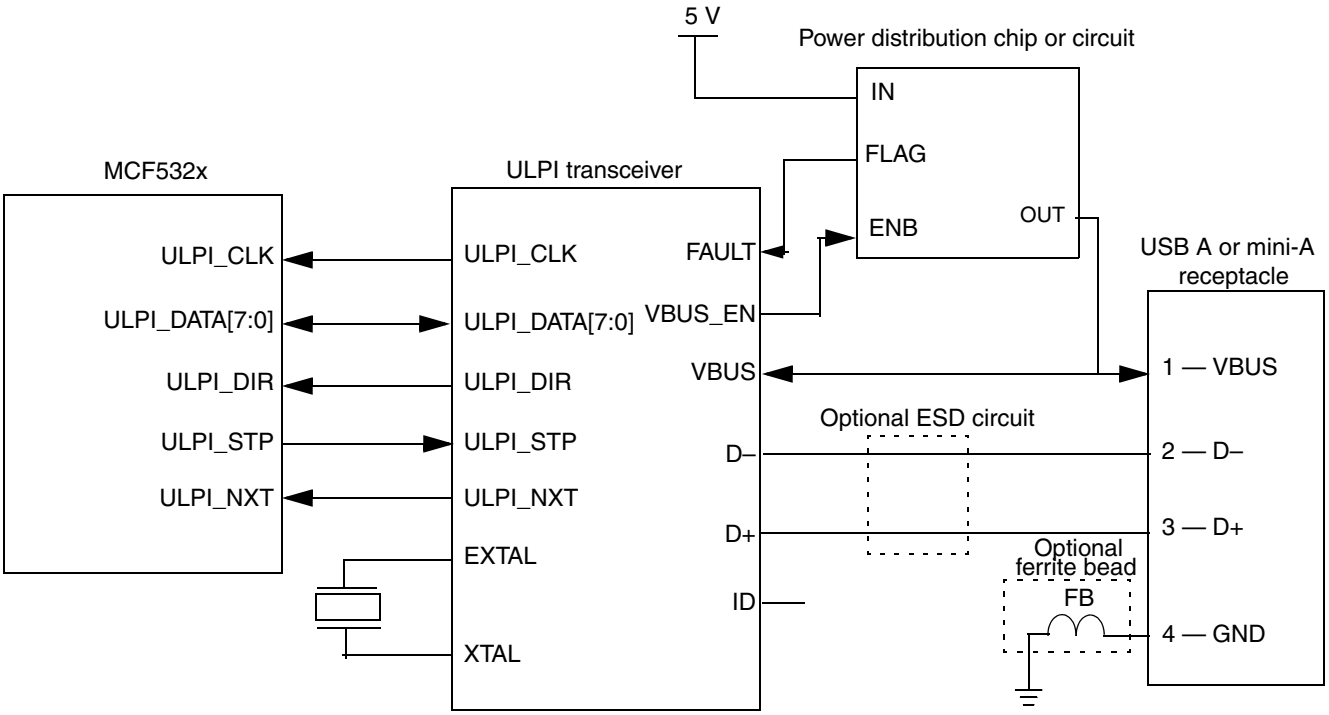

Figure 5. Using the Dual-Role Controller as a HS capable Host with a ULPI Transceiver

The connections between the MCF532x and the PHY remain the same. The primary change is the addition of the external power distribution switch. This allows for more current on the VBUS supply so non-OTG, bus-powered devices can be supported. This is a host-only implementation, so the ID pin on the ULPI PHY can be left floating. The mini-AB receptacle is also replaced by a standard A or mini-A receptacle.

5.3 USB Connectors

Since a ULPI PHY can support host, device, or OTG operation, a ULPI PHY can be used with any USB receptacle. The functionality that needs support determines the choice of receptacle. If OTG or dual-role functionality is needed, then a mini-AB connector should be used (as shown in Figure 4). For host only operations a standard-A or mini-A can be used (as shown in Figure 5). If only device functionality is needed, then a standard-B or mini-B receptacle would be used in place of the mini-AB receptacle.

6 USB Layout Considerations

6.1 Series Termination Resistor Values and Placement

When using the on-chip FS/LS transceiver, 33 Ω series termination resistors on the D+ and D– lines are recommended. To obtain the optimal eye diagram, these series resistors should be placed as close to the processor as possible.

6.2 General USB Layout Suggestions

- Route the USB D+ and D– signals as parallel 90 Ω differential pairs.
- Match trace lengths as closely as possible. Matching within 150 mils is a good guideline.
- Try to maintain short trace lengths.
- Avoid placing USB differential pairs near signals that might cause interference such as clocks, periodic signals, and I/O connectors.
- Minimize vias and corners.
- Route differential pairs on a signal layer next to the ground plane.
- Avoid signal stubs.

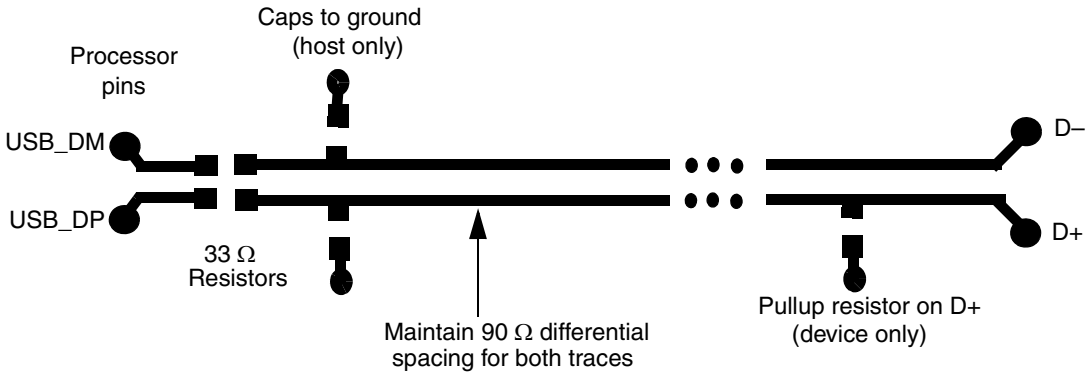

Figure 6. USB Routing Example

7 Additional Resources

Table 1 lists resources for more information on USB and/or the MCF532x processor.

Table 1. Additional Resources

Document	Website	Description
MCF5329 Data Sheet	http://www.freescale.com/coldfire	Hardware data sheet for the MCF532x family processors.
MCF5329 Reference Manual	www.freescale.com/coldfire	Detailed reference manual for the MCF532x family processors.
Universal Serial Bus Specification	www.usb.org/developers/docs	Official USB specification
USB On-The-Go Supplement	www.usb.org/developers/docs	OTG specific additions to the USB specification
High- Speed USB Platform Design Guidelines	www.usb.org/developers/docs	Document with detailed design guidelines. This document is targeted towards PC motherboard design, but the information is still helpful for embedded applications.
ULPI Specification	www.ulpi.org	Official specification for ULPI

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