AVR32787: AVR32 AT32UC3A3 High Speed USB Design Guidelines

1. Introduction

This document provides guidelines for integrating an AVR®32 AT32UC3A3x high speed USB device controller onto a 4-layer PCB. The material covered can be broken into two main categories: board design guidelines and layout examples.

High speed USB operation is described in the USB 2.0 Specification (http://www.usb.org/developers/docs.html).

The usb.org also provides the High Speed USB Platform Design Guidelines (http://www.usb.org/developers/docs/hs_usb_pdg_r1_0.pdf) for integrating a high-speed USB host controller onto a 4-layer desktop motherboard. It covers board design, EMI/ESD, and front panel USB guidelines.

Application diagrams (device mode in self-powered or bus-powered, Host and OTG modes) are described in the AVR32UC3A3x datasheet, chapter USB.

32-bit AVR® Microcontroller

Application Note

32122B–AVR32–04/09

2. Layout Guidelines

2.1 General Routing and Placement

Use the following general routing and placement guidelines when laying out a new design. These guidelines will help to minimize signal quality problems.

1. Place the high-speed USB host controller and major components on the unrouted board.
2. With minimum trace lengths, route high-speed clock and high-speed USB differential pairs.
   Maintain maximum possible distance between high-speed clocks/periodic signals to high speed USB differential pairs and any connector leaving the PCB (such as, I/O connectors, control and signal headers, or power connectors).
3. Route high-speed USB signals using a minimum of vias and corners. This reduces signal reflections and impedance changes.
4. When it becomes necessary to turn 90°, use two 45° turns or an arc instead of making a single 90° turn. This reduces reflections on the signal by minimizing impedance discontinuities.
5. Do not route USB traces under crystals, oscillators, clock synthesizers, magnetic devices or ICs that use and/or duplicate clocks.
6. Stubs on high speed USB signals should be avoided, as stubs will cause signal reflections and affect signal quality.
7. Route all traces over continuous GND plane with no interruptions. USB ground plane should be isolated from other ground plane.

2.2 High Speed USB Trace Spacing

Figure 2-1 provides an illustration of the recommended trace spacing while Table 2-1 gives some trace calculation examples. Use the following guidelines.

1. Use an impedance calculator to determine the trace width (W) and spacing (S) required for the specific board stack-up being used. W is calculated to achieve a trace impedance (Z0) of ~50 Ω and S is calculated to achieve a differential trace impedance of 90 Ohm. These impedances depend in first approximation on the following PCB parameters delivered by the PCB manufacturer:
   – e_r: dielectric relative permittivity
   – H: dielectric height
   – T: trace thickness
2. Maintain parallelism between USB differential signals with the trace spacing calculated to achieve 90W differential impedance. Deviations will normally occur due to package breakout and routing to connector pins. Ensure the amount and length of the deviations are kept to the minimum.
3. Minimize the length of high-speed clock and periodic signal traces that run parallel to high speed USB signal lines to minimize crosstalk. Based on EMI testing experience, the minimum suggested spacing to clock signals is 50 mils.
4. Based on simulation data, use 20-mil minimum spacing between high-speed USB signal pairs and other signal traces for optimal signal quality. This helps to prevent crosstalk.

Figure 2-1. Recommended Trace Spacing

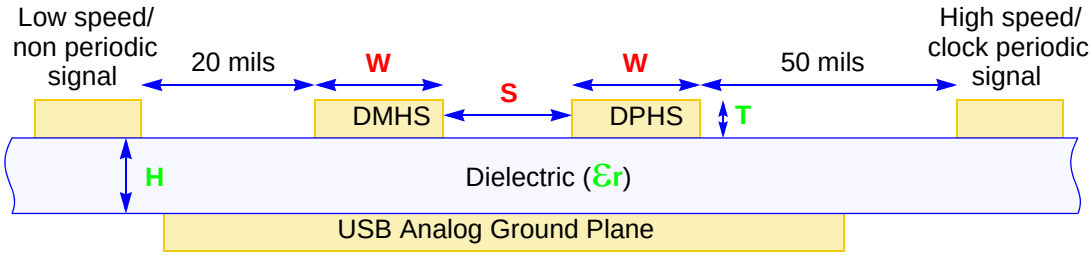


Table 2-1. Trace Characteristics Examples

PCB Characteristics			Trace Characteristics	
er	H(mils)	T(mils)	W(mils)	S(mils)
4.6	4.5	1.4	7.5	7.5
3.9	5.5	1.7	10	10

2.3 High Speed USB Termination

The AVR32 AT32UC3A3x microcontroller high-speed USB design requires 39 Ω termination resistor at both DMFS and DPFS pins. Place the termination resistors as close as possible to the AT32UC3A3 signal pins.

2.4 High Speed USB Trace Length Matching

High-speed USB signal pair traces should be trace-length matched. Max trace-length mismatch between high-speed USB signal pairs should be no greater than 150 mils.

2.5 High Speed USB Bias Filter

AT32UC3A3x high-speed USB design requires a 6.81 KΩ 1% resistor in parallel to a 10pF capacitor connected from USB_VBIAS pin to ground. The resistor defines the master biasing of the AT32UC3A3x high-speed pad and should be placed as close as possible to the USB_VBIAS pin by taking care to minimize noise injection at this point.

2.6 High Speed USB ESD Protection

Full-speed USB provide ESD suppression using in-line ferrites and capacitors that form a low pass filter. This technique doesn't work for high-speed USB due to the much higher signal rate of high-speed data. A recommended device that has been tested successfully is a LittelFuse® component, PulseGuard® PGB0010603MR (0603 package size). Proper placement of the devices is on the data lines as close as possible to the USB connector. Other low-capacitance ESD protection devices may work as well. We recommend including the footprints for this device, or some other proven solution, as a stuffing option in case it is needed to pass ESD testing and in the event that a problem occurs (general routing and placement guidelines should be followed).

2.7 High Speed USB Connectors

In order to provide direct connection of high-speed USB signals, we recommend to use through hole mini-AB or surface mount mini-AB receptacle connector. In case AT32UC3A3x OTG capability is not requested, we recommend to use through hole mini-B or surface mount mini-B receptacle connector or surface mount std-A plug.

3. Layout Examples

Figure 3-1 and Figure 3-2 shows an example of AT32UC3A3x high-speed USB routing with a standard mini AB receptacle.

Figure 3-1. Standard Mini AB Receptacle - USB Routing Example with QFP144 Package

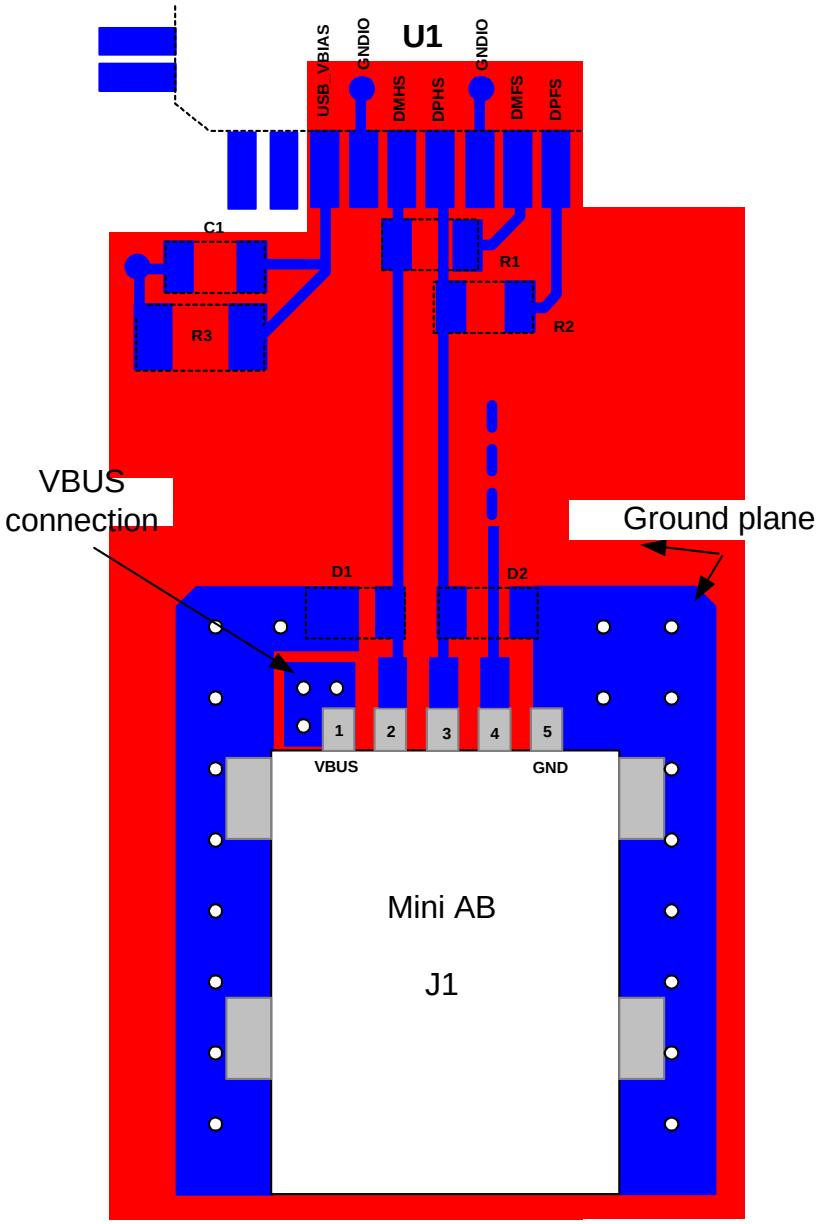
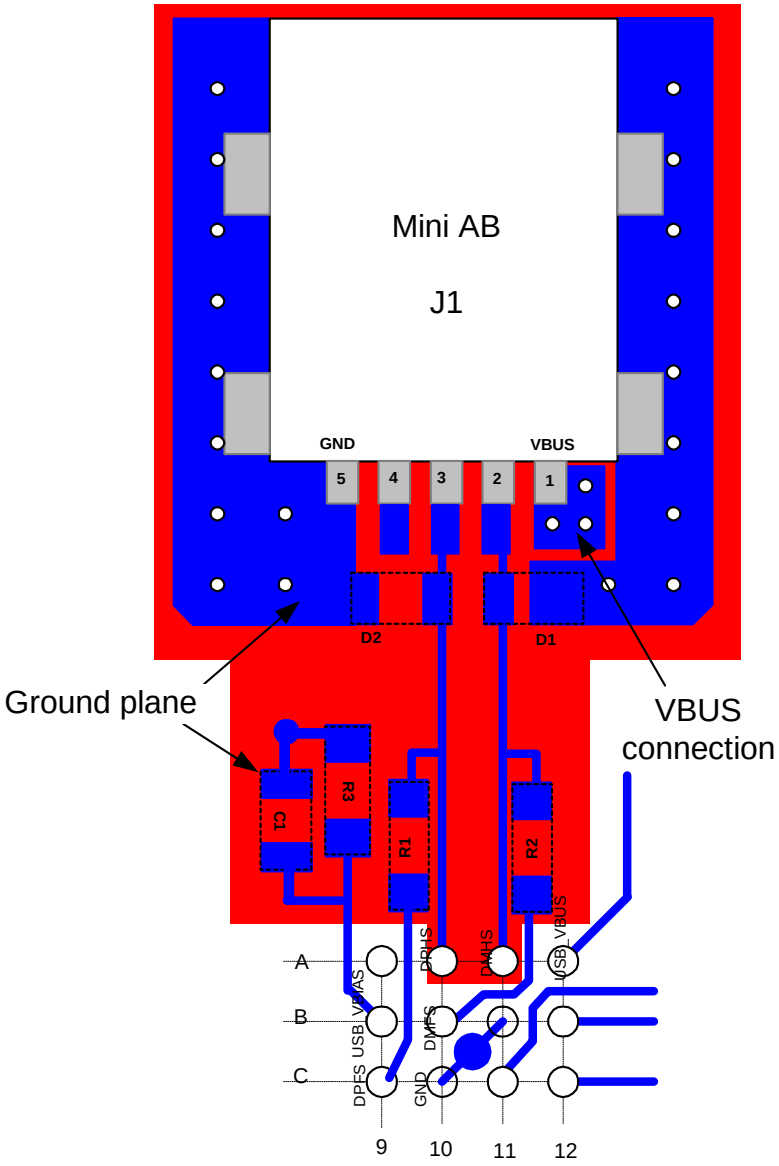


Figure 3-2. Standard Mini AB Receptacle - USB Routing Example with BGA144 Package



Note: For R1, R2, R3, C1 values, refer to AT32UC3A3x datasheet.

Headquarters

Atmel Corporation
2325 Orchard Parkway
San Jose, CA 95131
USA
Tel: 1(408) 441-0311
Fax: 1(408) 487-2600

International

Atmel Asia
Unit 1-5 & 16, 19/F
BEA Tower, Millennium City 5
418 Kwun Tong Road
Kwun Tong, Kowloon
Hong Kong
Tel: (852) 2245-6100
Fax: (852) 2722-1369

Atmel Europe
Le Krebs
8, Rue Jean-Pierre Timbaud
BP 309
78054 Saint-Quentin-en-
Yvelines Cedex
France
Tel: (33) 1-30-60-70-00
Fax: (33) 1-30-60-71-11

Atmel Japan
9F, Tonetsu Shinkawa Bldg.
1-24-8 Shinkawa
Chuo-ku, Tokyo 104-0033
Japan
Tel: (81) 3-3523-3551
Fax: (81) 3-3523-7581

Product Contact

Web Site
www.atmel.com

Technical Support
avr32@atmel.com

Sales Contact
www.atmel.com/contacts

Literature Requests
www.atmel.com/literature