AN 20.2

USB 2.0 High Speed Interface Design

INTRODUCTION

As product form factors continue to shrink, designers are increasingly pushed to find new and innovative ways to incorporate the USB interface into their products. To enable the development of these new system architectures, the Microchip USB Transceiver products are also evolving to address the needs associated with the High Speed USB 2.0 interface.

To enable maximum reliability and flexibility of design in the customer application, Microchip's USB Transceivers offer superior software configurability and hardware integration:

- Programmable Transmitter Amplitude
- Programmable Receiver Sensitivity
- Integrated USB Switch
- Integrated ESD Protection

Optimizing both the Transmitter and Receiver allows for maximum USB transfer speeds and simplifies High Speed USB-IF certification. Through the use of PHYBoost and VariSense technology, Microchip USB Transceivers allow designers maximum flexibility when defining their product while reducing risk and time to market.

Whether you are looking to improve margin on an existing product design or avoid a hardware modification to pass USB-IF certification, Microchip transceivers provide unsurpassed configurability to enable product success.

References

Universal Serial Bus Specification, Revision 2.0, April 27, 2000

USB-IF 2.0 Electrical Test Specification, Revision 1.2, April 1, 2003

Microchip USB Transceiver Data Sheets:

- USB331x
- USB332x
- USB333x

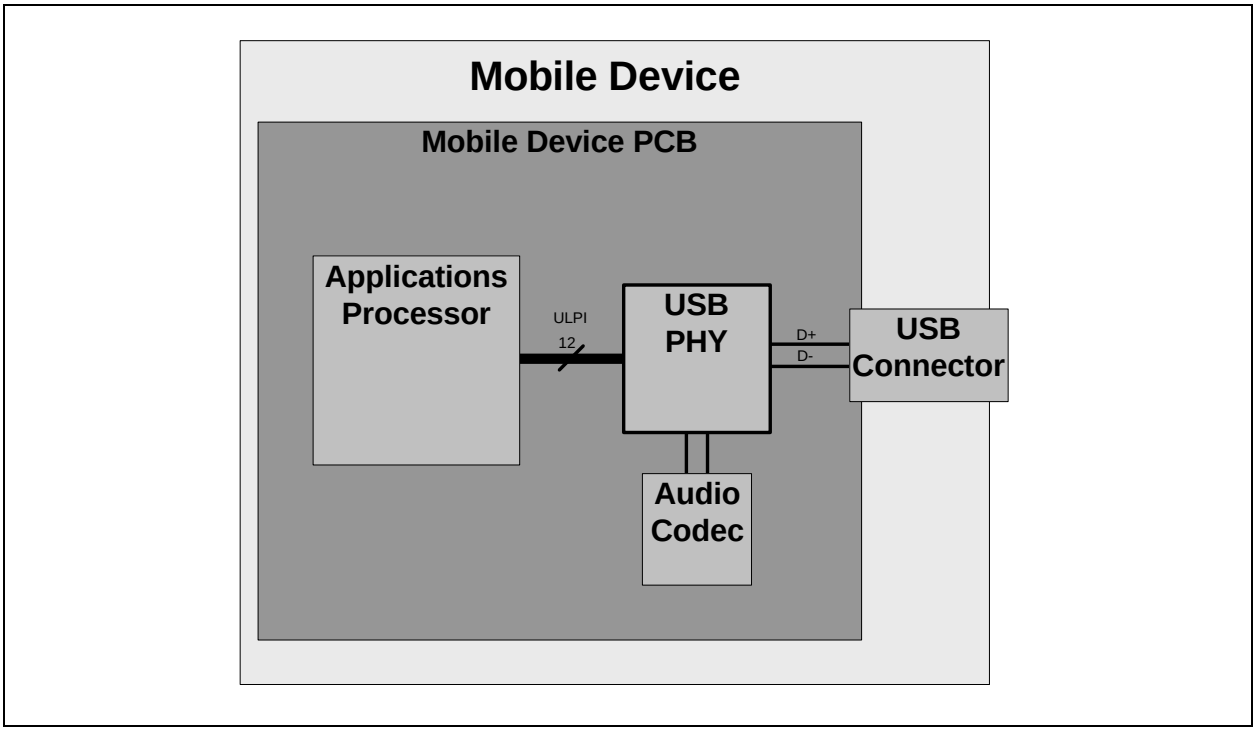
Definitions

HS = USB 2.0 High Speed

DESIGN CHALLENGES

In many applications, the USB interface design has a minimal number of components, as shown in Figure 1. In this case, the product designer may desire maximum margin on the transmitter and receiver for USB interface performance and certification.

FIGURE 1: COMMON USB ARCHITECTURE FOR MOBILE DEVICE



Successful USB designs require that great attention be paid to the D+ and D- signal routing. The D+ and D- traces must be routed according to the following guidelines:

- Routed 90 ohm differential
- Length matched within 0.025” (0.635mm) of each other
- Minimize total trace length

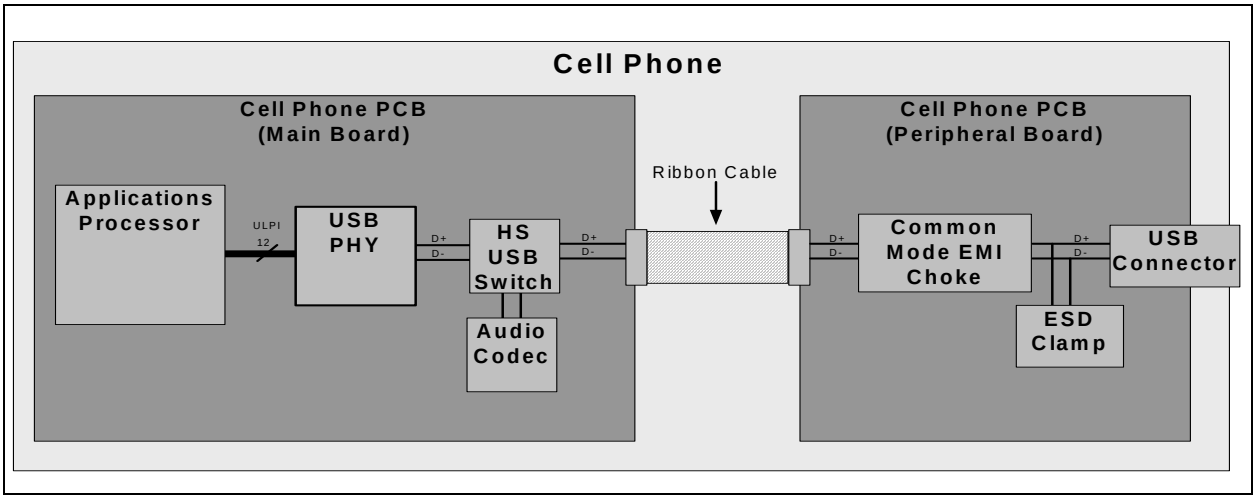
Common system elements which negatively impact the USB electrical performance of products include:

- Common Mode EMI Chokes
- ESD Suppression Devices
- External USB Switches
- Cables between the USB Transceiver and the USB connector
- Captive (Proprietary) USB Cables

By integrating significant ESD protection and the USB switch, the Microchip USB Transceiver provides design margin for both the USB Transmitter and Receiver.

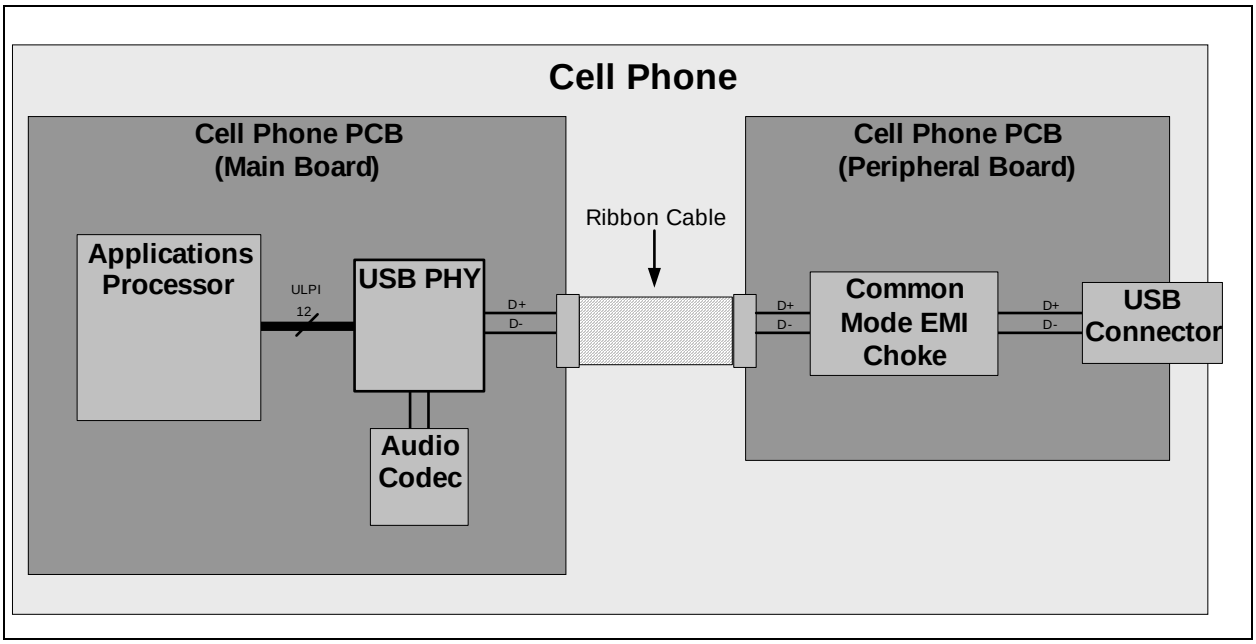
Figure 2 shows a real-world example of a cell phone which puts a heavy demand on the USB PHY Transmitter and Receiver.

FIGURE 2: EXAMPLE OF COMPLEX CELL PHONE ARCHITECTURE



By integrating the USB Switch and ESD Protection, the Microchip Transceiver improves the transmitter and receiver performance of the product by removing serial and parallel elements from the signal path. Figure 3 shows this refined signal path using the Microchip Transceiver.

FIGURE 3: CELL PHONE BLOCK DIAGRAM WITH MICROCHIP USB TRANSCEIVER



For all of these architectures, an additional lossy element in the system which can cause USB-IF certification issues is the use of a “captive cable”. A captive cable is a hard-wired or, more commonly, a custom detachable cable used to connect the USB device to the USB host. All USB-IF certification is required to occur with the captive cable installed, and this means that the USB High Speed Electrical Test measurements for the Transmitter and Receiver are made at the end of the captive cable. This presents additional challenges when trying to meet the requirements of the USB-IF High Speed Electrical Test Specification.

HIGH SPEED TRANSMITTER

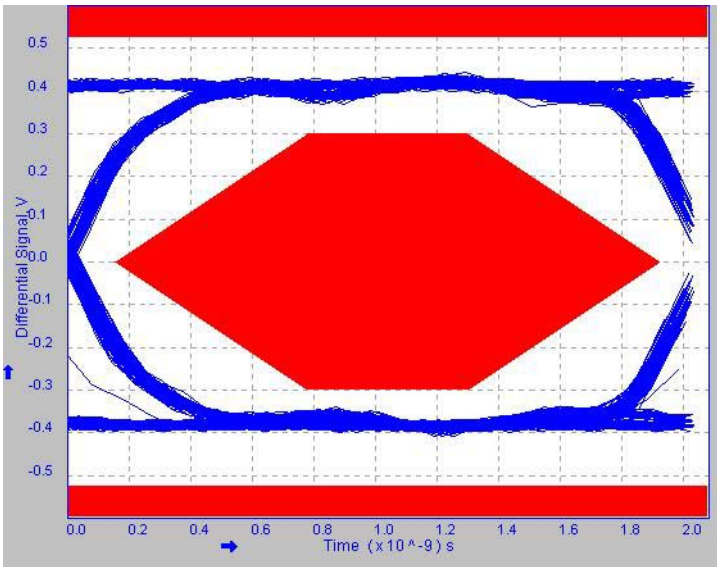
Platforms that place internal cables, EMI components, or other serial lossy elements on DP/DM can experience difficulty in passing the High Speed Eye Diagram tests for USB-IF certification. To overcome the losses associated with these elements, Microchip USB Transceivers offer PHYBoost. PHYBoost, also known as “TX Boost”, increases the current drive of the DP/DM transmitters.

USB-IF Certification Requirements

There are five High Speed Electrical Tests associated with the Transmitter: EL_2, EL_4, EL_5, EL_6, and EL_7. EL_5 tests the product’s eye diagram.

Figure 4 shows the eye diagram from a Microchip USB Transceiver with the default transmitter settings.

FIGURE 4: TRANSMITTER EYE (NO BOOST)



Optimizing Transmitter Performance with PHYBoost

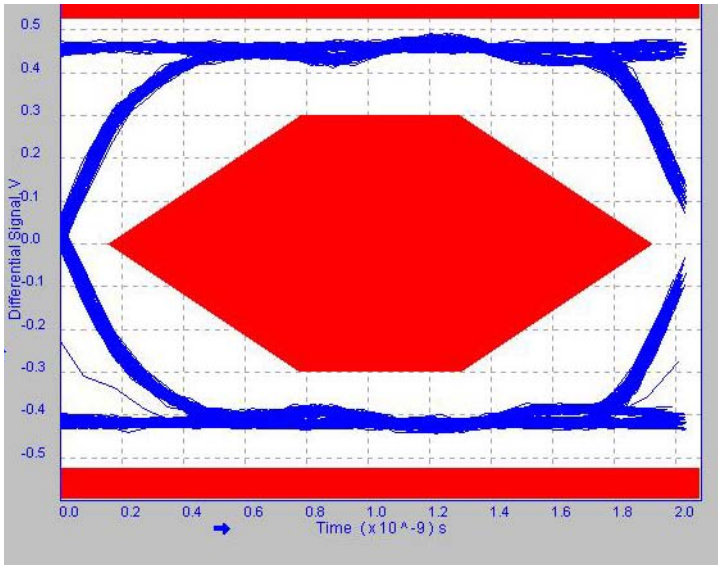
Due to losses in the path of D+ and D- or noise in the platform, the amplitude of the eye diagram may need to be increased.

PHYBoost is technology that enables software to configure the drive strength of the USB High Speed Transmitter. Microchip USB Transceivers can overcome attenuation on the USB transmitter path through the use of PHYBoost. Consult the data sheet for specific Microchip USB Transceivers for a detailed definition of the PHYBoost capabilities.

If the elements which attenuate the eye diagram are primarily frequency dependent (inductive or capacitive), then the designer must take care not to violate the TEST_J or TEST_K tests by applying too high of a PHYBoost setting. TEST_J and TEST_K are DC tests of the D+ and D- static drive voltages. If PHYBoost is set too high in an effort to overcome AC losses, the TEST_J and TEST_K tests can exceed the maximum DC limit for D+ and D-.

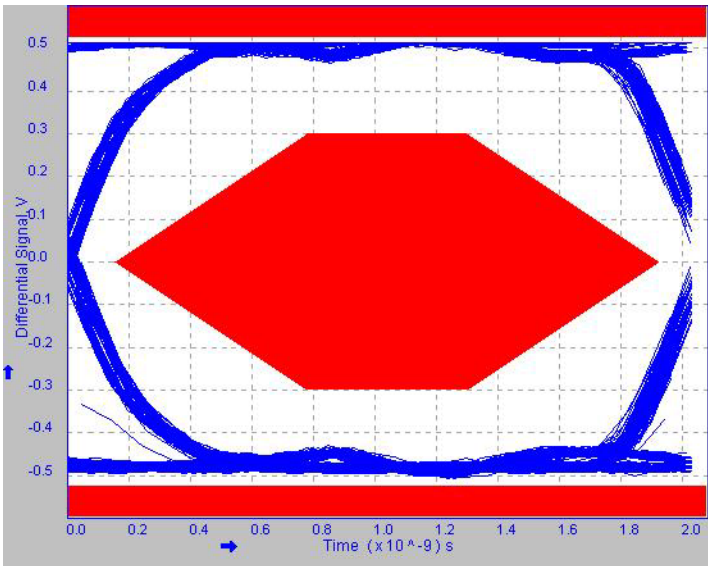
In Figure 5, an 11% PHYBoost setting has been applied.

FIGURE 5: TRANSMITTER EYE (11% BOOST)



In Figure 6, a 25% PHYBoost setting has been applied.

FIGURE 6: TRANSMITTER EYE (25% BOOST)



HIGH SPEED RECEIVER

All Microchip USB Transceivers are certified with the USB-IF to meet the USB specification for silicon components. However, the mobile device product must also pass within the same limits. System elements connected to D+ and D- such as common mode chokes, ESD suppression arrays, and external switches serve to reduce the overall Receiver Sensitivity of the USB device and produce higher test values for EL_17 and EL_16.

HS Receiver Sensitivity: EL_17 (“Un-Squelch”)

The USB-IF USB 2.0 Electrical Test Specification defines test EL_17 as:

“A high speed capable device must implement a transmission envelope detector that does not indicate squelch (i.e. reliably receives packets) when a receiver’s input exceeds 150 mV differential amplitude.”

Since the release of the specification, the USB-IF has issued a waiver which extends this limit to 200mV. Devices or silicon passing with EL_17 between 150 mV and 200 mV passes with an automatic “waiver”. If required, this waiver is automatically granted by the test facility without a need for special application or justification.

HS Receiver Sensitivity: EL_16 (“Squelch”)

The USB-IF USB 2.0 Electrical Test Specification defines test EL_16 as:

“A high speed capable device must implement a transmission envelope detector that does indicates squelch (i.e. never receives packets) when a receiver’s input falls below 100 mV differential amplitude.”

Optimizing Receiver Sensitivity with VariSense

Many Microchip USB Transceivers feature VariSense. VariSense is technology that Microchip offers in its USB transceivers to configure the Receiver Sensitivity of the USB Transceiver via software.

For some mobile products, no customizing is necessary and the product will pass USB-IF certification using the default VariSense receiver sensitivity settings. However, as smartphone architectures evolve, a greater number of products require extra help in passing USB-IF certification testing or improving the performance of the USB interface. VariSense makes this possible.

VariSense gives the product designer the ability to lower the threshold of the squelch detector simply by modifying a ULPI register. For a mobile device, this means that a lower amplitude signal received at the USB transceiver will still be detected.

Consult the data sheet for specific Microchip USB Transceivers for a detailed definition of each USB Transceiver’s VariSense capabilities.

APPENDIX A: APPLICATION NOTE REVISION HISTORY

TABLE A-1: REVISION HISTORY

Revision Level & Date	Section/Figure/Entry	Correction
DS00002954A (02-13-19)	Replaces previous SMSC version Rev. 1.0 (11-26-12)	
Rev. 1.0 (11-26-12)	Document co-branded: Microchip logo added, modification to legal disclaimer	
Rev. 1.0 (08-03-09)	Document release	

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

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