CP3UB17/CP3BT10 External USB Components

National Semiconductor
Application Note 1267
Jamie Aitken
September 2003

1.0 Abstract

The CP3BT10 Connectivity Processor can be made compliant with Revision 2.0 of the USB Specification by means of a few external components. This application note outlines the external circuitry requirements for CP3BT10 based USB devices. This document should be consulted during the schematic design phase for any CP3BT10 based USB device application.

2.0 Device Speed Identification

The CP3BT10 is a full speed (12Mb/s) device. High Speed (480Mb/s) functionality and low-speed (1.5Mb/s) functionality are not supported. Full-speed USB devices are identified by upstream host or hub ports by a 1.5kΩ ± 5% pull-up resistor on the D+ line tied to a voltage source between 3.0V and 3.6V. This pull-up resistor is depicted in *Figure 1* as R_{PU}.

Figure 7-20 on page 141 of Revision 2.0 of the USB Specification depicts a typical full-speed device cable and resistor connection while section 7.1.5 of the USB Specification describes Device Speed Identification in more detail.

3.0 Impedance Matching

Section 7.1.1.1 of the USB Specification Revision 2.0 states that "When the full-speed driver is not part of a high-speed capable transceiver, the impedance of each of the drivers (Z_{DRV}) must be between 28Ω and 44Ω." Section 7.1.1.1 also states that, "For a typical CMOS implementation, the driver impedance will typically be realized by a CMOS driver with an impedance significantly less than this resistance with a discrete series resistor making up the balance."

This series resistance is represented in *Figure 1* as R_S. The optimal value of R_S for the CP3BT10 that provides the fastest D+ and D- rise and fall times while limiting reflections on the USB cable is 18Ω. However, any value in the range of 18Ω to 24Ω will suffice.

4.0 Voltage Protection Diodes

Section 7.1.1 of Revision 2.0 of the USB Specification states that, "A USB transceiver is required to withstand a continuous short circuit of D+ and/or D- to V_{BUS}, GND, other data line, or the cable shield at the connector."

What this means is that if your USB cable gets slammed in a door, nothing upstream or downstream should become damaged.

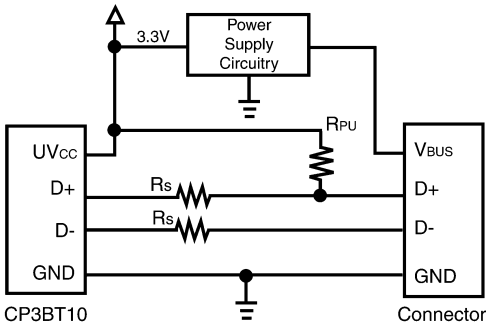
In order to meet this part of the USB Specification, and because the gate oxide on the transceiver driver transistors is only reliable up to 4.2V, external voltage protection diodes should be used. These diodes are depicted as D1 and D2 in *Figure 1*.

When these external voltage protection diodes are used, R_S will be required to dissipate a large amount of power if a short occurs. As such, 1/4 W, 1206 size, SMD resistors are recommended for R_S.

5.0 Bus-Powered Device

5.1 Typical Interface Circuitry

Figure 1 depicts a typical interface for a CP3BT10 based bus-powered USB device.



Refer to *Table 1* for component values and part numbers.

FIGURE 1. Bus-Powered Device

5.2 V_{BUS} Regulation

In a bus powered device, a buck converter (switching regulator) or a linear regulator can be used to regulate V_{BUS} to provide power to the USB device. The regulator is required to operate from a minimum of 4.40V, 100 mA of power supplied via V_{BUS} (see section 7.2 of the USB Specification Revision 2.0).

6.0 V_{BUS} Sensing Circuitry

Section 7.1.5.1 of the USB Specification Revision 2.0 states that, "The voltage source on the pull-up resistor must be derived from or controlled by the power supplied on the USB cable such that when V_{BUS} is removed, the pull-up resistor does not supply current on the data line to which it is attached."

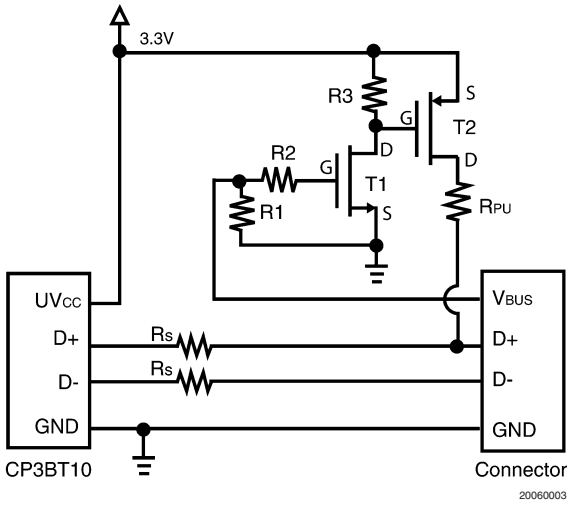
Compliance with this section of the specification is enforced by way of a test for back-voltage on D+ and D-. Section H of the USB-IF Full and Low Speed Electrical and Interoperability Compliance Test Procedure document outlines back-voltage testing. No more than 400mV may be present on either data line before a connection event or after a disconnect event.

The V_{BUS} Sensing circuitry required for CP3BT10 based self-powered USB device compliance is depicted in *Figure 2*. V_{BUS} Sensing circuitry is not required for bus-powered devices.

7.0 Self Powered Device

7.1 Typical Interface Circuitry

Figure 2 depicts a typical interface for a CP3BT10 based self-powered USB device.



Refer to *Table 1* for component values and part numbers.

FIGURE 2. Self-Powered Device

7.2 V_{BUS} Sensing Current Consumption

Section 7.2.3 of Revision 2.0 of the USB Specification states that, "All USB devices initially default to low-power. Low-power devices or high-power devices operating at low-power are limited to 500 µA of suspend current."

The V_{BUS} Sensing circuitry depicted in *Figure 2* will consume a maximum of 5.25V/240kΩ = 21.9 µA from V_{BUS}. This is well within the 500 µA maximum value.

8.0 Components

Table 1 lists the components found in *Figure 1* and *Figure 2*.

TABLE 1. Components

Designator	Description	Value
R_S	Impedance Matching Series Resistor	18Ω, 1206, 1/4W
R_{PU}	Pull-Up Resistor	1.5kΩ
D1	Voltage Protection Diode	B0520LW
D2	Voltage Protection Diode	B0520LW
R1	Biasing Resistor	240kΩ
R2	MOSFET Gate Protection Resistor	10kΩ
R3	Biasing Resistor	240kΩ
T1	N-Channel MOSFET	MMBF170
T2	P-Channel MOSFET	BSS84

Notes

Notes

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

National Semiconductor
Americas Customer
Support Center
Email: new.feedback@nsc.com
Tel: 1-800-272-9959

www.national.com

National Semiconductor
Europe Customer Support Center
Fax: +49 (0) 180-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

National Semiconductor
Asia Pacific Customer
Support Center
Email: ap.support@nsc.com

National Semiconductor
Japan Customer Support Center
Fax: 81-3-5639-7507
Email: jpn.feedback@nsc.com
Tel: 81-3-5639-7560