Using Low Voltage I2C with I2C2PC and BL233

July 27, 2013

1 Introduction

The I2C-2-PC adaptor has internal regulators for 5V and 3.3V. It can be used for either or a mixture of the two supplies.

It is also possible to use the adaptor with slave devices operating from voltages as low as 1.8V. A built in clamp feature on Bus#3 supports operation down to 1.8V.

From 2011, there is space for you to add a 3rd regulator to supply other voltages to bus 3. (eg 2.5,V 1.8V)

Short Summary

Bus 1&2 will support slaves operating at 5V or 3.3V

Bus 3 will work down to 1.8V with a 3.3V

5V Tolerant Devices

Before going to any trouble, you should make sure that the IC you are interfacing has *not* got 5V tolerant pins for the I2C ports. This is very common, and in this case you will be free to use any bus without doing anything. Devices with 5V tolerant outputs do not have diodes to VDD from the SDA&SCL lines, and so the voltage will be 5V.

Contents

2 Revision History

Rev	Date	Changes
0	17 Dec 07	First Release
1	11 Jun 09	Add schematic of diode clamp to Bus 3 section. Add Errata to Bus 3 section
2	12 Sep 10	U9 Optional LV regulator added to 2011 year adaptors. Added note about INT pin levels
3	27 July 13	Add updated schematics for V4 adaptors

3 BL233B

3.1 Input Thresholds

The BL233B chip has 4 I2C ports. Bus#1, 2 have Schmitt Trigger input levels. Bus#3,4 have TTL compatible levels. INT has TTL input level.

Jumper J6 selects VDD to be 5V or 3.3V.

Logic	Type	Bus#	4.5-5.5V	3.3V	3.0V
VHi	Schmitt	1,2	4V	2.64	2.4
VLo	Schmitt	1,2	2V	0.66V	0.6
VHi	TTL	3,4	2V	1.65V	
VLo	TTL	3,4	0.8V	0.48V	
47ohm			0.15V	0.1V	

Note that in the I2C2PC adaptor there is a 47 ohm series resistor in the I2C bus. This will drop an additional 0.1V at 2.2mA bus current (ie VDD=3.3V). This changes the minimum VLo to 0.37V at the slave.

3.2 Low VDD for BL233

The BL233B can be operated down to 3V. At 3V, a reduced crystal frequency is recommended. A 9.8304MHz crystal will change the default baud rate to 38.4k

A low voltage qualified version is available in quantity, which is rated for operation at voltages as low as 2V. At 2.5V we would recommend a 4.9152MHz crystal, which will give a default baud rate of 19.2k. It likely that the standard BL233B will operate at low voltages if tried.

At lower crystal frequencies, the speed of operation will be proportionally reduced.

Note that we have not done any testing of the BL233B at low voltages, but have no particular reason to expect problems.

4 I2C2PC

4.1 Documentation

All documentation, schematics and drawings for the I2C2PC can be found in http://www.i2cchip.com/pdfs/i2c2pc_all_docs.zip

Application notes and documentation for other I2CCHIP products is located at: http://www.i2cchip.com/pdfs

4.2 I2C-2-PC Low Voltage Bus#3

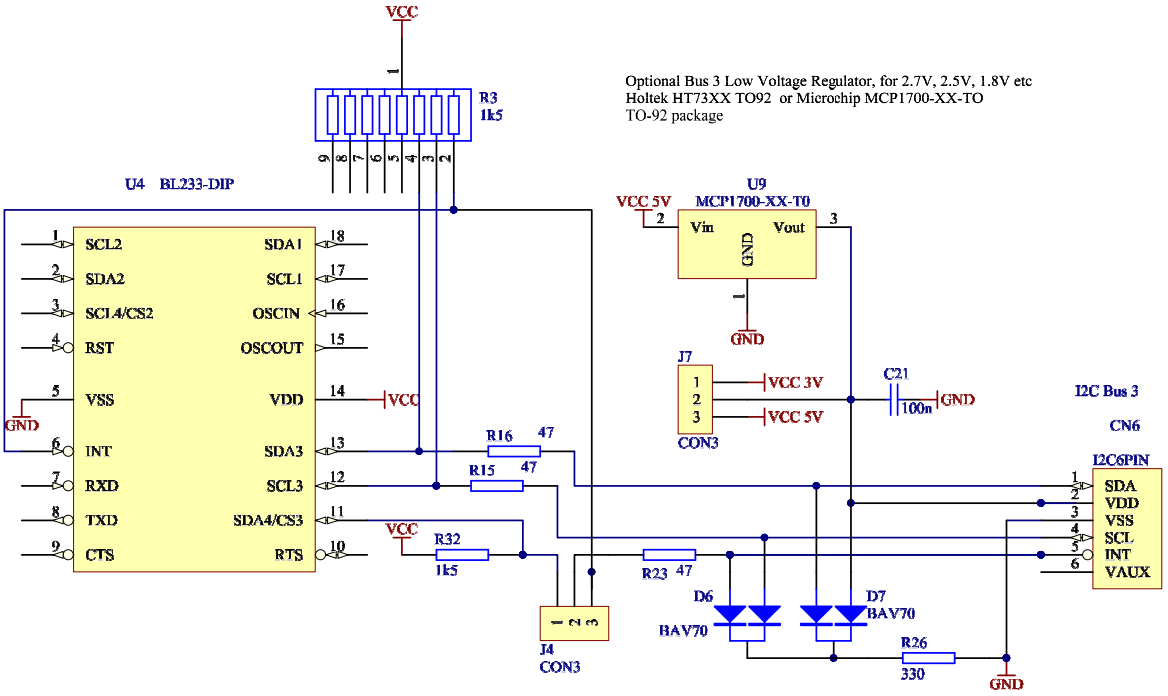
In the I2C2PC adaptor Bus#3 is already prepared for low voltage operation. It has a diode clamp arrangement (see schematic at end) that clamps the bus voltage to VDD at the connector.

Jumper J7 allows you to supply VDD at either 5V or 3.3V to Bus#3 from the I2C2PC. Alternatively, you can leave J7 off, and feed it in from the I2C bus.

If you fit optional internal regulator U9, leave J7 off.

When VDD is 5V, Bus 3 can be as low as 2.5V. When VDD is 3.3V, Bus 3 can be as low as 1.8V.

The diode clamp arrangement also provides a pseudo constant current operation that speeds up rise times, improving reliability at low voltages.



4.2.1 Errata

Some units have been manufactured (2009-2010) with incorrect diodes D6, D7 on Bus 3. The incorrect diodes are marked A6. (correct diodes are type BAV70, marked A4). Symptoms are that when J7 is removed, Bus3 IRQ (pin 5) is 1.4V (correct), but SDA and SCL (pins 1 & 4) are at VDD (5V). Request a replacement from sales@i2cchip.com.

Will this be a Problem?

Probably not. Most devices have either a 5V tolerant I2C port, or they have internal protection diodes. The protection diodes will act to clamp the bus. If the adaptor is set to 3.3V, then there is only 100µA clamp current for a 2.5V device. At 5V it is still only 1.2mA

4.3 Optional Low Voltage Regulator for Bus 3

During 2011 a new version will be introduced. It has provision for an optional low voltage regulator U9 which may be fitted to power Bus 3 only. The regulator is in T092 3 lead package.

Regulators are Microchip MCP1700-XX-TO and Holtek HT73XX TO92.

- Select a regulator suitable for the voltage you will be using. Regulators are available for 1.8V, 2.5V and 3.3V
- Remove solder from pcb holes if required
- Fit new regulator
- Do *NOT* fit the jumper J7

4.4 Bus #4

Bus#4 is provided on the BL233B, and SDA4 is a TTL level.

	BL233B	I2C2PC-Bus	I2C2PC CN10
SDA4	11	Bus3, pin5, CS	6
SCL4	3	Bus2, pin5, CS	-

On the I2C2PC it is not brought out on a dedicated connector. Set J4,5 to CS position to connect these pins to the IRQ pins of Bus#2,3 connectors.

4.5 Interrupt Pin

The *INT* pin is common to all 3 buses. If using Bus 3 with a lower voltage than Bus1,2, then it will be held to the lower voltage. As it is a TTL input this should not be a problem. If you are not using the INT input, then don't fit the respective jumper.

5 1.8V Operation

The BL233 should have VDD=3.3V

Set J6 to 3.3V

Bus 3 should be used for I2C, with the external device feeding 1.8V to the VDD pin of Bus#3 (pin 2).

Remove J7 to disconnect the internal supply from the Bus 3 connector.

Idiot Diode

We recommend that you fit an "idiot diode" to your 1.8V device.

This will protect from the inevitable, wherein a new adaptor is plugged into your DUT[1] with its jumpers set to connect 5V to VDD. Suitable protection would be a stabistor, low voltage zener, or 3 or 4 power diodes in series.

In some applications two 1N4001 diodes in series from 3.3V to the connector VDD will provide a 1.8V supply to the slave that is close enough.

6 2.5V Operation

Bus#3 can certainly be used as described above for 1.8V.

It will obviously operate with the BL233's VDD at either 5V or 3.3V

Looking at the input level table for BL233's VDD of 3.3V, it is apparent that Bus1,2 are likely to work at 2.5V.

[1] Device Under Test

If you set the BL233 to 3.3V (J6 to 3.3), then the pull ups will be to 3.3V not 2.5V. If your device has standard ESD protection diodes from the I2C pins to VDD, then the bus will be clamped to ~3.1V anyway. As the current through the protection diodes will only be ~130uA there is unlikely to be any issue with doing this.

So you should only need to make sure that the 3.3 VDD of the adaptor is not connected directly to the slave's VDD of 2.5V

Modifying the adaptor.

Note that Bus#1,2 have a zero ohm resistor in the VDD connection to which can be removed. (FB10,11)

In some applications an 1N4001 diode from 3.3V to the connector VDD will provide a 2.6V supply to the slave that is good enough.

7 3.3V Operation

The I2C2PC can be operated completely from 3.3V and all buses can be used. Set J6 and J7 to 3.3V

You can also use just Bus3# at 3.3V and Bus#1,2 from 5V. In this case set J7 to 3.3V, and J6 to 5V

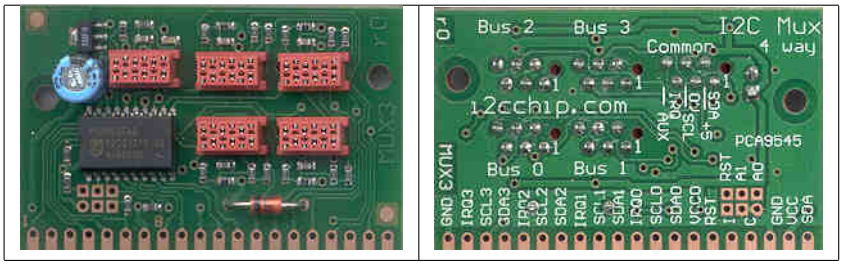
8 Other Approaches

8.1 Bus Switch

The PCA9545A is a quad bidirectional translating switch controlled via the I2C bus.

The pass gates of the switches are constructed such that the VCC pin can be used to limit the maximum high voltage, which will be passed by the PCA9545A. This allows the use of different bus voltages on each pair, so that 1.8-V, 2.5-V, or 3.3-V parts can communicate with 5-V parts, without any additional protection. External pull up resistors pull the bus up to the desired voltage level for each channel.

Mux3 Bus Switch http://www.i2cchip.com/pdfs/BusSwitch_MUX3.pdf



The 3.3V regulator in the top left corner could easily be replaced with a lower voltage one, or simple disconnected and the downstream VCC supplied by the low voltage slave device

8.2 Level Shifters

Level shifting can be done with a simple low-vgs fet.

The NXP GTL2002 and GTL2010 are this type. They can allow I2C bus voltages as low as 5V.

There are now also quite a wide range of special level shifting IC's available from many manufacturers.

8.3 Galvanic Isolation & Level Shifting

Analog devices make a magnetic isolator product ADUM1250/1 that also is useful for level shifting. While the device itself will only operate from 3.3 - 5V, one side (SDA1,SCL1) has low thresholds of 0.6V, and will interface to an I2C bus as low as 1.2V.

Beware that side 2 has Schmitt levels and will not interface to low voltages.

Silabs also a similar part.

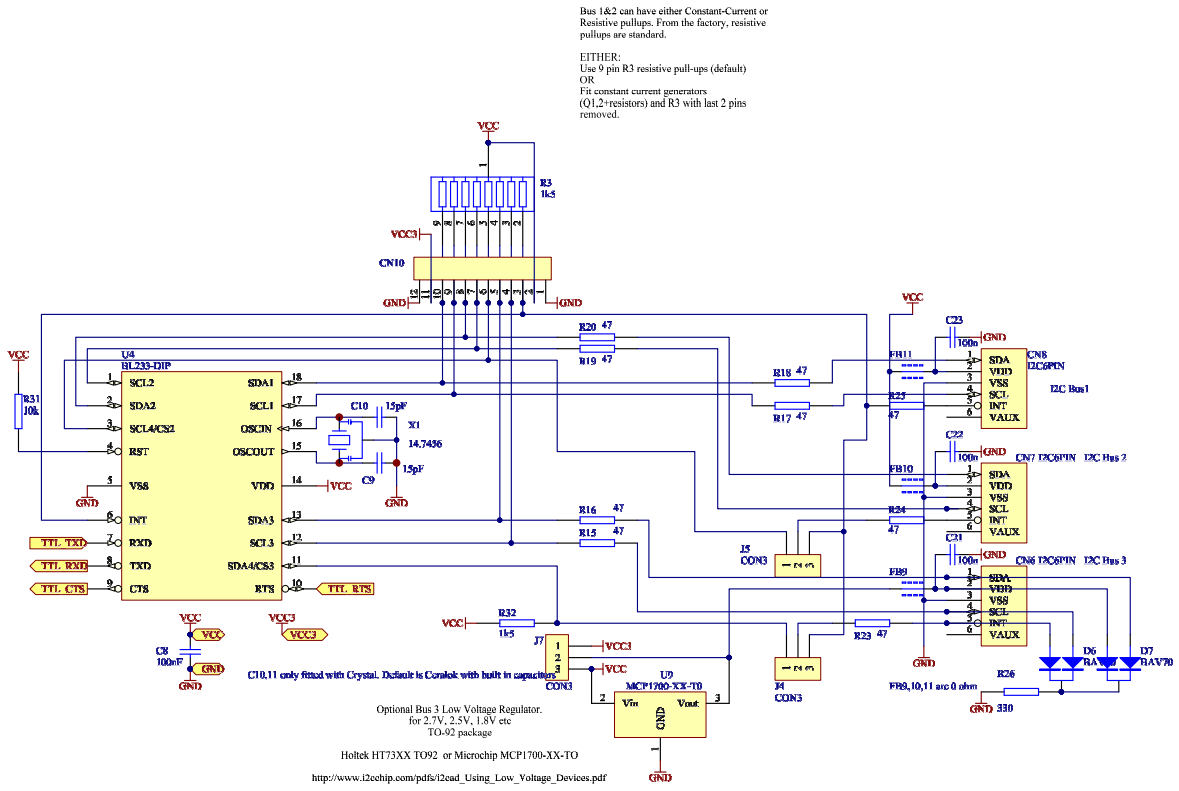
9 BL233 Versions

The BL233A did not operate at 3.3V unless a special version was ordered from the factory. Older I2C2PC adaptors using BL233A will not have 3.3V regulators and other features described above. BL233B is a plug in replacement.

BL233B & BL233C (when released) are as descibed above

10 Schematics and Drawings:

10.1 V4: After year 2011



10.2 V3: Before year 2011