Mux3: Bus Switch using PCA9545

Contents

Revision History

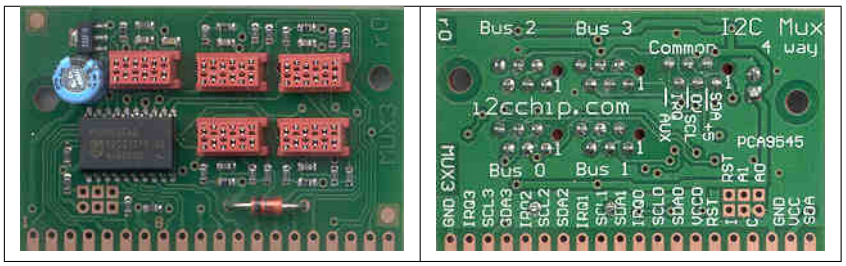
Rev	Date	Changes
1	26 November 2007	First Release
2	20 Jan 2015	Add I2C commands, Fatal Lockup section, update template
3		

1 Introduction

The PCA9545A is a quad bidirectional translating switch controlled via the I2C bus. The SCL/SDA upstream pair fans out to four downstream pairs, or channels. Any individual SCn/SDn channel or combination of channels can be selected, determined by the contents of the programmable control register. Four interrupt inputs (INT3-INT0), one for each of the downstream pairs, are provided. One interrupt (INT) output acts as an AND of the four interrupt inputs.

An active-low reset (RESET) input allows the PCA9545A to recover from a situation in which one of the downstream I2C buses is stuck in a low state. Pulling RESET low resets the I2C state machine and causes all the channels to be deselected, as does the internal power-on reset function.

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 pullup resistors pull the bus up to the desired voltage level for each channel. All I/O pins are 5.5-V tolerant.[1]



1.1 Why use a Bus Switch

There are several reasons to use this Bus Switch Module in a system

- More ports to use with more chips that have the same address.
- To build up large systems with lots of the same chip, e.g. a large array of temperature sensors.
- Where excessive bus capacitance is slowing the bus down, it allows the bus to be broken into smaller pieces. Similarly when one segment of the bus has a long cable which requires low speed operation this can be isolated.

[1] TI.com description

- Where low speed devices (e.g. software I2C slaves) are used, they can be isolated from high speed slaves to avoid slowing the whole bus down.
- Level Shifting: The PCA9545 will level shift. The module has a built in 3.3V regulator, so you can optionally run the switched ports at 3.3V or 5V when the main bus is 5V
- Fault Tolerance: Isolate faulty segments or to act as a sacrifical element to limit the extent of overvoltage damage.
- Hot Swapping: Isolate segments until connected.

1.2 Features of MUX3 Bus Switch Module

- Built in regulator for 3.3V level shifting if desired with jumper for voltage selection
- 4 Slave Addresses: up to 16 buses with a single level of switching.
- Standard I2C Micromatch connectors
- SIP connector to use as a daughter board
- External RESET input to force clear the switch.
- Power LED
- 2 mounting holes

1.3 Features of PCA9545

- A bus switch rather than a multiplexor, so you can have any combination of ports selected
- Has hardware reset pin. This means that a fault on one segment can be cleared without blocking the multiplexor.
- IRQ inputs as well as SDA & SCL. (note that IRQ's are inputs, and are not switched)
- Performs level shifting for bus voltages as low as 1.8V
- 2.3 - 5.5V operation.
- 2nd sourced: NXP and TI
- Possible to get 3 alternative slave address versions from NXP

2 Module Details

2.1 Slave Address of 9545

Slave Address is set by JP1-1, JP1-2

Address	A0	A1
0xE0	-	-
0xE2	fitted	-
0xE4	-	fitted
0xE6	fitted	fitted

Alternative address versions of the chip are available from NXP, and could be supplied to special order. These would allow up to 12 switches or 48 downstreams per bus.

Type	Base Address
PCF9545A	0xE0
PCF9545B	0xD0
PCF9545C	0xB0

2.2 Edge Connector Pinout

The silkscreen on the bottom of the pcb shows most pin names and jumper functions.

Pin	Function	Pin	Function
1	SDA Common	11	SDA1
2	VCC In (common)	12	SCL1
3	GND	13	IRQ1 In
4	SCL Common	14	SDA2
5	IRQ Out (common)	15	SCL2
6	RST In/AUX	16	IRQ2 In
7	VCC Out	17	SDA3
8	SDA0	18	SCL3
9	SCL0	19	IRQ3 In
10	IRQ0 In	20	GND

2.3 Power On State

All switches are OFF at power up.

Standby Power Drain

For very low standby power applications you can remove the power LED.

2.4 $\overline{RESET}$ Input

Jumper 1-3 connects the external *ACTIVE LOW* $\overline{RESET}$ to the PCA9545. The external reset is connected to the SIP pads and pin 6 (AUX) of the input micromatch.

The Reset input exists because the switch is controlled by the same bus that is connected to the slaves. So if there is a fault on any downstream bus that blocks the bus, then it becomes impossible to command the switch and disconnect that segment.

2.5 IRQ inputs

The $\overline{IRQ}$ lines are not switched. They are inputs to an AND gate. If *any* $\overline{IRQ}$ input goes low, the $\overline{IRQ}$ output will go low. This allows interrupts to be sensed on disconnected bus segments.

By reading the bus switch STATUS byte you can check the individual $\overline{IRQ}$ pin states.

The $\overline{IRQ}$ lines cannot be used as CS outputs in an SPI system - they are inputs only.

If you are not using the $\overline{IRQ}$ function, then you may prefer to remove the IRQ jumper inside your I2C2PC adaptor.

2.6 Downstream VDD and Level Shifting

The module has a built in 3.3V, 200mA regulator which can be bypassed by JP2 (L1). The default is JP2 fitted, and downstream busses are at the main VDD voltage.

On Rev0 boards L1 must be removed to use the regulator. On Rev1, Jumper JP2 is used.

All downstream busses will be operating at the VDD voltage of the PCA9545. The PCA9545 acts as a level shifter, so the main bus can run at 5V and the downstream buses at 3.3V. By replacing IC2, you can use other voltages.

Isolating Downstream VDD

L2-L5 are zero ohm jumpers in series with VDD to each downstream port. You can replace them with PTC protection devices, filter inductors, or remove them completely where the device is self powered.

2.7 PCB Revisions

Rev 0

VDD selection by removing component L1 (0603 package zero ohm link)

Rev 1

Mechanical dimensions unchanged. Electrical function unchanged.

Uses TSSOP20 package IC.

VDD selection jumper JP2 fitted instead of 0603 jumper L2

3 I2C Commands

Realterm has controls for the PCA9545 on the I2C-2 tab. Select the address on the I2C tab first.

If you use the $\overline{RESET}$ pin, then the I2C2PC's CS pins can be toggled from the I2C Misc tab.

Function	Command
Read Status	`S E1 01 P`
Select 1	`S E0 01 P`
Select 2	`S E0 02 P`
Select 3	`S E0 04 P`
Select 4	`S E0 08 P`
Select All	`S E0 0F P`
Deselect All	`S E0 00 P`
Reset CS2	`O00EF O00FF`
Reset CS3	`O00DF O00FF`

3.1 Fatal Lockups from Bus Faults & Reset

In test systems, when a faulty I2C bus connected to the switch output, it can fatally lock up the system. This situation arises in test systems, where untested I2C devices are attached which have I2C bus faults such as short circuits, on the I2C pins.

What happens?

- At power on the switches are all open
- You write to the PCA9545, enabling the faulty bus
- The bus fault (eg short circuit to ground) is now connected to the I2C that controls the PCA9545
- You can no longer send commands on that bus to the PCA9545, to deselect the faulty bus.

There are only two possible ways out of this fatal lockup:

- Reset the PCA9545
- Power cycle the switch, or the whole system - this requires a power switch

The PCA9545 $\overline{RESET}$ is connected via J1-3 to pin 6 (AUX) of the input micromatch I2C connector.

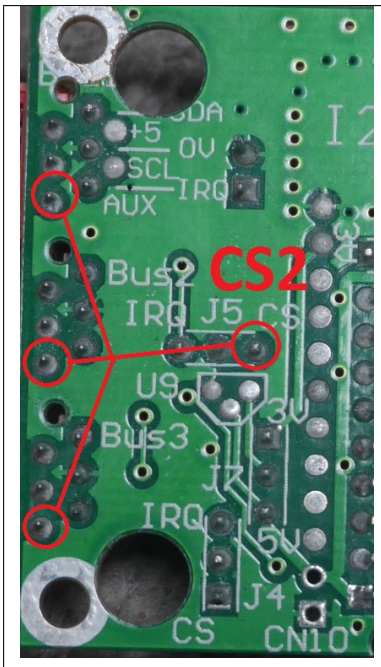
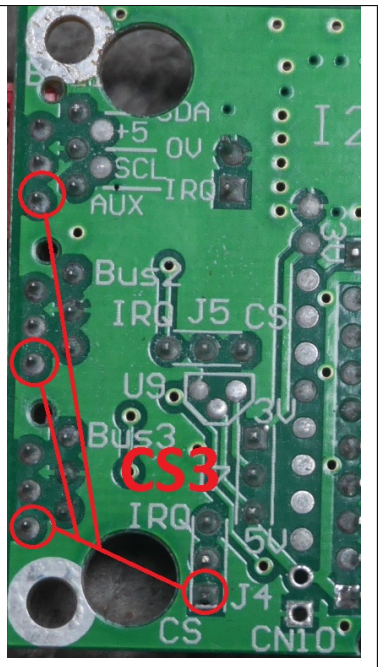
Controlling with I2C2PC

To control the Reset input from the I2C2PC adaptor you will need to modify the adaptor to link an unused control line (for example the CS2 pin), to the AUX pin (pin6) of the I2C bus connector controlling the switch.

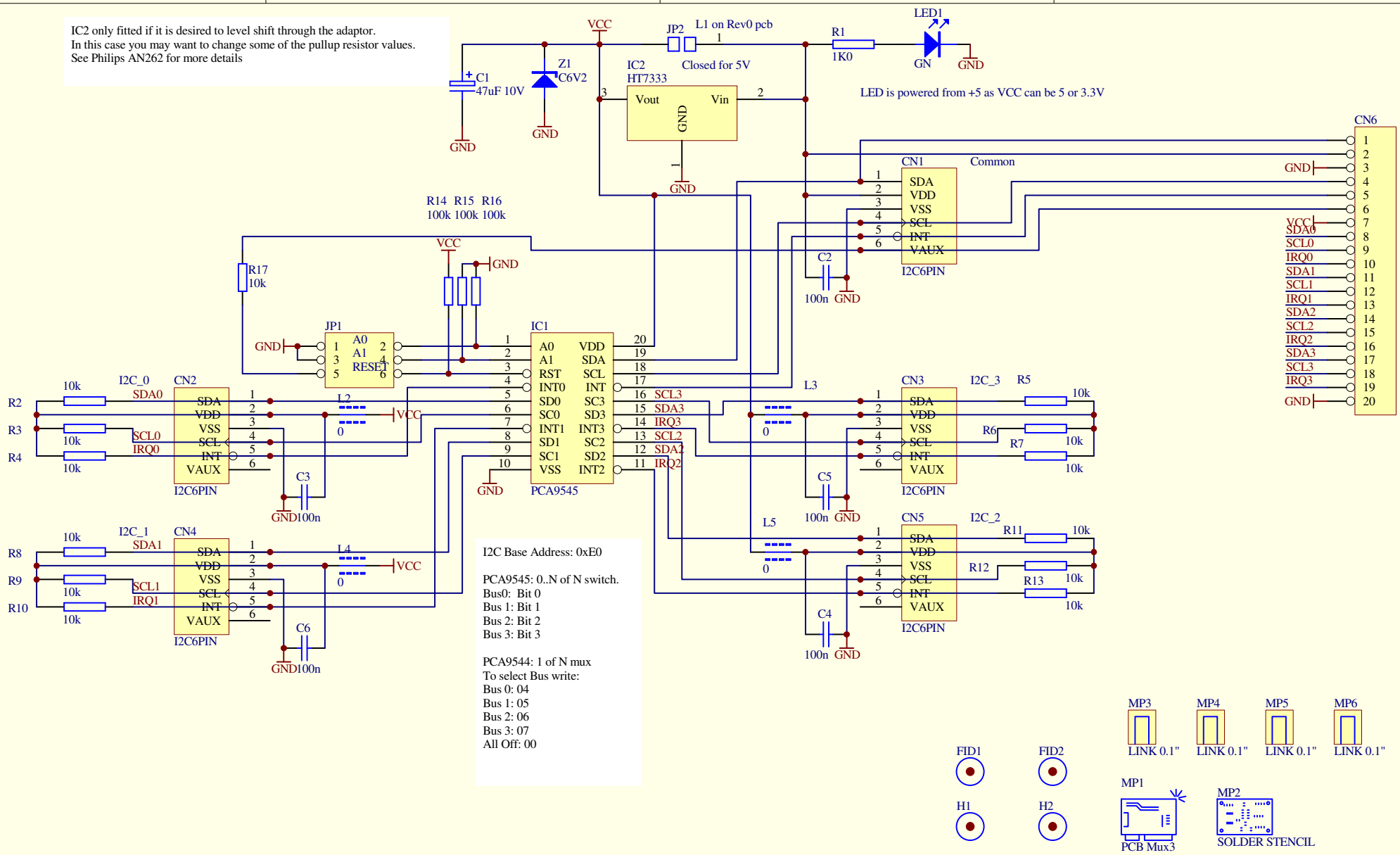
Then you control the reset line using the direct pin commands. See the BL233 datasheet and SPI application notes for more information. Realterm has buttons for controlling CS1 and CS2 pins.

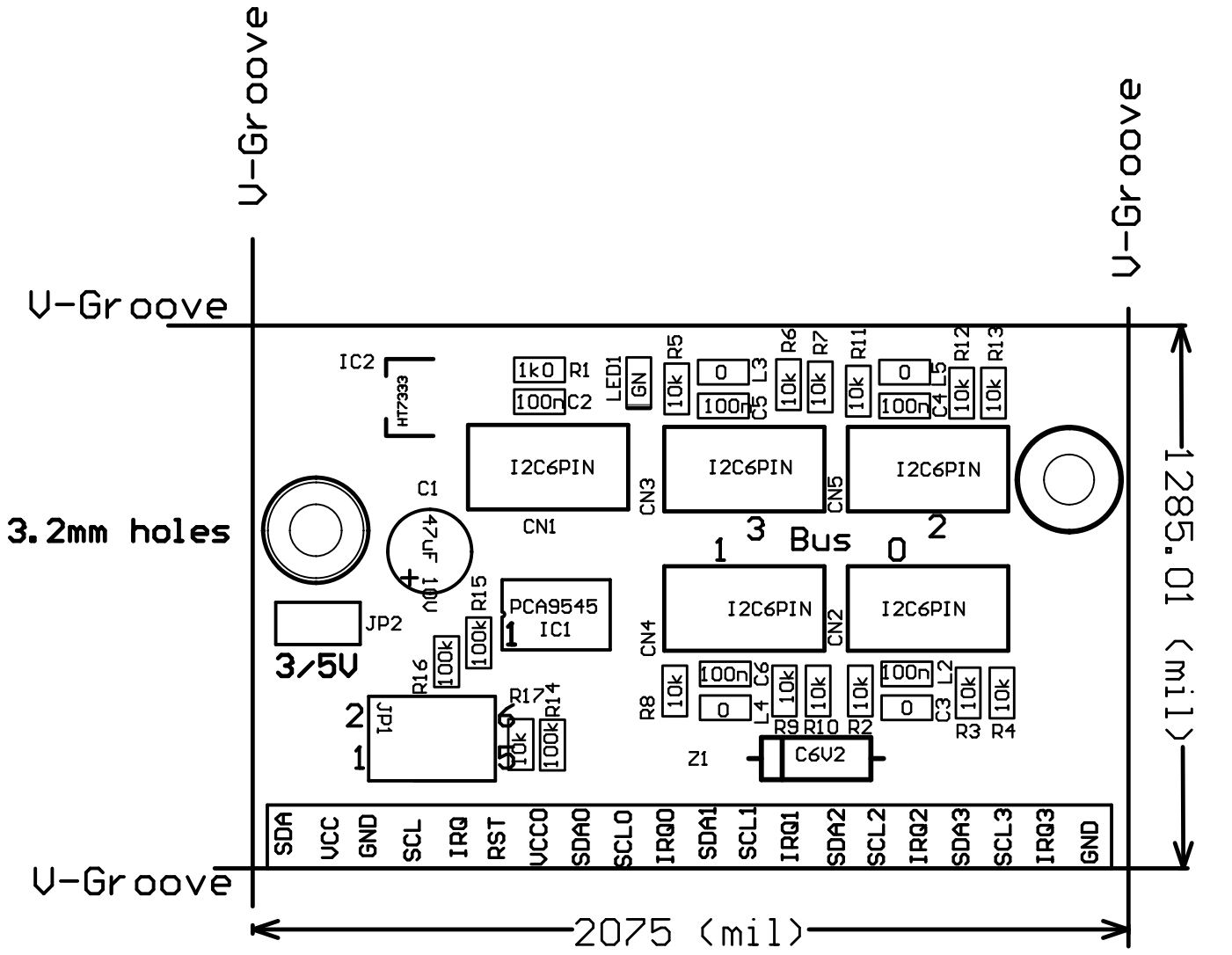
In a tests system you can either:

- detect a fault has occurred, and reset
- Use the reset command every time to deselect the buses rather than sending the select none command. This may be a more reliable approach.

Link CS2 - AUX	Link CS3 - AUX
	

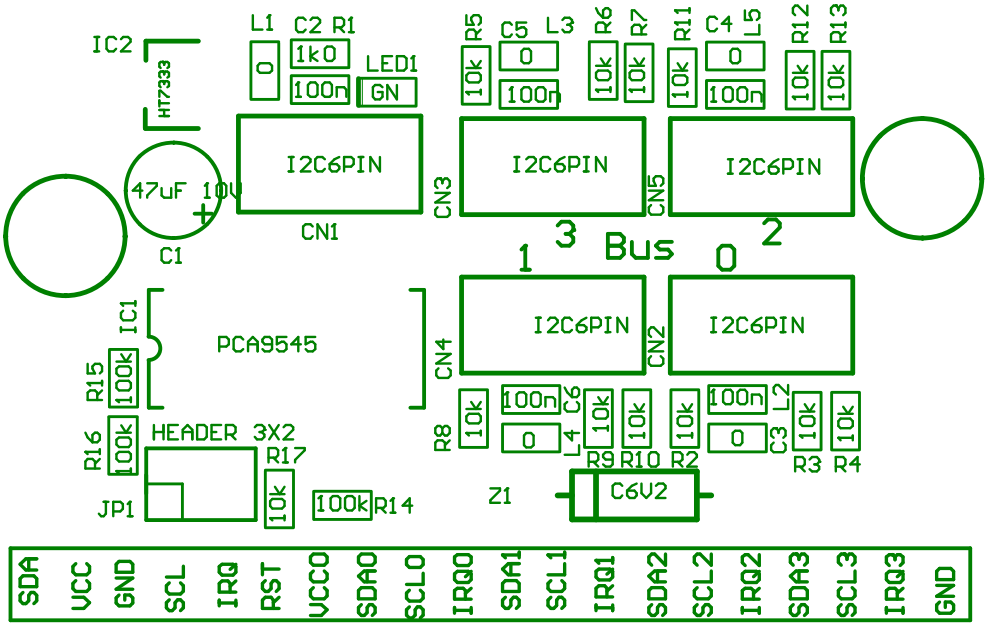
4 Schematics and Drawings

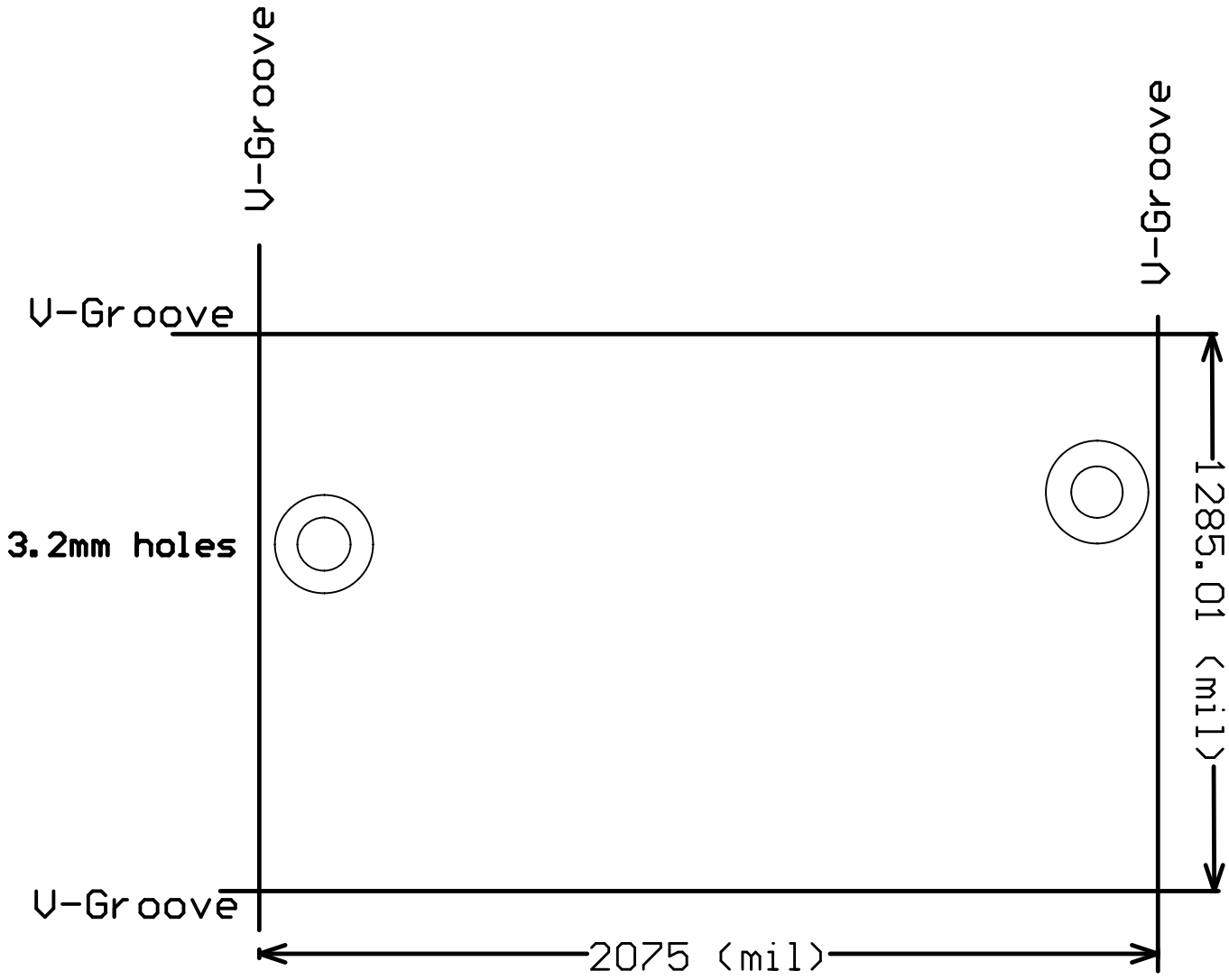

IC2 only fitted if it is desired to level shift through the adaptor.
In this case you may want to change some of the pullup resistor values.
See Philips AN262 for more details
VCC
JP2
L1 on Rev0 pcb
R1
1K0
LED1
GN
GND
C1
47uF 10V
Z1
C6V2
IC2
HT7333
Vout
Vin
GND
Closed for 5V
LED is powered from +5 as VCC can be 5 or 3.3V
CN6
CN1
Common
SDA
VDD
VSS
SCL
INT
VAUX
I2C6PIN
C2
100n
R14 R15 R16
100k 100k 100k
R17
10k
JP1
A0
A1
RESET
IC1
PCA9545
A0
A1
RST
INT0
SD0
SC0
INT1
SD1
SC1
VSS
VDD
SDA
INT
SC3
SD3
INT3
SC2
SD2
INT2
SCL3
SDA3
IRQ3
SCL2
SDA2
IRQ2
I2C_0
SDA0
SCL0
IRQ0
CN2
R2
R3
R4
10k
L2
0
C3
100n
L3
CN3
I2C_3
R5
R6
R7
C5
L5
CN5
I2C_2
R11
R12
R13
C4
I2C_1
SDA1
SCL1
IRQ1
CN4
R8
R9
R10
L4
C6
I2C Base Address: 0xE0
PCA9545: 0..N of N switch.
Bus0: Bit 0
Bus 1: Bit 1
Bus 2: Bit 2
Bus 3: Bit 3
PCA9544: 1 of N mux
To select Bus write:
Bus 0: 04
Bus 1: 05
Bus 2: 06
Bus 3: 07
All Off: 00
MP3
MP4
MP5
MP6
LINK 0.1"
FID1
FID2
H1
H2
MP1
PCB Mux3
MP2
SOLDER STENCIL
Title
Size
A4
Number
Revision
Date:
17-Oct-2007
Sheet of
File:
C:\cad\a\I2CAd\I2CAd.ddb
Drawn By:



Silk Screen: Bottom Overlay only

Plated Through Holes


IC2
HT7333
L1
C2 R1
0
1k0
100n
LED1
GN
R5
C5 L3
10k
0
100n
R6
R7
10k
10k
R11
C4 L5
10k
0
100n
R12
R13
10k
10k
I2C6PIN
CN3
I2C6PIN
CN5
I2C6PIN
47uF 10V
C1
CN1
3
Bus
1
0
2
IC1
PCA9545
CN4
I2C6PIN
CN2
I2C6PIN
R15
100k
R16
100k
HEADER 3X2
JP1
R17
10k
100k R14
R8
10k
100n
0
C6
L4
10k
10k
R9 R10
10k
100n
0
L2
C3
10k
10k
R2
R3 R4
Z1
C6V2
SDA
VCC
GND
SCL
IRQ
RST
VCC0
SDA0
SCL0
IRQ0
SDA1
SCL1
IRQ1
SDA2
SCL2
IRQ2
SDA3
SCL3
IRQ3
GND



Silk Screen: Bottom Overlay only
Plated Through Holes