# Using the Custard Pi 6 Circuit description
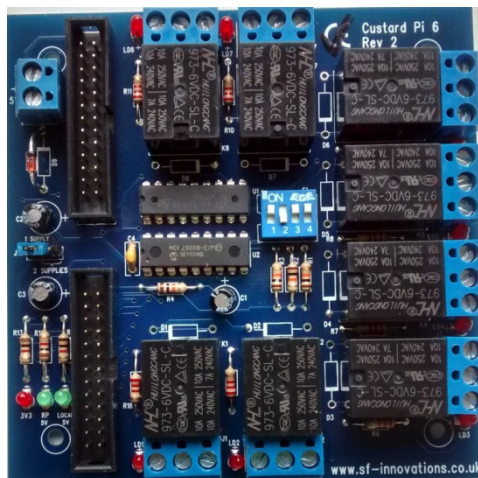## 23rd October 2019

General

This document describes the Custard Pi 6 circuit. It allows the user to get the best out of this product. The updated version of this product is driven from 5V and does not require a separate 12V supply. Both the Custard Pi 6 and the Raspberry Pi can be driven from the same 5V supply.
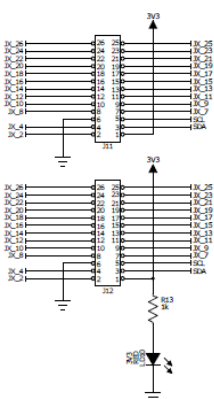
Custard Pi 6 5V V1 PCB Assembly
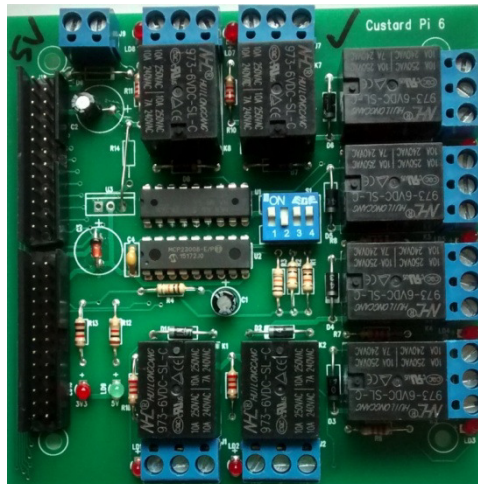

Custard Pi 6 V2 PCB Assembly

Connection to the Raspberry Pi

There are two connectors provided on the Custard Pi 6. One is for connection to the Raspberry Pi GPIO and the other is for "daisy chaining" out to either a second Custard Pi 6 PCB assembly, a Custard Pi 3 (8 input analogue card) or some other suitable accessory.

One ribbon cable is supplied with the Custard Pi 6 kit. THis ribbon cable is supplied with a 2 x 13 way connector that allows the Custard Pi 6 to be connected to a 40 pin GPIO connector as provided on the Raspberry Pi A+, B+, 2 and 3 as shown below. It is also compatible ith the 26 way GPIO provided on the older A and B models.
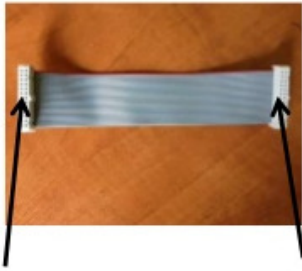
To Raspberry Pi
Notch to the right

To Custard Pi 6
Notch to the right

Two LEDs are provided. One is on the 5V rail and the other is on the 3V3 rail.

I2C interface

The MCP23008 chip is used to provide 8 ports using the I2C interface and is powered from the 3.3V rail from the GPIO bus. The benefit of using the I2C bus for this is that other than the SDA and SCL pins, the other pins on the GPIO are available to the user when the Custard Pi 6 is in use.

For example, it is possible to drive 8 Custard Pi 6's from one Raspberry Pi and control 64 relays using the I2C bus.
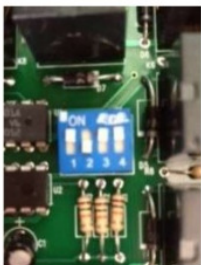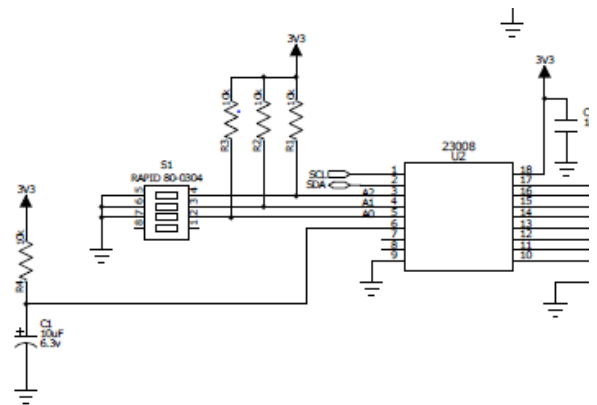
| S1 pos 2	S1 pos 3	S1 pos 4	Address
ON	ON	ON	add0
OFF	ON	ON	add1
ON	OFF	ON	add2
OFF	OFF	ON	add3
ON	ON	OFF	add4
OFF	ON	OFF	add5
ON	OFF	OFF	add6
OFF	OFF	OFF	add7

Position 1 is not used.

The 4 way DIL switch allows the user to select the I2C address. This is set as shown below.

Note: add0 to add7 refers to the addresses set in the functions supplied by SF Innovations. If writing your own I2C routines please note that these map as follows.

| add 0	ox20
add 1	ox21
add 2	0x22
add 3	0x23
add 4	0x24
add 5	0x25
add 6	0x26
add 7	0x27

Relay Driver
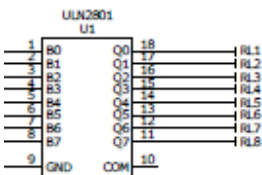
The output from the MCP23008 is not powerful enough to drive the relays directly. A ULN2801 is used as a relay driver. This has open collector darlington outputs that can sink up to 500mA.

Relay circuit
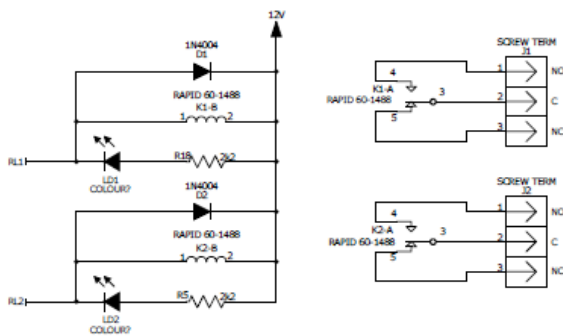
The standard Custard Pi 6 uses 12V single pole changeover relays. When a relay is switched on an LED also comes on to confirm this. A diode is provided across each relay coil to prevent high voltages being generated when the relay is switched off.

Power supply (V1)
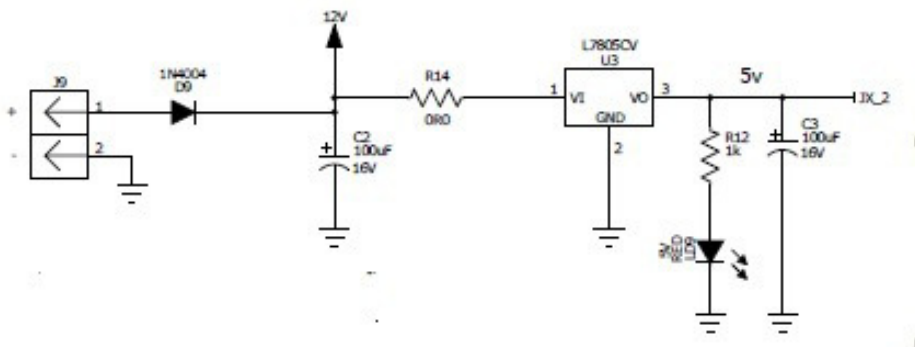
The Custard Pi 6 uses a 5V supply for the relays and the LEDs.

In the Custard Pi 6 circuit, components R14, U3, C3 are omitted and the following modifications are carried out to enable the circuit to work from a single 5V supply.

1.   Diode D9 is replaced with a short circuit link.

3.   A connection is made from one side of R14 to pin 3 of U3. (Do not fit U3)

3.   A 6V2 1.3W Zener is fitted in the position provided for C3. This will prevent the voltage from going higher than 6.2V

Connect a 5V 1 Amp supply to the Custard Pi 6 PCB using connector J9. **(Note: There is no reverse voltage protection so please make sure that this is connected correctly.)** The 5V LED will come ON. When the ribbon cable is plugged into the GPIO header of the Raspberry Pi, it should power up and supply 3.3V to the Custard Pi 6. This will in turn light up the 3.3V LED.

Power Supply (V2 from August 2016)
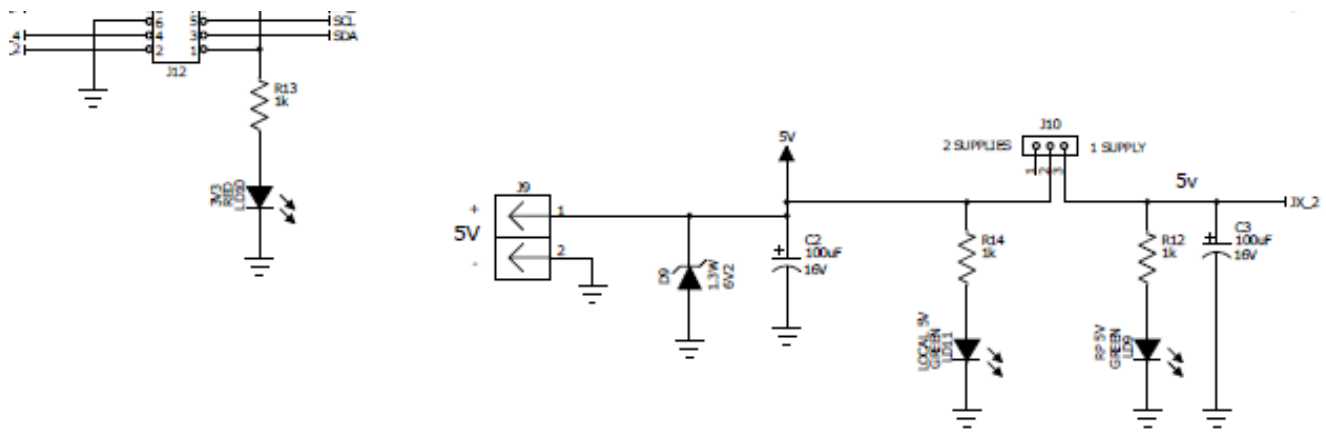
This V2 PCB makes it easier to adopt the Custard Pi 6 to different powering arrangements.

Powering Options for Custard Pi 6

When using one Custard Pi 6 this can be easily powered from the Raspberry Pi
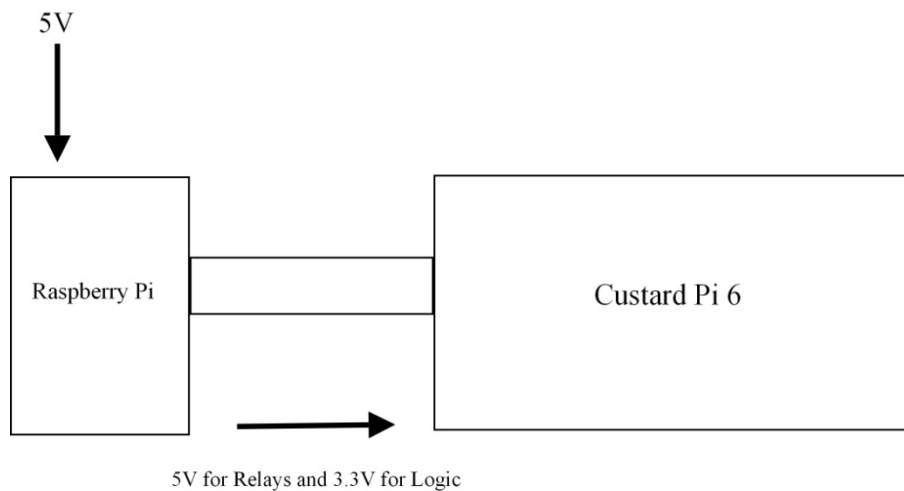
5V for Relays and 3.3V for Logic

When using the V2 PCB, make sure that the link is connected to the 1 supply position. All three LEDs should come ON when the ribbon connector is plugged in.
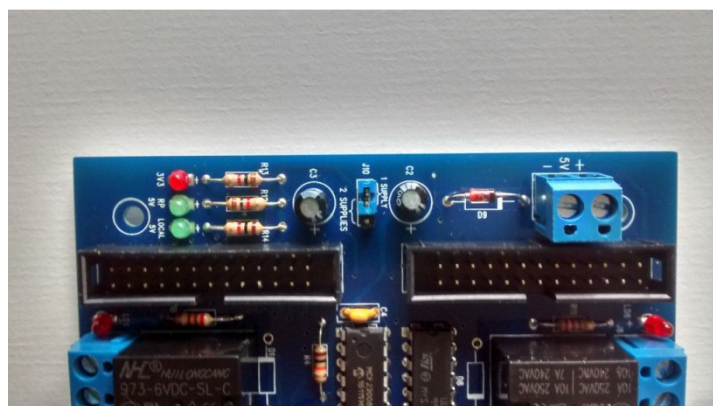
Alternatively, the Custard Pi 6 can be powered from a 5V supply which in turn will power the Raspberry Pi. (Please note: Do not connect another 5V supply to the Raspberry Pi in the configuration below).
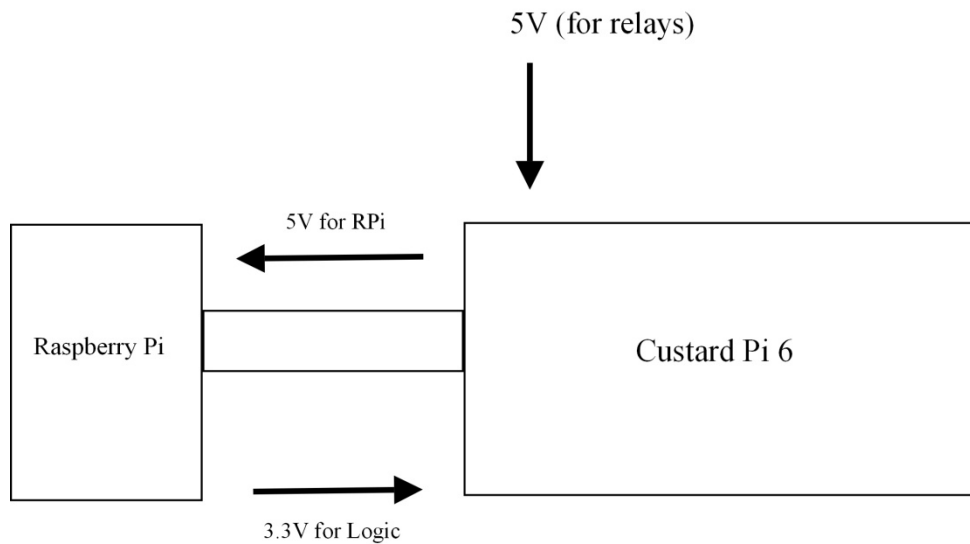
When using the V2 PCB, make sure that the link is connected to the 1 supply position. All three LEDs should come ON when the ribbon connector is plugged in.

This method should be used when 2 Custard Pi 6s are connected to the Raspberry Pi. The Raspberry Pi 5V output is current limited and will not be able to power 2 Custard Pi 6 relay cards.
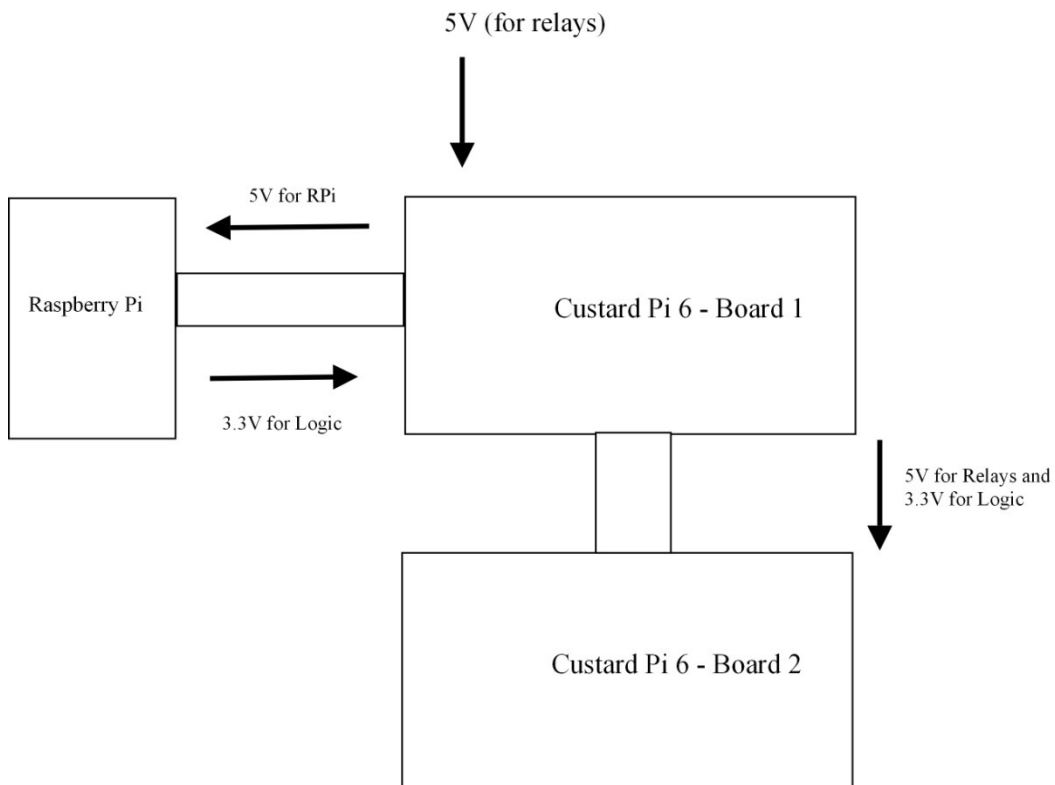
Upto 8 Custard Pi 6s can be connected to the Raspberry Pi. The user will need to set up a different I2C address for each card so it can be individually addressed. However powering 8 cards may present a problem with voltage drops along the ribbon cable. If there are problems with maintaining the 5V supply on all the cards, the configuration below will provide a solution.

The Custard Pi 6 cards are supplied with their own 5V supply which is separate from the 5V supply to the Raspberry Pi. **(Note: The link between R14 and U3 has to be snipped on each board that has it's own 5V supply to prevent a connection between these two supplies)**. When this link is snipped each Custard Pi 6 board has to have it's own connection to the 5V supply as shown below.

On the V2 Custard Pi boards, simply move the link to the "2 supplies" position.

5V

5V (for relays)

Raspberry Pi

3.3V for Logic

Snip link between R14 and U3

Custard Pi 6 - Board 1

Snip link between R14 and U3

Custard Pi 6 - Board 4

3.3V for Logic

3.3V for Logic

Snip link between R14 and U3

Custard Pi 6 - Board 2

Snip link between R14 and U3

Custard Pi 6 - Board 5

3.3V for Logic

3.3V for Logic

Snip link between R14 and U3

Custard Pi 6 - Board 3

Snip link between R14 and U3

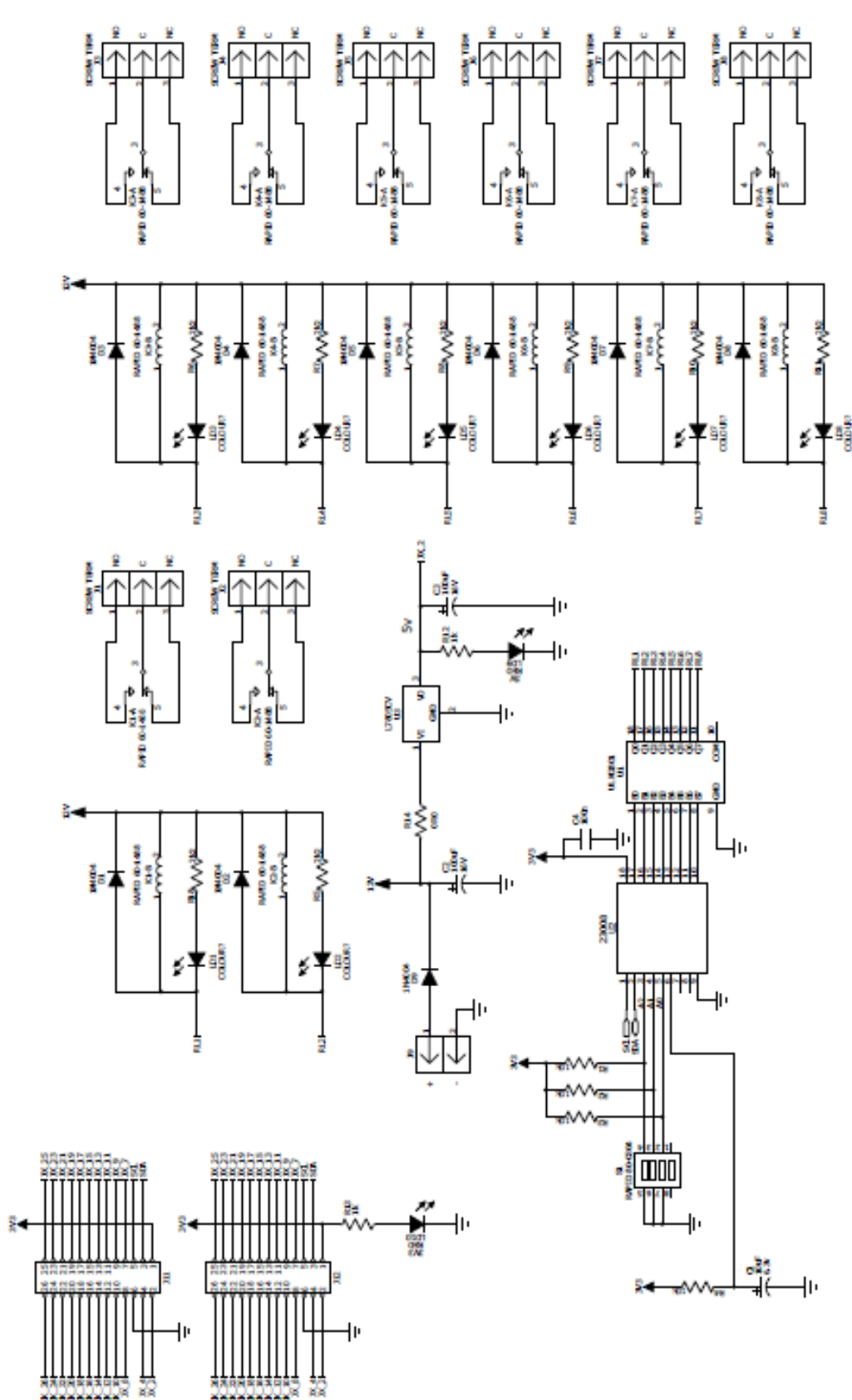Custard Pi 6 - Board 6

Custard Pi 6 V1 Parts List

This is the parts list for a V1 Custard Pi 6 with a 5V supply.

Description	Circuit reference	Notes	Picking list
Printed Circuit Board (PCB)	Custard Pi 6		
MCP23008 - 18 pin DIL IC	U2	Make sure notch on IC matches with notch on PCB	
ULN2801 - 18 pin DIL IC	U1	Make sure notch on IC matches with notch on PCB	
4 x 10k resistors	R1,2,3,4	Can be inserted either way round	
8 x 2k2 resistors	R5,6,7,8,9,10,11,18	Can be inserted either way round	
2 x 1k resistors	R12, R13	Can be inserted either way round	
8 x 1N4004 diodes	D1,2,3,4,5,6,7,8	The white line on the diode has to line up with the line on the PCB	
1 x Link	In D9 position		
9 x 3mm red LEDs	LD1,2,3,4,5,6,7,8,10	Make sure that the longer leg is inserted into hole marked +	
1 x 3mm green LED	LD9		
100 nF capacitor	C4	Can be inserted either way round	
10 uF electrolytic capacitor	C1	Make sure that the longer leg is inserted into hole marked +	
47uF electrolytic capacitor	C2	Make sure that the longer leg is inserted into hole marked +	
4 way DIL switch	S1	Align side marked 1,2,3,4 towards resistors R1,2,3.	
8 x 3-way, 5mm screw terminal block	J1,2,3,4,5,6,7,8	Make sure the wire access is facing the edge of the PCB	
2-way, 5mm screw terminal block	J9	Make sure the wire access is facing the edge of the PCB	
2 x 26 way straight boxed header	J11, J12	Slice ends off at both sides with craft knife to fit in white box on PCB. Align to notch.	
8 x 6V 10A relays	K1,2,3,4,5,6,7,8	Can only be inserted one way.	
1 x 5V6 zener	In C3 position		
1 x link	From D9/R14 junction to R12/C3 junction		
Omit components	R14, U3	For future use	

Custard Pi 6 V1 Schematic

Custard Pi 6 V2 Parts List

Description	Circuit reference	Notes
Printed Circuit Board (PCB)	Custard Pi 6	Rev 2 PCB
4 x 10k resistors	R1,2,3,4	Can be inserted either way round
8 x 2k2 resistors	R5,6,7,8,9,10,11,18	Can be inserted either way round
3 x 1k resistors	R12, 13, 14	Can be inserted either way round
MCP23008 - 18 pin DIL IC	U2	Make sure notch on IC matches with notch on PCB
ULN2803 - 18 pin DIL IC	U1	Make sure notch on IC matches with notch on PCB
9 x 3mm RED LEDs	LD1,2,3,4,5,6,7,8 LD10 (marked 3v3)	Make sure that the longer leg is inserted into hole marked +
2 x green LED	LD9 (marked RP5V) LD11 (marked Local 5V)	Make sure that the longer leg is inserted into hole marked +
3 way 0.1" pitch pin header	J10	Plug in jumper link
100 nF capacitor	C4	Can be inserted either way round
10 uF electrolytic capacitor	C1,C2, C3	Make sure that the longer leg is inserted into hole marked +
4 way DIL switch	S1	Align side marked 1,2,3,4 towards resistors R1,2,3.
8 x 3-way, 5mm screw terminal block	J1,2,3,4,5,6,7,8	Make sure the wire access is facing the edge of the PCB
2-way, 5mm screw terminal block	J9	Make sure the wire access is facing the edge of the PCB
2 x 26 way straight boxed header	J11, J12	
8 x 12V 10A relays	K1,2,3,4,5,6,7,8	Can only be inserted one way.
6V2 1.3W Zener	D9	The white line on the diode has to line up with the line on the PCB. Raise the Zener 5mm off the PCB
Insert link		Between pin10 of U1 and +ve of D8
Insert link		Between +ve of D4 and D2
9 x 1N4004 diodes **DO NOT FIT**	D1,2,3,4,5,6,7,8,9	**DO NOT FIT**

Custard Pi 6 V2 Schematic
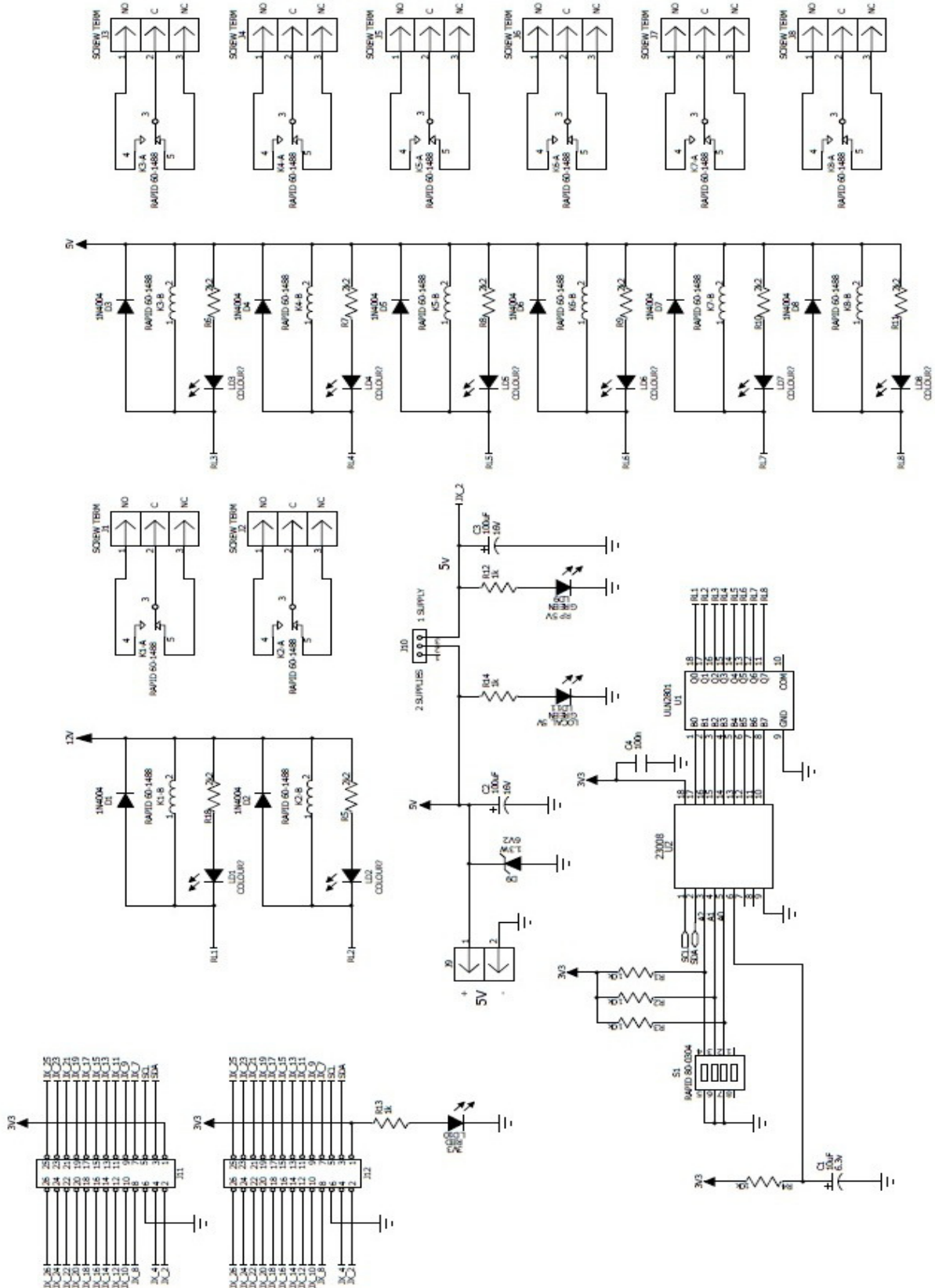
Custard Pi 6 Driver

We use the function cpi6x.py to control the Custard Pi 6. This is listed below. This function provides the user with the following features.

Addressing a particular Custard Pi 6 card

The user can use add0 through to add7 to directly control up to 8 Custard Pi 6 cards and therefore control a total of 64 relays. Earlier in this chapter we showed how to set up a CPi6 card to a particular address.

Switching a relay ON

This is done by using the 'setbit' command along with the 'ONrelay' parameter. For example, to switch on relay 7 on a Custard Pi6 set to add7, we will use the command 'cpi6x.setbit(board1, cpi6x.ONrelay7)'. The program using this command needs to set board1=cpi6x.add7 to specify a particular Custard Pi 6 board.

Switching a relay OFF

This is done in a similar way with the commands 'clrbit' and 'OFFrelay' being used instead of the 'setbit' and 'ONrelay' commands.

Switching all relays OFF

When initialising the Custard Pi 6 card the command 'alloff' is available to switch all relays OFF.

Initialising the CPi6 card

The command 'setasoutput' is used at the start of any program using this function to initialise the I2C chip.

```
#1/usr/bin/env python
import time
import smbus

#*******************************************
# Custard Pi 6 resources v2.0 9th Sept 2013

#I2C addresses
#use switch S1 on Custard Pi 6 to set the address

add0= 0x20
add1= 0x21
add2= 0x22
add3= 0x23
add4= 0x24
add5= 0x25
add6= 0x26
add7= 0x27

bus=smbus.SMBus(1)

#set IODIR register
iodir= 0x00
#set default to all off
allout= 0x00
#set GPIO register
gpio= 0x09
#set output latch
olat=0x0A

#set relay ON
ONrelay0= 0x01
ONrelay1= 0x02
```

```
ONrelay2= 0x04
ONrelay3= 0x08
ONrelay4= 0x10
ONrelay5= 0x20
ONrelay6= 0x40
ONrelay7= 0x80

#set relay OFF
OFFrelay0= 0xFE
OFFrelay1= 0xFD
OFFrelay2= 0xFB
OFFrelay3= 0xF7
OFFrelay4= 0xEF
OFFrelay5= 0xDF
OFFrelay6= 0xBF
OFFrelay7= 0x7F


def setbit(address, byte):
    #sets selected port pin
    outstatus = bus.read_byte_data(address, olat) | byte
    bus.write_byte_data(address, gpio, outstatus)

def clrbit(address, byte):
    #clears selected port pin
    outstatus = bus.read_byte_data(address, olat) & byte
    bus.write_byte_data (address, gpio, outstatus)

def setasoutput(address):
    #set all 8 bits as outputs
    bus.write_byte_data(address, iodir, allout)

def alloff(address):
    #clear all relays
    bus.write_byte_data (address, gpio, 0x00)

#*****************************************
```

Testing out the Custard Pi 6

This program sets all relays on board 1 ON and then turns them all OFF again. This is done continuously until the program is aborted by a CTRL C. When testing, please make sure that switch S1 is set correctly for add1. The program has the line 'import cpi6x' in order to use the commands available in that function.

```
#1/usr/bin/env python

import time
import cpi6x

#start program

board1=cpi6x.add1
cpi6x.setasoutput(board1)
cpi6x.alloff(board1)


while True:
    cpi6x.setbit(board1, cpi6x.ONrelay0)
    time.sleep (0.2)
    cpi6x.setbit(board1, cpi6x.ONrelay1)
    time.sleep (0.2)
    cpi6x.setbit(board1, cpi6x.ONrelay2)
    time.sleep (0.2)
    cpi6x.setbit(board1, cpi6x.ONrelay3)
    time.sleep (0.2)
```

```
        cpi6x.setbit(board1, cpi6x.ONrelay4)
        time.sleep (0.2)
        cpi6x.setbit(board1, cpi6x.ONrelay5)
        time.sleep (0.2)
        cpi6x.setbit(board1, cpi6x.ONrelay6)
        time.sleep (0.2)
        cpi6x.setbit(board1, cpi6x.ONrelay7)
        time.sleep (0.2)

        time.sleep (2.0)

        cpi6x.clrbit(board1, cpi6x.OFFrelay0)
        time.sleep (0.2)
        cpi6x.clrbit(board1, cpi6x.OFFrelay1)
        time.sleep (0.2)
        cpi6x.clrbit(board1, cpi6x.OFFrelay2)
        time.sleep (0.2)
        cpi6x.clrbit(board1, cpi6x.OFFrelay3)
        time.sleep (0.2)
        cpi6x.clrbit(board1, cpi6x.OFFrelay4)
        time.sleep (0.2)
        cpi6x.clrbit(board1, cpi6x.OFFrelay5)
        time.sleep (0.2)
        cpi6x.clrbit(board1, cpi6x.OFFrelay6)
        time.sleep (0.2)
        cpi6x.clrbit(board1, cpi6x.OFFrelay7)
        time.sleep (0.2)

        time.sleep (1.0)


import sys
sys.exit()
```

Setting up the I2C Bus

By default, the I2C bus routines are turned off in the operating system. The following steps need to be followed to enable these.

Step 1

At the command prompt type:

```
sudo nano /etc/modules
```

This uses the nano editor to make some changes to the modules file. Add the following two lines to this file

i2c-bcm2708
i2c-dev

Then save and exit the file using CTRL-x and Y.

Step 2

Make sure that you have the I2C utilities installed by executing the following two commands. The Pi will need to be connected to the Internet for this.

```
sudo apt-get install python-smbus
sudo apt-get install i2c-tools
```

If you get a 404 error do an update first:

```
sudo apt-get update
```

Note : The installation could take a few minutes to do, depend on how busy the server is.

Now add a new user to the i2c group:

```
sudo adduser pi i2c
```

Step 3

On the Raspberry Pi, the I2C and the SPI buses are usually disabled. This is done in the /etc/modprobe.d/raspi-blacklist.conf file.

If this file is not present then there is nothing to be done. Otherwise edit the file by typing the following at the command prompt.

```
sudo nano /etc/modprobe.d/raspi-blacklist.conf
```

If the I2C and the SPI is blacklisted, you will see the following commands.

blacklist spi-bcm2708
blacklist i2c-bcm2708

Insert a # in front of these to comment them out. Then save and exit the file using CTRL-x and Y. After editing the file, you will need to reboot for the changes to take effect.
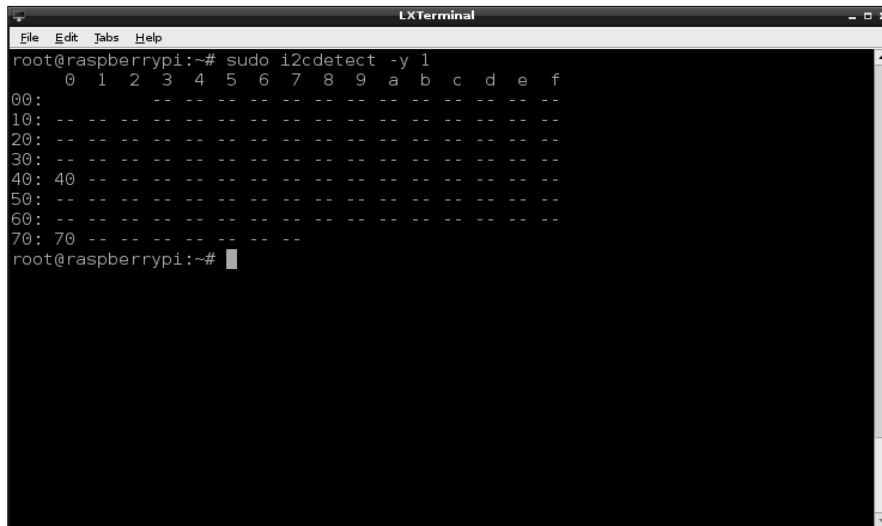
Step 4

Now we need to test if the I2C bus is working correctly. Connect up the Custard Pi 6 board (or any other I2C bus device) and run the following command.

`sudo i2cdetect -y 1` (for Rev 2 boards which uses port 1)

Or

`sudo i2cdetect -y 0` (for Rev 1 boards which uses port 0)

If everything is OK, then the I2C address of the device will be shown as on the following slide. This shows two devices with address 40 and 70 in hexadecimal code. **When connected to the Custard Pi 6, depending on the setting of the DIL switch an address between 20 and 27 will be shown.**

```
                                       LXTerminal                        _ □ ✕
 File  Edit  Tabs  Help
root@raspberrypi:~# sudo i2cdetect -y 1
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:          -- -- -- -- -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40: 40 -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70: 70 -- -- -- -- -- -- --
root@raspberrypi:~# ▊
```

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