

DATASHEET

4D SYSTEMS

TURNING TECHNOLOGY INTO ART

4DPi-32

3.2” Primary Display for the Raspberry Pi

REVISION 2.0 HARDARE

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1. Description

The 4DPi-32 (Revision 2.x Hardware) is a 3.2" Primary Display for the Raspberry Pi* A+, B+ and Pi2, which plugs directly on top and displays the primary output like what is normally sent to the HDMI or Composite output. It features an integrated Resistive Touch panel, enabling the 4DPi-32 to function with the Raspberry Pi without the need for a mouse.

Communication between the 4DPi-32 and the Raspberry Pi is interfaced with a high speed 48Mhz SPI connection, which utilises an on-board processor for direct command interpretation and SPI communication compression, and features a customised DMA enabled kernel. This combination allows this display to output 25FPS when displaying a typical image/video, and can achieve higher depending if the image can be compressed.

The 4DPi-32 is designed to work with the Raspbian Operating System running on the Raspberry Pi, as that is the official Raspberry Pi operating system.

Note*: Raspberry Pi is a trademark of the Raspberry Pi Foundation, and all references to the words 'Raspberry Pi' or the use of its logo/marks are strictly in reference to the Raspberry Pi product, and how *this* product is compatible with but is not associated with the Raspberry Pi Foundation in any way.

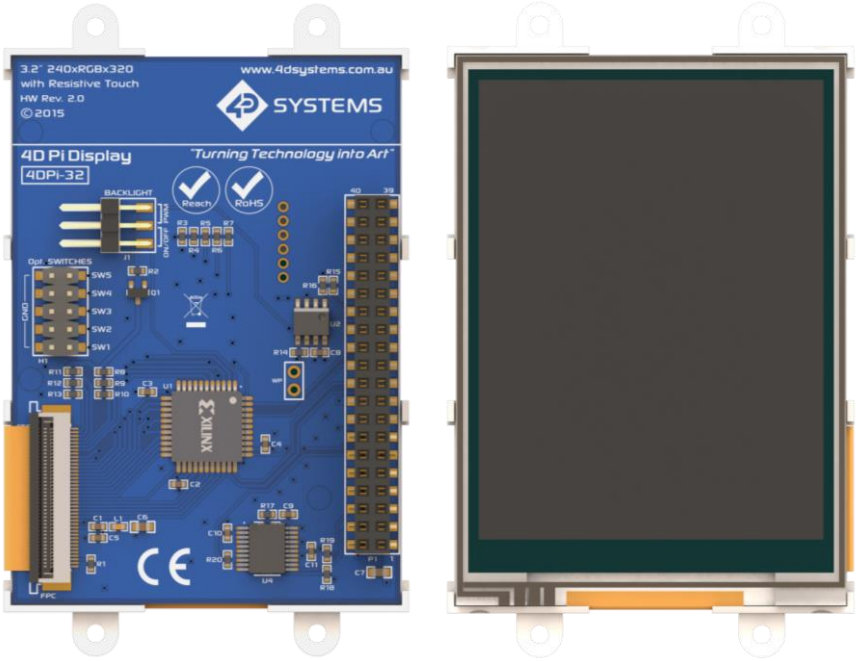
2. Features

- Universal 3.2" Primary Display for the Raspberry Pi.
- Compatible with Raspberry Pi A+, B+ and PI2. Revision 2.x hardware is not compatible with older A or B models.
- 320x240 QVGA Resolution, RGB 65K true to life colours, TFT Screen with integrated 4-wire Resistive Touch Panel.
- Display full GUI output / primary output, just like a monitor connected to the Raspberry Pi
- High Speed 48MHz SPI connection to the Raspberry Pi, featuring SPI compression technology.
- Typical frame rate of 25 Frames per second (FPS), higher if image can be compressed further by the kernel. Lower if no compression is possible.
- Powered directly off the Raspberry Pi, no external power supply is required.
- On/Off or PWM controlled backlight, selectable by on board jumper.
- On board EEPROM for board identification, following the HAT standard.
- Module dimensions: 57.3 x 92.4 x 20.5mm (including corner plates). Weighing ~ 55g.
- Display Viewing Area: 48.60 x 64.80mm
- 4x corner plates with 2.6mm holes for mechanical mounting.
- RoHS and CE Compliant.





3. Pin Configuration and Summary



P1 Pinout (Raspberry Pi Connector – FEMALE connector)			
Pin	**Symbol**	**I/O**	**Description**
1	+5V	P	+5V Supply Pin, connected to the main 5V supply of the Raspberry Pi
2	+3.3V	P	+3.3V Supply Pin, connected to the main 3.3V supply of the Raspberry Pi
3	+5V	P	+5V Supply Pin, connected to the main 5V supply of the Raspberry Pi
4	SDA1	I/O	I2C SDA1
5	GND	P	Ground Pin, connected to the main system Ground of the Raspberry Pi
6	SCL1	O	I2C SCL1
7	GPIO14	I/O	GPIO on the Raspberry Pi - **unused**
8	GPIO4	I/O	GPIO on the Raspberry Pi - **unused**
9	GPIO15	I/O	GPIO on the Raspberry Pi - **unused**
10	GND	P	Ground Pin, connected to the main system Ground of the Raspberry Pi
11	GPIO18	I/O	GPIO on the Raspberry Pi – Can be used for PWM Backlight, else **unused**
12	PENIRQ	I	Interrupt for the touchscreen controller
13	GND	P	Ground Pin, connected to the main system Ground of the Raspberry Pi
14	KEYIRQ	I	Interrupt for the push buttons
15	GPIO23	I/O	GPIO on the Raspberry Pi - **unused**
16	GPIO22	I/O	GPIO on the Raspberry Pi - **unused**
17	GPIO24	I/O	GPIO on the Raspberry Pi - **unused**
18	+3.3V	P	+3.3V Supply Pin, connected to the main 3.3V supply of the Raspberry Pi
19	GND	P	Ground Pin, connected to the main system Ground of the Raspberry Pi
20	MOSI	O	SPI MOSI Pin
21	GPIO25	I/O	GPIO on the Raspberry Pi - **unused**
22	MISO	I	SPI MISO Pin
23	SPI-CS0	O	SPI Chip Select 0 – Used for Xilinx Processor for Display, to Raspberry Pi
24	SCK	O	SPI SCK Clock Pin
25	SPI-CS1	O	SPI Chip Select 1 – **ususued**
26	GND	P	Ground Pin, connected to the main system Ground of the Raspberry Pi

Continued overleaf...

I = Input, O = Output, P = Power

P1 Pinout continued…			
Pin	**Symbol**	**I/O**	**Description**
27	ID-SC	O	I2C ID EEPROM
28	ID-SD	I/O	I2C ID EEPROM
29	GND	P	Ground Pin, connected to the main system Ground of the Raspberry Pi
30	GPIO5	I/O	GPIO on the Raspberry Pi - **unused**
31	GPIO12	I/O	GPIO on the Raspberry Pi - **unused**
32	GPIO6	I/O	GPIO on the Raspberry Pi - **unused**
33	GND	P	Ground Pin, connected to the main system Ground of the Raspberry Pi
34	GPIO13	I/O	GPIO on the Raspberry Pi - **unused**
35	GPIO16	I/O	GPIO on the Raspberry Pi - **unused**
36	GPIO19	I/O	GPIO on the Raspberry Pi - **unused**
37	GPIO20	I/O	GPIO on the Raspberry Pi - **unused**
38	GPIO26	I/O	GPIO on the Raspberry Pi - **unused**
39	GPIO21	I/O	GPIO on the Raspberry Pi - **unused**
40	GND	P	Ground Pin, connected to the main system Ground of the Raspberry Pi

I = Input, O = Output, P = Power

Note: The on board processor of the 4DPi-32 utilises one of the Chip Select (CS) pins on the Rapsberry Pi's SPI Bus (SPI-CS0). There is SPI-CS1 still available for use by the User.

Note: The on board Touch Screen Controller utilises the I2C bus (SDA1, SCL1) to communicate to the Raspberry Pi. The SPI Bus is capable of communicating with other devices also, so isn't restricted only to the 4DPi's touch controller.

4. Connecting the Display to the Pi

4.1. Hardware Connection

The 4DPi-32 is easily connected to a Raspberry Pi, by simply aligning the Female 40 way header with the Raspberry PI's Male 40 way header, and connecting them together – ensuring the aligning is correct and all pins are seated fully and correctly.

NOTE: The 4DPi-32 is supported only by the 40 way header, and therefore pressing on the touch screen may result in the 4DPi-32 moving towards the Raspberry Pi, and therefore the circuitry touching the Raspberry Pi. This could result in damage to either product if a short circuit were to occur. It is therefore highly encouraged to mount the display and attach the Pi to the mounted display.

If development is desired on the bench prior to the mounting of the display, please ensure some sort of support is provided between the 4DPi-32 and the Raspberry Pi so they do not touch inadvertently.

Included in the box is a small double sided sticky rubber pad. This is optional, however can be placed on the top of the Ethernet connector of the Raspberry Pi, to provide some support to the display.

4.2. Software Download / Installation

4D Systems has prepared a custom DMA enabled kernel for use with the Raspbian Operating System, which is available for download as a single Package. This can be installed over your existing Raspbian installation, or it can be applied over a fresh image.

If you are starting from scratch, start from Step 1, else skip to step 3 if you already have a Raspbian Image and which to apply this kernel to that. Please note, it is impossible for us to know what you have done to your Raspbian image, if you are not installing from scratch – so if you encounter issues, please try and use a fresh image to determine if possible modifications are conflicting with our kernel release.

1) Download the latest Raspbian Image from the Raspberry Pi website: http://downloads.raspberrypi.org/raspbian_latest

2) Load the Raspberry Pi image onto a SD card, using the instructions provided on the Raspberry Pi website for Linux, Mac or PC: http://www.raspberrypi.org/documentation/installation/installing-images/README.md

3) Insert the SD card into the Raspberry PI. Do not connect the 4DPi-32 yet. You will need an external monitor / keyboard / network connection, else simply a network connection to the Pi and the rest can be done over an SSH connection. Start up the Pi with at minimum an Ethernet connection connected.

4) Either log into the Raspberry Pi from your keyboard/monitor using the standard 'pi' and 'raspberry' credentials, else SSH into your raspberry PI and log in via your SSH session.

5) It is highly recommended to do an apt-get update and apt-get upgrade to ensure you are running the latest version of the kernel and firmware on your Pi, before you patch it for the 4Dpi. Especially if you are using Wheezy.

6) Once logged into your Raspberry Pi, you will need to download and install the kernel which supports the 4DPi-32. The following step requires 'root' access.

```
# sudo su
```

7) To download and install files, enter the following commands in terminal/shell /SSH to download the kernel from the 4D Systems Server:

8)
```
# wget
http://www.4dsystems.com.au/downloads/4
DPi/All/4d-hats_4-1-10_v1.0.tar.gz
# tar -xzvf 4d-hats_4-1-10_v1.0.tar.gz
-C /
```

By default the package is configured for Raspberry Pi2. To use the kernel on Raspberry Pi1, modify the content of /boot/config.txt.

```
# nano /boot/config.txt
```

Find and modify the following line:

```
kernel=kernel7_hat.img
```

change to:

```
kernel=kernel_hat.img
```

Save the changes made to /boot/config.txt.

Booting the Raspberry Pi directly to Desktop GUI is possibly by using the raspi-config tool, and selecting the option to boot directly to the GUI.

9) Shutdown the Raspberry Pi safely, and remove the power.

10) Connect the 4DPi-32 to the Raspberry Pi, and reapply power. The terminal should begin to show on the 4DPi-32, and will be ready to use once the Raspberry Pi has booted.

4.3. Calibrating the Touch Screen

Each 4DPi-32 which is shipped from the 4D Systems factory is slightly different, in the sense that each of the touch screens has a slightly different calibration. In order to get the best from your 4DPi-32, you will need to calibrate the display so it is as accurate as possible.

To calibrate the touch screen for the LDXE GUI, the xinput_calibrator is required and the following steps should be carried out. Make sure LDXE is not running before you start, quite LDXE if it is and return to the terminal prompt.

1) Delete the old calibration file, in preparation for the new one. Do this BEFORE running startx and the calibrator.

```
sudo rm /etc/X11/xorg.conf.d/99-calibration.conf
```

2) This step is to be performed via a SSH session to your Raspberry PI. If you wish to do this directly with a keyboard on the Raspberry Pi instead, skip to the next step. Enter the following two commands:

```
FRAMEBUFFER=/dev/fb1 startx &

DISPLAY=:0.0 xinput_calibrator
```

3) This step is instead of step 2, if you are using a keyboard connected to your Pi. Start the LXDE GUI using the following command:

```
FRAMEBUFFER=/dev/fb1 startx
```

4) Execute the `xinput_calibrator` command from the terminal after the LXDE GUI has started.

5) Follow the directions on the screen. Once complete you should get an output which contains information such as this:

```
Section "InputClass"
        Identifier      "calibration"
        MatchProduct    "ads7846"
        Option  "Calibration"   "119
3736 3850 174"
#         Option  "SwapAxes"      "1"
EndSection
```

6) If the /etc/X11/xorg.conf.d directory does not exist, it needs to be created manually.

```
mkdir /etc/X11/xorg.conf.d
```

7) Run the following command
`sudo nano /etc/X11/xorg.conf.d/99-calibration.conf`

Copy the information shown in step 4 into this file, save it and exit nano.

8) Restart your Raspberry Pi. You should now have a perfectly calibrated 4DPi-32.

4.4. Change the Display Orientation

To change the display orientation, simply edit the /boot/cmdline.txt file

Find the parameter:

```
4dpi.rotate = 0
```

And change this to have the value of 0, 90, 180 or 270.

Save the file and restart your Raspberry Pi.

The touch screen with automatically remap the alignment thanks to the custom kernel.

4.5. Change the SPI Freq and Compression

The 4DPi-32 can be adjusted to work with a range of SPI Frequencies and levels of compression, depending on the requirements of the end product/project.

Increasing the frequency can result in a higher Frame Rate (FPS), however will use more power and processor time.
Increasing the level of the compression can also result in a higher FPS, but may cause the display to corrupt.

By default, a SPI Frequency of 48Mhz is used, with a Compression level of 7.

The following parameters are the defaults in the /boot/cmdline.txt file, and can be edited to adjust the Frequency and Compression level.

```
4dpi.sclk=48000000
4dpi.compress=7
```

Setting compress to be 1 will enable the kernel to control the level of compression based on the frequency selected. This however is not guaranteed to have a good end result, and may require manually setting the compression level if corruption on the display is experienced.

If corruption or display anomalies occur at any given compression level, try to lower it by 1 value and check if this has improved.

Note, changing the frequency and compression require a restart of the Raspberry Pi.

4.6. Backlight Control

The backlight is controllable in two possible ways. One is using simple on/off control, which is controllable by sending a GPIO command to the on-board processor, which then turns the backlight on and off. The other is using a DMA - PWM output from the Raspberry PI and controlling the backlight brightness.

The control of the backlight is selected using the Jumper J1, but selecting either ON/OFF or DMA control. For the simple ON/OFF control GPIO18 is used.

The backlight brightness can be controlled from the terminal, or from a bash script. The following command can be used to set the backlight from 0 to 100%.

```
echo 80 > /sys/class/backlight/32-hat-pwm/brightness
```

The above will set the backlight to 80%. Simply change the 'echo 80' to be anything from 0 to 100.

To control the backlight using ON/OFF control, ensure the cmdline.txt file has been edited appropriately (and restart the Pi), place the jumper in the ON/OFF position and executing the following commands will control the backlight:

To turn the backlight off:

```
sudo echo 0 > /sys/class/backlight/32-hat/brightness
```

To turn the backlight on:

```
sudo echo 1 > /sys/class/backlight/32-hat/brightness
```

4.7. Parameters Listing

The following is a list of all the custom parameters used by the 4DPi-32.

rotate: Screen rotation 0/90/180/270 (int)
compress: SPI compression 0/1/2/3/4/5/6/7 (int)
sclk: SPI clock frequency (long)

Valid SPI Frequency values (4dpi.sclk):
Values can be almost anything. This has been tested up to 64Mhz. Common values would include 64000000 (64MHz), 48000000 (Default), 32000000, 24000000 etc.

Valid Compression values (4dpi.compress):
0 (compression off)
1 (compression on, auto set based on sclk value)
2 (lowest), 3, 4, 5, 6, 7 (highest compression)

These parameters can be set or read from the /boot/cmdline.txt file, and they can be read from the /sys/modules/4dpi/parameters directory.

For example:

```
cat /sys/modules/4dpi/parameters/rotate
```

Will display the current rotation saved.

4.8. HDMI or 4DPi Output

To switch the X Windows output being displayed on HDMI or 4DPi output, X can be launched using the following commands:

```
startx -- -layout TFT
```

```
startx -- -layout HDMI
```

Alternatively, these commands do the same thing:

```
FRAMEBUFFER=/dev/fb1 startx
```

```
Startx
```

4.9. Changing DPI output

It is possible to change the DPI output of the 4DPi the same way as other LXDE based systems.

login as pi and open terminal

```
nano .Xresources
```

Add this line:

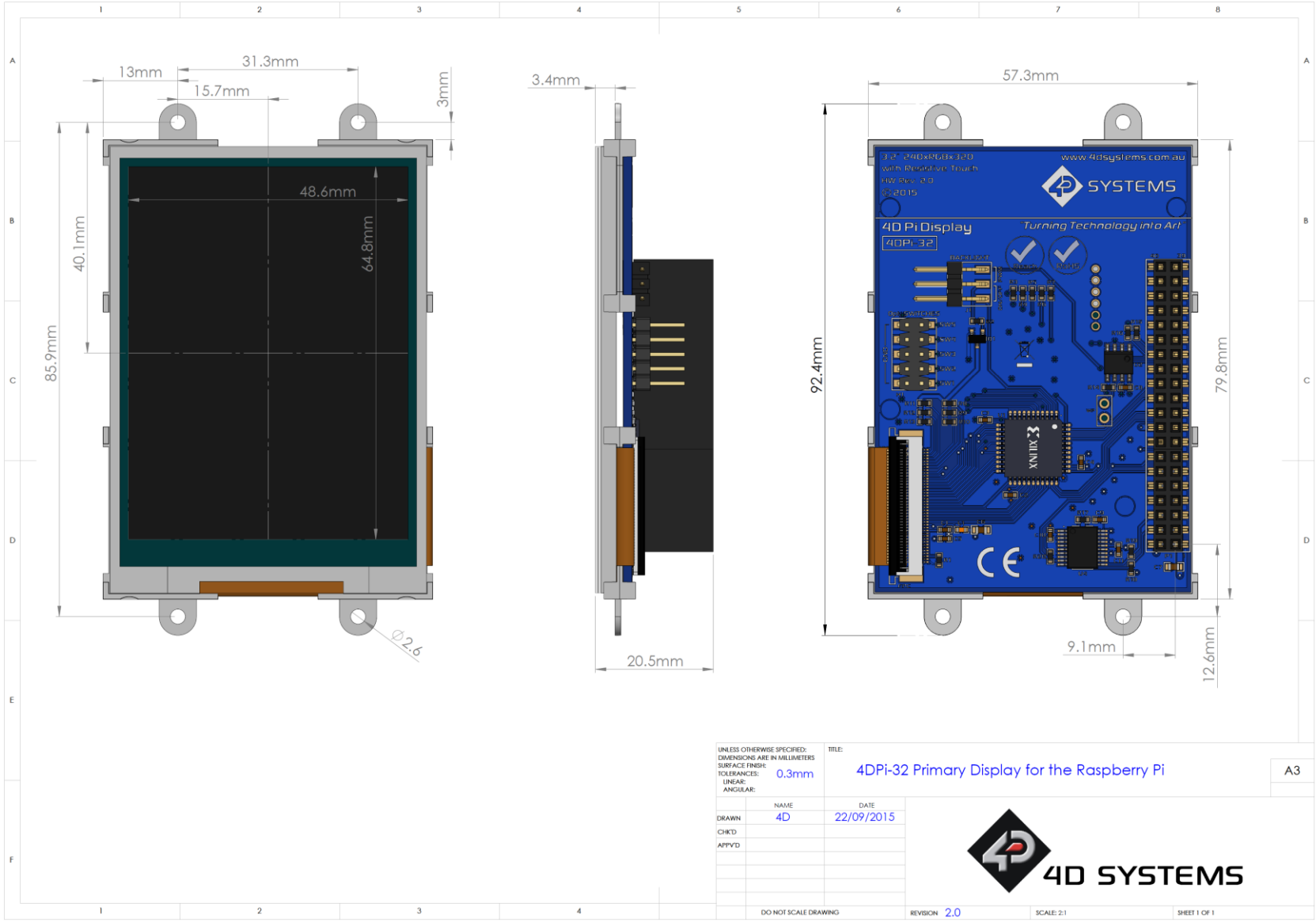
```
Xft.dpi: 75
```

reboot... This will set the DPI to be 75

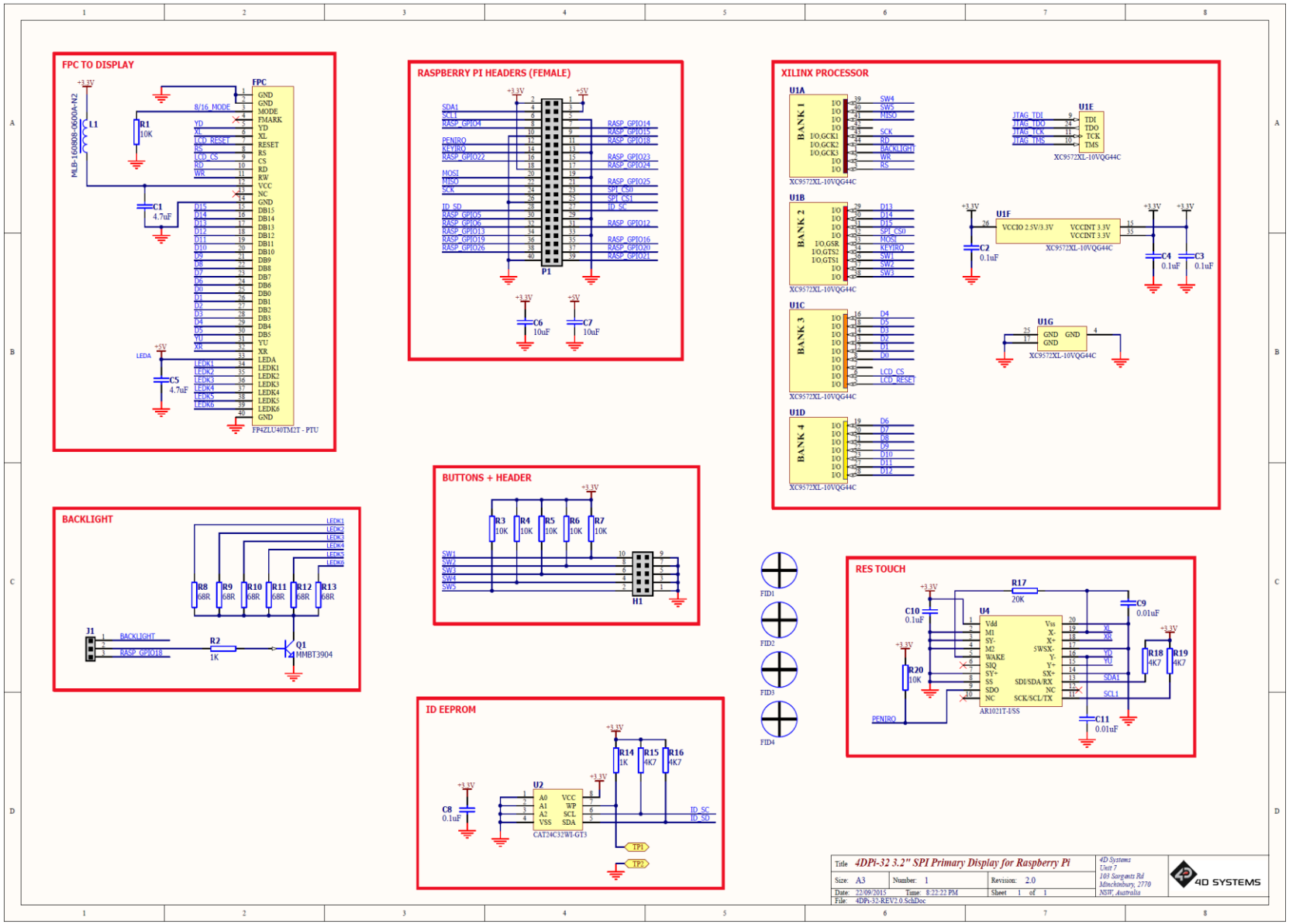
5. Notes

6. Scribble Box

7. Mechanical Details



8. Schematic Diagram



9. Specifications and Ratings

ABSOLUTE MAXIMUM RATINGS	
Operating ambient temperature	-15°C to +65°C
Storage temperature	-30°C +70°C

NOTE: Stresses above those listed here may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the recommended operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Units**
Supply Voltage (+3.3V)	Stable external supply required	3.0	3.3	4.0	V
Supply Voltage (+5V)	Stable external supply required	4.5	5.0	5.5	V
Operating Temperature		-10	--	+60	°C

GLOBAL CHARACTERISTICS BASED ON OPERATING CONDITIONS					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Units**
Supply Current (ICC)	3.3V Supply	--	100	--	mA
Backlight Current (ICC)	5V Supply	--	150	--	mA
Display Endurance	Hours of operation, measured to when display is 50% original brightness	--	20000	--	H

PERFORMANCE					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Units**
Frame Rate (FPS)	Video Playback, Full Screen, 320x240. A higher FPS can be achieved if display outputting lots of blocks of the same colour. See Section 4.5	--	25	--	FPS

ORDERING INFORMATION
Order Code: 4DPi-32 (Revision 2.x) **Packaging:** Module sealed in a 4D Systems box

10. Legal Notice

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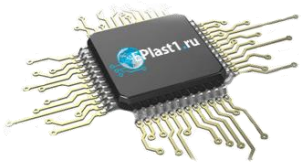
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