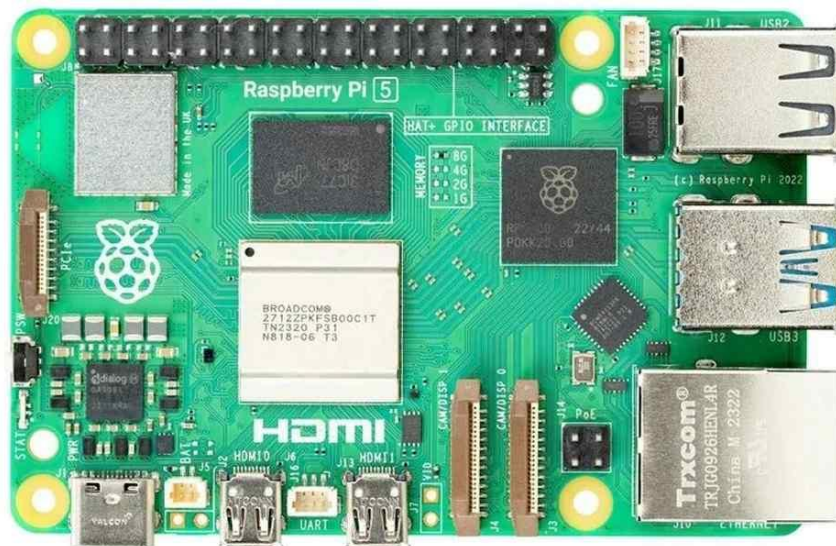# Raspberry Pi

Tutorial

Using RPi.GPIO calls on a Raspberry Pi Model 5 or Bookworm OS

Bob Rathbone Computer Consultancy

www.bobrathbone.com

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Contents

Figures

Introduction

The Raspberry Pi Model 5 was introduced at the end of 2023. It only works with **Raspberry Pi Bookworm OS** or later.

However, the biggest impact for most developers is that the **RPi.GPIO** input/output library does not work on the **Raspberry Pi model 5** or on systems running **Bookworm**. This is because the **RPi Model 5** now has a separate chip called **RP1** for controlling I/O including the pins on the GPIO header (**j8**). In the case of Bookworm, the authors of **RPi/GPIO** have apparently not yet updated their software (this will no doubt change in the future). This means that hundreds of thousands of programs or maybe even millions of programs need to be modified to use one of the newer libraries such as **gpiod** or **lgpio**. The **RP1** chip also controls USB ports, Gigabyte Ethernet, MIPI Camera Controllers and Low Speed Peripherals compatible with earlier versions of the Raspberry Pi.

My own product, the **Raspberry Pi Internet Radio** is also such a program and would have meant a lot of work to convert all the GPIO routines to say **GPIOD** which does run on the RPi Model 5. So, I decided to write a simple interface called **GPIOconverter** which converts **RPi.GPIO** calls to one of the newer GPIO interfaces. This is a so-called **software shim**. See the following link for more information: **https://en.wikipedia.org/wiki/Shim_(computing)**. **GPIOD** was advocated as the best way forward however, at the time, I found that GPIOD was poorly documented and there didn't seem to be any examples of how to handle interrupts. This has improved since. I eventually settled on using the excellent **python3-lgpio** library for the **GPIOconverter** software. The architecture of the interface is shown below:

OUTPUT: User Program --> GPIO calls --> GPIOconverter --> LGPIO

INPUT: LGPIO events --> GPIOconverter --> User Program

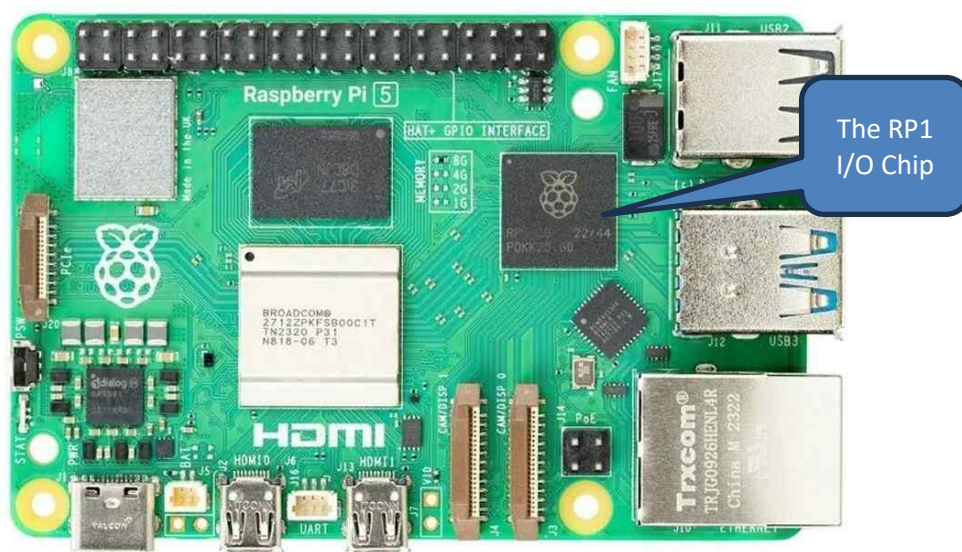The following illustration shows the location of the RPP1 I/O chip.

Figure 1 The Raspberry Pi Model 5 RP1 I/O chip

See *Appendix B - The RP1 general purpose I/O Chip* on page 14 for more information.
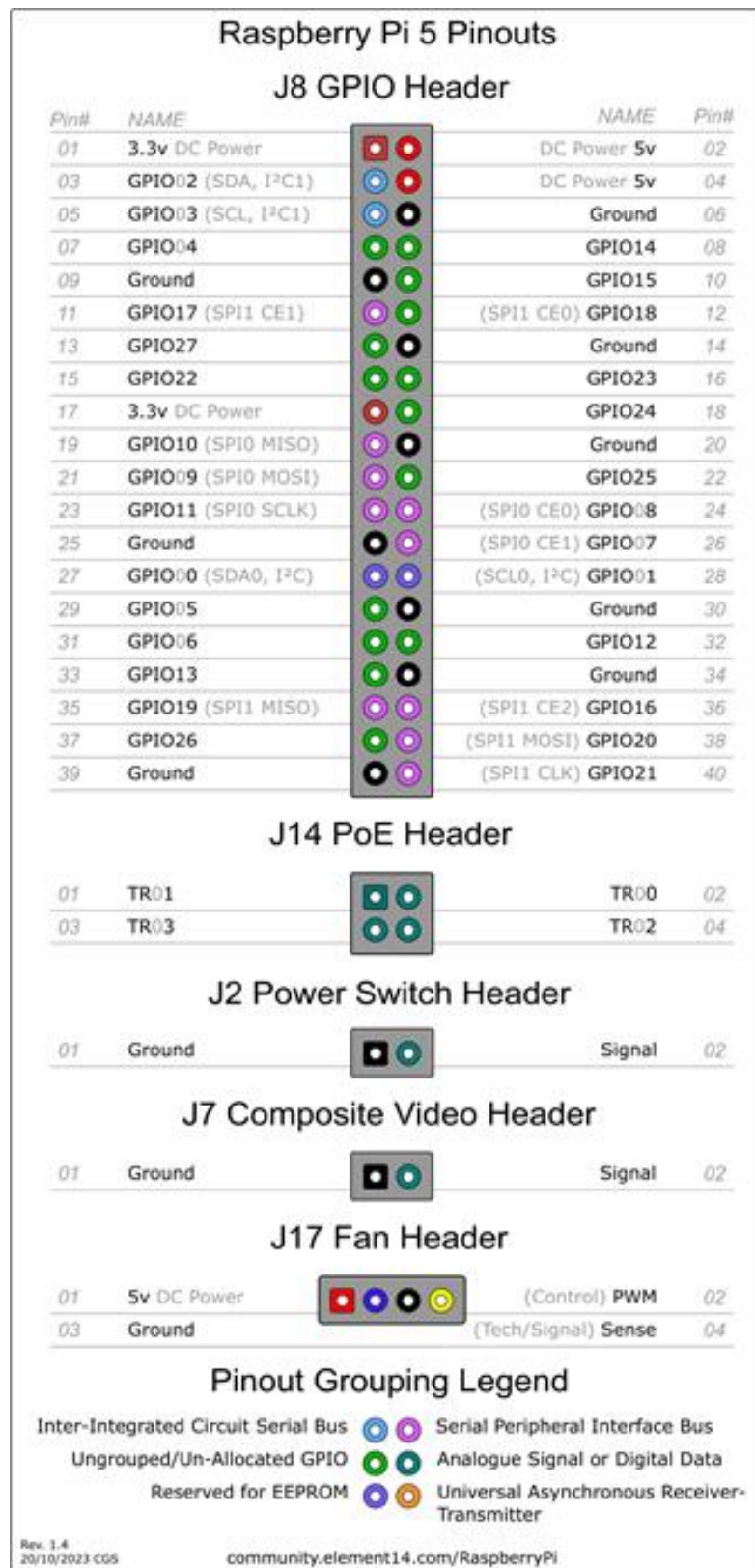
GPIO Hardware Notes

Raspberry Pi 5 Pinouts

J8 GPIO Header

Pin#	NAME			NAME	Pin#
01	3.3v DC Power			DC Power 5v	02
03	GPIO02 (SDA, I²C1)			DC Power 5v	04
05	GPIO03 (SCL, I²C1)			Ground	06
07	GPIO04			GPIO14	08
09	Ground			GPIO15	10
11	GPIO17 (SPI1 CE1)			(SPI1 CE0) GPIO18	12
13	GPIO27			Ground	14
15	GPIO22			GPIO23	16
17	3.3v DC Power			GPIO24	18
19	GPIO10 (SPI0 MISO)			Ground	20
21	GPIO09 (SPI0 MOSI)			GPIO25	22
23	GPIO11 (SPI0 SCLK)			(SPI0 CE0) GPIO08	24
25	Ground			(SPI0 CE1) GPIO07	26
27	GPIO00 (SDA0, I²C)			(SCL0, I²C) GPIO01	28
29	GPIO05			Ground	30
31	GPIO06			GPIO12	32
33	GPIO13			Ground	34
35	GPIO19 (SPI1 MISO)			(SPI1 CE2) GPIO16	36
37	GPIO26			(SPI1 MOSI) GPIO20	38
39	Ground			(SPI1 CLK) GPIO21	40

J14 PoE Header

01	TR01			TR00	02
03	TR03			TR02	04

J2 Power Switch Header

01	Ground			Signal	02

J7 Composite Video Header

01	Ground			Signal	02

J17 Fan Header

01	5v DC Power			(Control) PWM	02
03	Ground			(Tech/Signal) Sense	04

Pinout Grouping Legend

Inter-Integrated Circuit Serial Bus		Serial Peripheral Interface Bus
Ungrouped/Un-Allocated GPIO		Analogue Signal or Digital Data
Reserved for EEPROM		Universal Asynchronous Receiver-Transmitter

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Figure 2 GPIO and other Headers Information

Conventions used in this tutorial

Installation of the radio program requires you to enter lines at the command line prompt. This requires you to log into the Raspberry PI as user 'pi'. The default password is **raspberry**.

Note: Don't carry out any of the following commands just yet. They are just examples.

```
Raspberrypi login: pi
Password: raspberry
pi@raspberrypi:~$ Last login: Sun Apr  6 10:18:18 2014 from 192.168.2.100
pi@raspberrypi:~$
```

The prompt line is displayed ending with a **$** sign. The **pi@raspberrypi:~** string means user 'pi' on host machine called 'raspberrypi'. The ~ character means the user 'pi' home directory **/home/pi**. In this tutorial if you are required to do something as user **pi** then only the $ sign will be shown followed by the command as shown in the example below:

```
$ pinout
```

Some commands produce output which does not need to be shown. In such a case a ':' is used to indicate that some output has been omitted.

```
$ pinout
Description      : Raspberry Pi 5B rev 1.0
Revision         : c04170
: {Output ommited}
J8:
   3V3  (1) (2)  5V
 GPIO2  (3) (4)  5V
 GPIO3  (5) (6)  GND
 GPIO4  (7) (8)  GPIO14
   GND  (9) (10) GPIO15
GPIO17 (11) (12) GPIO18
GPIO27 (13) (14) GND
GPIO22 (15) (16) GPIO23
   3V3 (17) (18) GPIO24
GPIO10 (19) (20) GND
 GPIO9 (21) (22) GPIO25
GPIO11 (23) (24) GPIO8
   GND (25) (26) GPIO7
 GPIO0 (27) (28) GPIO1
 GPIO5 (29) (30) GND
 GPIO6 (31) (32) GPIO12
GPIO13 (33) (34) GND
GPIO19 (35) (36) GPIO16
GPIO26 (37) (38) GPIO20
   GND (39) (40) GPIO21
For further information, please refer to https://pinout.xyz/
```

END OF EXAMPLE COMMANDS.

Which OS works with my Raspberry Pi model

The following article contains a table showing which model Raspberry Pi's work with which Raspberry Pi OS: https://en.wikipedia.org/wiki/Raspberry_Pi_OS

RPi.GPIO.py

The **GPIO.py code** is only for use with the **Raspberry Pi Model 5** or for earlier models such as the **Model 3B** or **4B** which are running the **Bookworm 32-bit OS** or later. The code is designed to intercept traditional GPIO calls and convert them to LGPIO calls. See:
https://abyz.me.uk/lg/py_lgpio.html

> **NOTE:** On the **15th of March 2024** the **Raspberry Pi Foundation** released a new version of the **Bookworm** Operating System Firmware which completely broke the input functionality of the GPIO header pins on the **32-Bit** version of the OS. The **64-Bit** version is still OK at the time of writing. The error manifests itself as "Error: GPIO *nn* Failed to add edge detection" where *nn* is the GPIO number of the relevant pin. However, the **GPIO.py** program now supports the **gpiochip0** circuitry embedded in the BCM processor. Once **GPIOconverter** is enable it intercepts calls to **RPi.GPIO** and converts them to **lgpio** calls. This only works on **Bookworm** or later. Earlier versions of the OS such as **Bullseye** continue to use the legacy **RPi.GPIO** calls as normal.

Installation

There are two methods of installing **GPIOconverter** software:
1) Install as a systemwide package usually in **/usr/lib/python3/dist-packages/RPi**
2) In the project directory as your GPIO program as a local package

Method 2 means that only your local **RPi.GPIO** program(s) will be using **GPIOconverter**. All other system-wide GPIO programs will use the standard GPIO library in **/usr/lib/python3/dist-packages/RPi**

Installing GPIOconverter

There are two methods of installing GPIOconverter:

1. Installing from a ready-made package from the Bob Rathbone Web site
2. Installation to one or more local directories

Installation from the ready-made package

You can install the ready-made package from the https://bobrathbone.com Web site. Log into your Raspberry Pi and run the following.

```
sudo apt install python3-lgpio
curl -L -O
https://bobrathbone.com/raspberrypi/packages/gpioconverter_1.0_all.deb
sudo dpkg -i gpioconverter_1.0_all.deb
```

Note: The **GPIOconverter** package can only be installed on **Bookworm OS** or later and isn't required on earlier versions of the OS such as **Bullseye**.

Uninstalling GPIOconverter package

Run the following instruction:

```
$ sudo dpkg -r gpioconverter
```

Now restore the standard **RPi.GPIO library**

```
$ sudo mv /usr/lib/python3/dist-packages/RPi_standard /usr/lib/python3/dist-
packages/RPi
```

Installation to a local directory

It may well be that you only wish to install the package **GPIOconverter** software in a specific project directory leaving the rest of the system unaffected. If so, you do not need to create the package but only copy the main files to your project directory.

Create a sub-directory called RPi in the directory where your GPIO code is installed For example codein directory **/usr/share/myproject**:

```
$ cd /usr/share/myproject
$ mkdir RPi
$ cp /home/<user>/GPIOconverter/RPi/GPIO.py /usr/share/myproject/RPi/.
```

Where **<user>** is your log in name (usually 'pi')

Enabling GPIO.py

If running on a **Raspberry Pi model 5** or if running **Bookworm (32-bit)** or later. Example:

```
$ touch /usr/share/myproject/RPi/__init__.py
```

The above instruction will cause the code using the GPIO calls to see directory **RPi** as a package. For earlier models such as the 3B or 4 disable the package unless running on **Bookworm 32-bit OS** using the instruction below:

```
$ rm /usr/share/myproject/RPi/__init__.py
```

> **NOTE:** The first part of the above procedure is not necessary if you installed the software from the Debian package (**gpioconverter_1.0_all.deb**) as the installation process does this for you.

Building the GPIOconverter package

This is for developers only. The software is installed from the **GPIOconverter** package (gpioconverter_1.0_all.deb). To build it carry out the following procedure:

Install the python3-lgpio package

The **GPIOconverter** package requires the **python3-lgpio** module. Log into the Raspberry Pi and install the **python3-lgpio** package

```
$ sudo apt install python3-lgpio
```

Downloading GPIOconverter from GitHub

Now clone the **GPIOconverter** software to your home directory and run:

```
$ cd
$ git clone https://github.com/bobrathbone/GPIOconverter
```

Build the GPIOconverter package

```
$ cd GPIOconverter
$ chmod +x build.sh
$ ./build.sh
```

The build script will now create the **GPIOconverter** package. Towards the end of the build you will be asked if you wish to check the package with Lintian. This is only used by developers so - Answer n

```
Check using Lintian y/n: n
```

Installing the GPIOconverter package

At the end of the run the build script will display the instruction to install the package using **dpkg** installer as shown below:

```
Install the **gpioconverter_1.0_all.deb** package with the following
command:
sudo dpkg -i gpioconverter_1.0_all.deb
```

Known Issues

GPIO.setwarnings call limitations

The call **GPIO.setwarnings(True|False)** is currently not implemented in a compatible manner in **lgpio**. The **lgpio** package does not have the equivalent of **GPIO.setwarnings** but has the **lgpio.exceptions** call which can be set to True or False. So, the **setwarnings** call can either be ignored or be used to enable and disable **lgpio** exceptions. Set **IGNORE_WARNINGS** to **True** at the beginning of the **GPIO.py** program to prevent **lgpio exceptions** or control this with the **GPIO.setwarnings** call.

GPIO.cleanup does not clear used GPIOs

The **GPIO.cleanup()** call in the standard **RPi.GPIO** package normally clears all of GPIOs used in a run.

When using **GPIOconverter** it calls the **lgpio.gpiochip_close(chip)** routine. However **lgpio.gpiochip_close** does not clear the GPIOs used. To overcome this problem, you can call **GPIO.cleanup** with a list containing the used GPIOs as shown in the example below.

```
chan_list = [18,16,17,4]
GPIO.cleanup(chan_list)
```

Or for a single GPIO

```
GPIO.cleanup(16)
```

If you run the following this will close the I/O chip but leave the GPIOs that were used in their current state.

```
GPIO.cleanup()
```

This could be a problem if you are running say a stepper motor which might leave a winding with power on it which might lead to overheating.

Using GPIOconverter with Rotary Encoders

There is a lot of Python software for Rotary Encoders which was originally written by Ben Buxton in 2011. You may find that the Rotary Encoder is sluggish and misses a high number of turns. In the case of the Ben Buxton code this can be corrected by changing the **HALF_STEP** flag from **False** to **True**.

```
# Enable this to emit codes twice per step.
# HALF_STEP == True: emits a code at 00 and 11
# HALF_STEP == False: emits a code at 00 only
HALF_STEP     = True
STATE_TAB = HALF_TAB if HALF_STEP else FULL_TAB
```

Fortunately, the above change doesn't seem to affect operation when running the code using the standard **RPi.GPIO** calls on say a Raspberry Pi **Model 4B**.

Support

It is not possible to provide support for the standard **RPi.GPIO library** as literally hundreds of thousands of programs are using **RPi.GPIO** routines. The code is provided as is and without any warranties or "fit for purpose" etc. However, do contact bob@bobrahbone.com or raise an issue on https://github.com/bobrathbone/GPIOconverter for any errors or missing features found in the **GPIOconverter** software.

Source files

The software is stored on **GitHub** at https://github.com/bobrathbone/GPIOconverter or is available as an archive (tar) for download from: https://bobrathbone.com/raspberrypi/packages/GPIOconverter.tar.gz

The GPIO.py shim software

The **GPIO.py** file uses the Python 3 LGPIO library (python3-lgpio) to handle calls to and from the RP1 i/o chip. More information on LGPIO see: https://abyz.me.uk/lg/py_lgpio.html

Python code examples will be found at: https://abyz.me.uk/lg/examples.html#Python%20lgpio

The test_pwm.py program

The **test_pwm.py** program tests the **PWM** (Pulse-Width Modulation) function of **RPi.GPIO** which, which is a technique for creating variable-width pulses to encode or modulate a signal. PWM is used in many applications, including power supplies, DC-DC switching regulators, and DC motor control or in this case to brighten and dim a LED. To use it, amend the "led = 16" statement in the source code The test_pym.py program

First edit the **test_pwm.py** file and change the led GPIO setting to the the GPIO number you are using for the test.

```
# Change the following values to suit your system
Led = 16          # Led GPIO for mode BCM
```

Now run the program. The selected LED should brighten and dim. Press Ctrl-C to end the test.

```
cd /usr/share/myproject/RPi
./test_pwm.py
```

Note: If you are only using **GPIOconverter** in a local project directory then it is necessary to first copy **test_pwm.py** to it and run it from there as shown in the following example.

```
cd /usr/share/myproject
cp RPi/test_pwm.py .
./test_pwm.py
```

The above isn't necessary if you installed the **GPIOconverter** package as previously shown.

The test_group.py program

The **test_group.py** program is a simple test program used to test the **RPi.GPIO group** functions.

First edit the **test_group.py** file and change the list of GPIOs in **chan_list** parameter to change the GPIO list that you are using for the test.

```
chan_list = [18,16,17,4]       # Group GPIOs for mode BCM
chan_list_board = [12,36,11,7] # Group GPIOs for mode BOARD
```

If you are using mode **GPIO.BOARD** then also edit the **chan_list_board** definition. The mapping between **GPIO.BCM** and **GPIO.BOARD** will be found in the **pins** definition in **RPi.GPIO.py**

```
# pins is the mapping between GPIO.BOARD and GPIO.BCM. Format Pin:GPIO
pins = {
        3:2, 5:3, 7:4, 8:14, 10:15, 11:17, 12:18, 13:27, 15:22, 16:23,
18:24, 19:10,
        21:9, 22:25, 23:11, 24:8, 26:7, 27:0, 28:1, 29:5, 31:6, 32:12,
33:13, 35:19,
        36:16, 37:26, 38:20, 40:21,
        }
```

The program first flashes a single LED as configured by the **led** parameter and then switches alternate LEDs on and off as defined in **chan_list** and then closes the program.

Note: If you are only using **GPIOconverter** in a local project directory then it is necessary to first copy **test_group.py** to it and run it from there as shown in the following example.

```
cd /usr/share/myproject
cp RPi/group_pwm.py .
./group_pwm.py
```

The above isn't necessary if you installed the **GPIOconverter** package as previously shown.

The .gpioconverter file

In the **RPi** directory you will see a file called "**.gpioconverter**".

```
$ ls -la RPi/
:
-rw-r--r-- 1 pi pi    0 Feb 17 13:44 .gpioconverter
:
```

This file is used during package installation only to check if **GPIOconverter** has been previously installed in the **/usr/lib/python3/dist-packages** directory.

If it doesn't find this file it will know that the standard **RPi** package is still installed. It will rename the standard RPi package as **RPi-standard** and then install **GPIOconverter RPi** software in its place.

If it does find this file it will know that this is an upgrade and overwrite the contents of **/usr/lib/python3/dist-packages/RPi** with the upgrade.

Appendix A Licences

The software and documentation for this project is released under the GNU General Public Licence.

The GNU General Public License (GNU GPL or GPL) is the most widely used free software license, which guarantees end users (individuals, organizations, companies) the freedoms to use, study, share (copy), and modify the software. Software that ensures that these rights are retained is called free software. The license was originally written by Richard Stallman of the Free Software Foundation (FSF) for the GNU project.

The GPL grants the recipients of a computer program the rights of the Free Software Definition and uses *copyleft* to ensure the freedoms are preserved whenever the work is distributed, even when the work is changed or added to. The GPL is a *copyleft* license, which means that derived works can only be distributed under the same license terms. This is in distinction to permissive free software licenses, of which the BSD licenses are the standard examples. GPL was the first *copyleft* license for general use.

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The licences for the source and documentation for this project are:
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Acknowledgements

The people at https://abyz.me.uk/lg/index.html. who produced the **lgpio** package. No individuals are mentioned by name on their Web site but whoever they are, they have made an excellent product for General Purpose Input Output control on Linux Single Board Computers such as the Raspberry Pi Model 5 with extremely professional documentation. My compliments.

The GitHub member known only by the handle **fgmnts** who kindly implemented PWM support in **GPIOconverter**. See https://github.com/fgmnts

Appendix B - The RP1 general purpose I/O Chip

The RP1 general purpose I/O chip is a 12×12mm, 0.65mm-pitch BGA southbridge, which provides the majority of the I/O capabilities for Raspberry Pi 5.
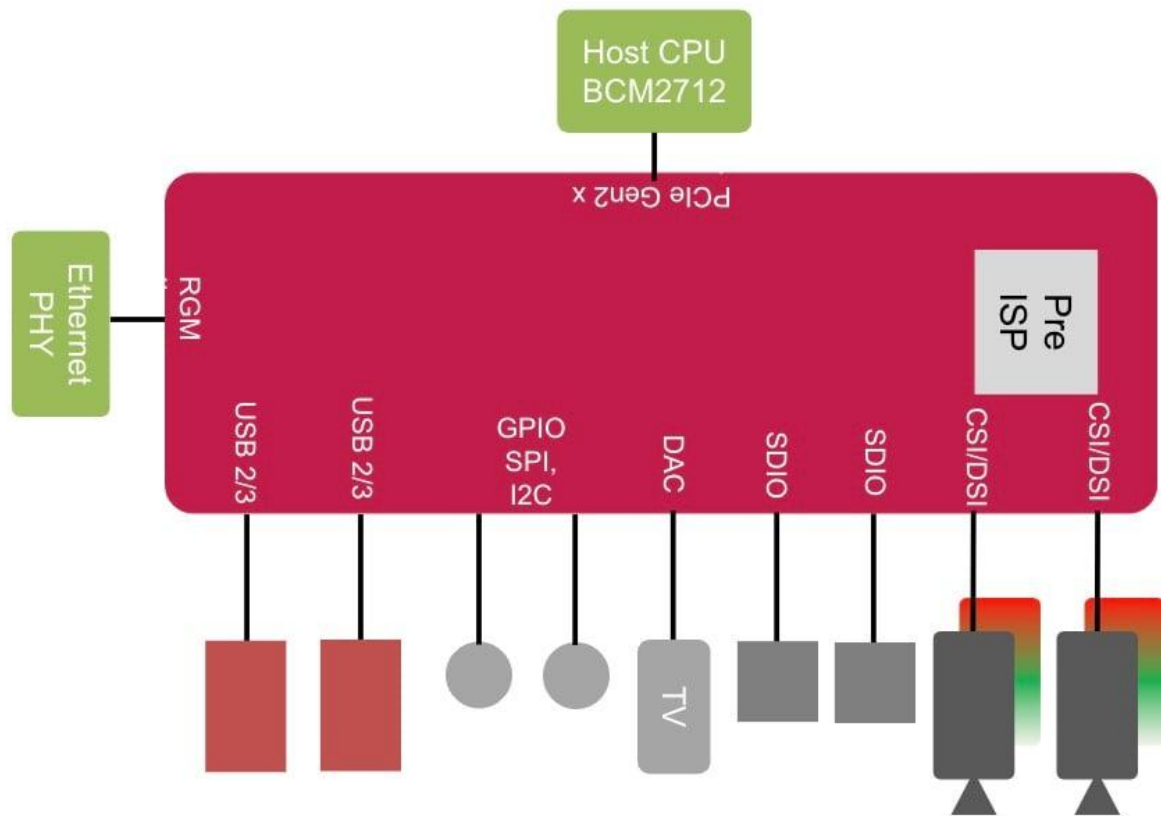

Figure 3 The RP1 General Purpose I/O Chip

The RPi chip provides:

- 4-lane PCIe 2.0 endpoint
- Gigabit Ethernet MAC
- 2× USB 3 host controllers
    - Each has 1× USB 3 and 1× USB 2 port
    - More than twice the usable USB bandwidth vs. Raspberry Pi 4
- 2× SDIO ports/eMMC (not used on Raspberry Pi 5)
- 2× MIPI transceivers (4-lane, supporting DSI and CSI-2)
- Video DAC (3-channel, supporting PAL/NTSC and VGA)
    - Only one channel (composite) used on Raspberry Pi 5
- Low-speed peripherals (SPI, UART, I2C, PWM, GPIO, I2S)
- Delta-sigma PWM audio out

More information on RP1 can be found in the RP1 Peripherals document.
See https://datasheets.raspberrypi.com/rp1/rp1-peripherals.pdf

Glossary

BGA   Ball Grid Array – A popular surface mount for Integrated Circuits (ICs)

CSI   Camera Serial Interface

DAC   Digital to Analogue Converter (In this case for audio output cards)

DSI   Display Serial Interface

GND   Ground, 0 Volts

GPIO   General Purpose IO (On the Raspberry PI)

I2C   Two-wire serial communication protocol

I2S   Electrical serial bus for connecting digital audio devices

PWM   Pulse-Width Modulation

RP1   Input Output Controller Chip for Raspberry Pi Model 5 peripherals

SPI   Serial Peripheral Interface – Interface us between digital components

USB   Universal Serial Bus