Getting started with the Raspberry Pi Build HAT

Control LEGO® Technic™ devices with Raspberry Pi

Colophon

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Introduction

The Raspberry Pi Build HAT is an add-on board that connects to the 40-pin GPIO header of your Raspberry Pi, which was designed in collaboration with LEGO® Education to make it easy to control LEGO® Technic™ motors and sensors with Raspberry Pi computers.

It provides four connectors for LEGO® Technic™ motors and sensors from the SPIKE™ Portfolio. The available sensors include a distance sensor, a colour sensor, and a versatile force sensor. The angular motors come in a range of sizes and include integrated encoders that can be queried to find their position.

The Build HAT fits all Raspberry Pi computers with a 40-pin GPIO header, including — with the addition of a ribbon cable or other extension device — Raspberry Pi 400. Connected LEGO® Technic™ devices can easily be controlled in Python, alongside standard Raspberry Pi accessories such as a camera module.

The Raspberry Pi Build HAT power supply, available separately, is designed to power both the Build HAT and Raspberry Pi computer along with all connected LEGO® Technic™ devices.

The LEGO® Education SPIKE™ Prime Set 45678 and SPIKE™ Prime Expansion Set 45681, available separately from LEGO® Education resellers, include a collection of useful elements supported by the Build HAT.

NOTE

> The HAT works with all 40-pin GPIO Raspberry Pi boards, including Raspberry Pi 4 and Raspberry Pi Zero. With the addition of a ribbon cable or other extension device, it can also be used with Raspberry Pi 400.

- Controls up to 4 LEGO® Technic™ motors and sensors included in the SPIKE™ Portfolio
- Easy-to-use Python library to control your LEGO® Technic™ devices
- Fits onto any Raspberry Pi computer with a 40-pin GPIO header
- Onboard RP2040 microcontroller manages low-level control of LEGO® Technic™ devices
- External 8V PSU available separately to power both Build HAT and Raspberry Pi

Preparing your Raspberry Pi

Raspberry Pi recommend the use of Raspberry Pi Imager to install an operating system on your SD card. You will need another computer with an SD card reader to install the image.

Using Raspberry Pi Imager

Raspberry Pi have developed a graphical SD card writing tool that works on Mac OS, Ubuntu 18.04, and Windows called Raspberry Pi Imager; this is the easiest option for most users since it will download the image automatically and install it to the SD card.

Download the latest version of Raspberry Pi Imager and install it. If you want to use Raspberry Pi Imager from a second Raspberry Pi, you can install it from a terminal using `sudo apt install rpi-imager`. Then:

- Connect an SD card reader with the SD card inside.
- Open Raspberry Pi Imager and choose the required OS from the list presented.
- Choose the SD card you wish to write your image to.
- Review your selections and click on the `Write` button to begin writing data to the SD Card.

NOTE

> If using Raspberry Pi Imager on Windows 10 with controlled folder access enabled, you will need to explicitly allow Raspberry Pi Imager permission to write the SD card. If this is not done, the imaging process will fail with a "failed to write" error.

You can now insert the SD card into the Raspberry Pi and power it up. For Raspberry Pi OS, if you need to manually log in, the default user name is `pi`, with password `raspberry`, and the default keyboard layout is set to United Kingdom (UK).

You should change the default password straight away to ensure your Raspberry Pi is secure.

Configuring the Serial Port

Once the Raspberry Pi has booted, open the Raspberry Pi Configuration tool by clicking on the Raspberry Menu button and then selecting “Preferences” and then “Raspberry Pi Configuration”.

Click on the “interfaces” tab and adjust the Serial settings as shown below:

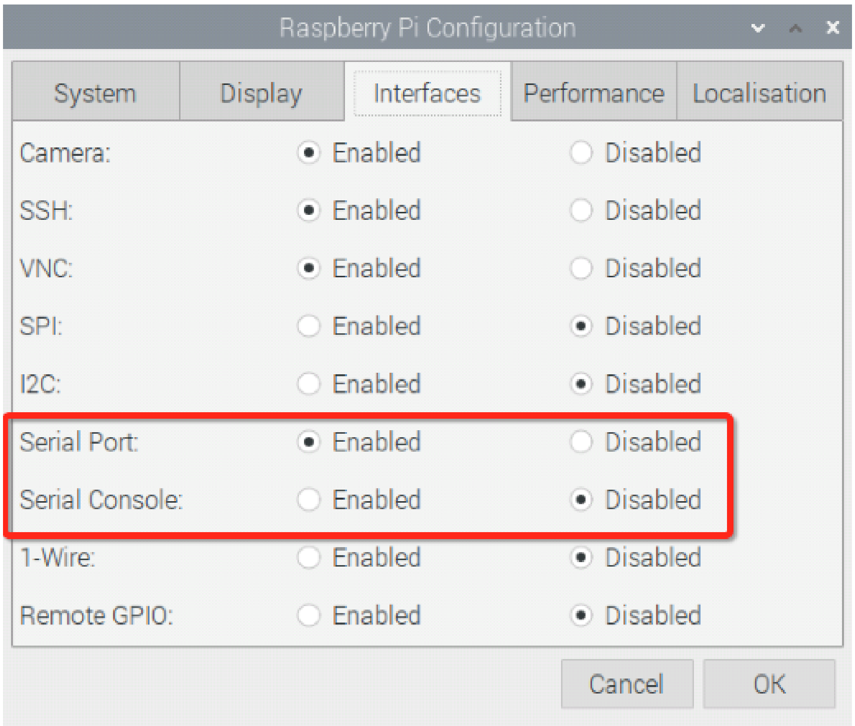


Figure 1. Configuring the serial connection to the Raspberry Pi Build HAT.

Using a Headless Raspberry Pi

If you are running your Raspberry Pi headless and using `raspi-config`, select “interface options from the first menu”.

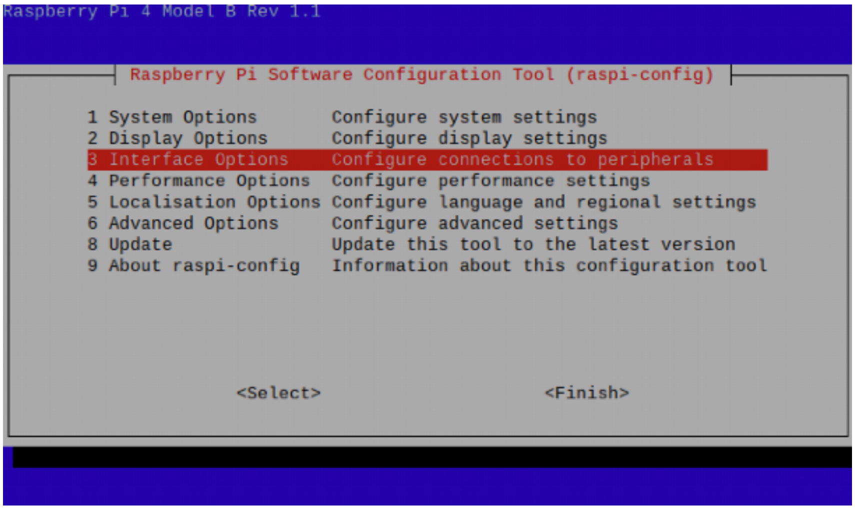


Figure 2. Configuring the serial connection to the Raspberry Pi Build HAT using `raspi-config`.

Then “P6 Serial Port”.

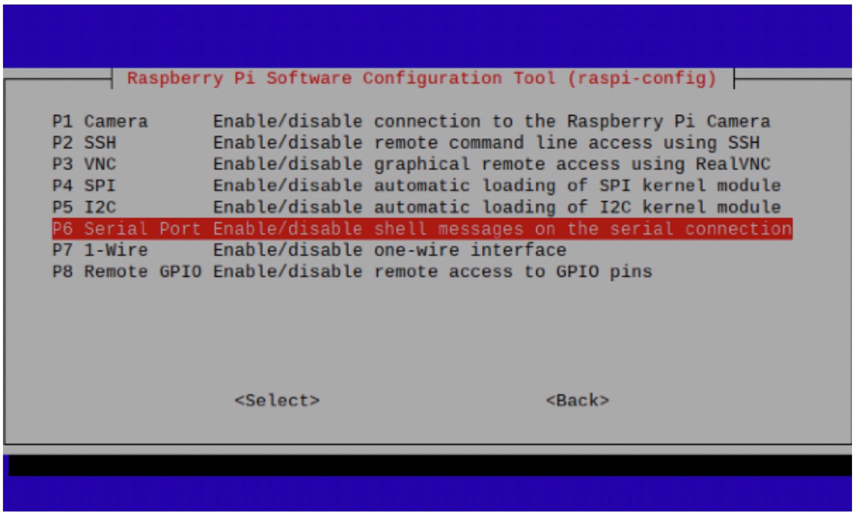


Figure 3. Configuring the serial connection to the Raspberry Pi Build HAT using `raspi-config`.

Disable the serial console:

Figure 4. Configuring the serial connection to the Raspberry Pi Build HAT using `raspi-config`.

And enable the serial port hardware.

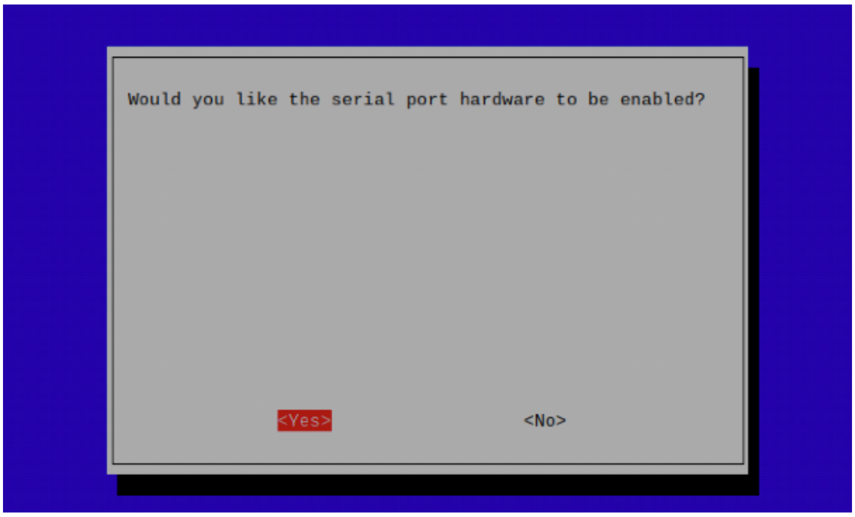


Figure 5. Configuring the serial connection to the Raspberry Pi Build HAT using `raspi-config`.

The final settings should look like this.

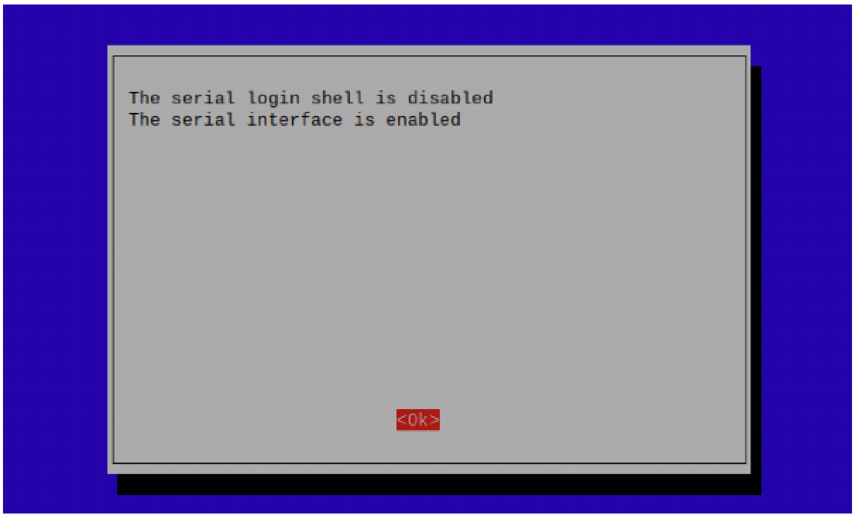


Figure 6. Configuring the serial connection to the Raspberry Pi Build HAT using `raspi-config`.

You will need to reboot at this point if you have made any changes.

Preparing the Build HAT

Attach 9mm spacers to the bottom of the board. Seat the Raspberry Pi Build HAT onto your Raspberry Pi. Make sure you put it on the right way up. Unlike other HATs, all the components are on the bottom, leaving room for a breadboard or LEGO elements on top.

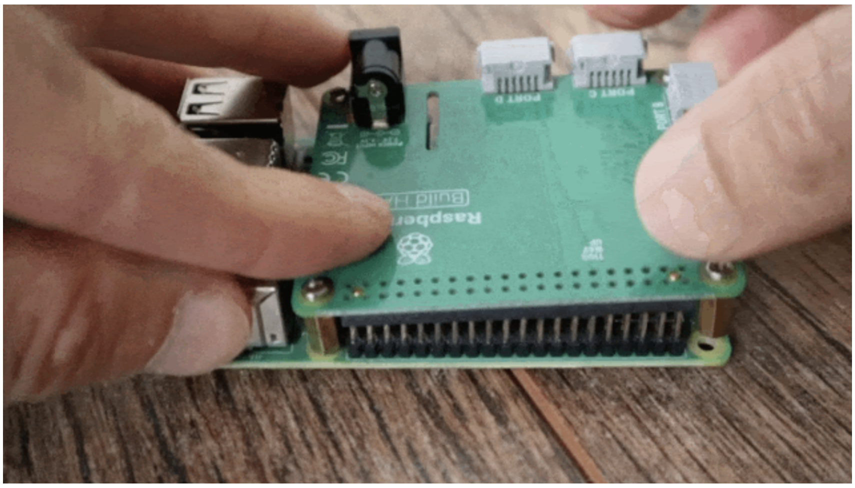


Figure 7. Fitting the Build HAT to your Raspberry Pi

Access the GPIO Pins

If you want to access the GPIO pins of the Raspberry Pi, you can add an optional tall header and use 15 mm spacers, see Figure 8.

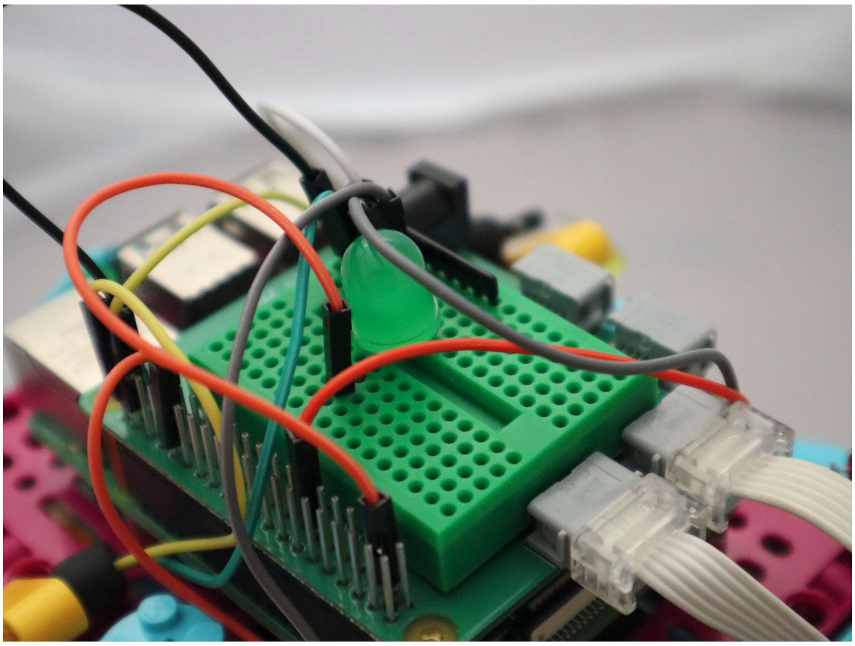


Figure 8. The Raspberry Pi Build HAT connected using the optional tall header and 15mm spacers.

The following pins are used by the Build HAT itself and you should not connect anything to them.

GPIO	Use	Status
GPIO0/1	ID prom	
GPIO4	Reset	

GPIO	Use	Status
GPIO14	Tx	
GPIO15	Rx	
GPIO16	RTS	unused
GPIO17	CTS	unused

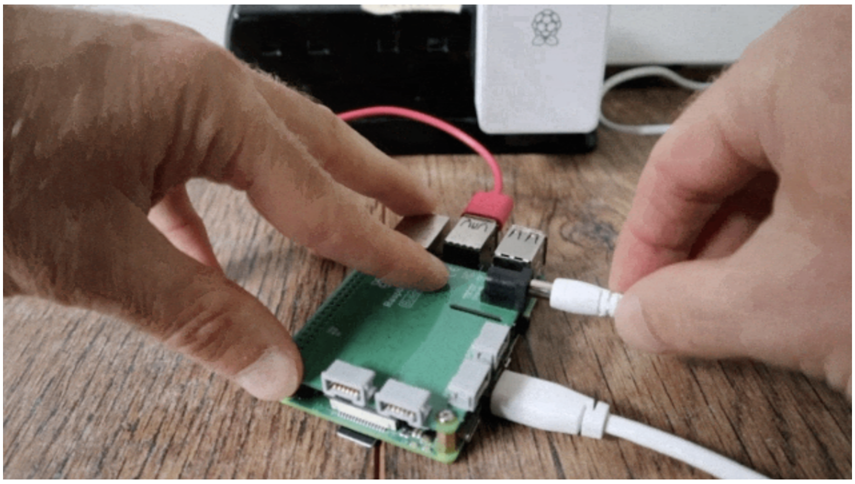
Powering the Build HAT

Connect an external power supply — the official Raspberry Pi Build HAT power supply is recommended — however any reliable +8V±10% power supply capable of supplying 48W via a 5.5mm × 2.1mm × 11mm centre positive barrel connector will power the Build HAT. You don't need to connect an additional USB power supply to the Raspberry Pi as well, unless you are using a Raspberry Pi 400.

NOTE

The Build HAT can not power the Raspberry Pi 400 as it does not support being powered via the GPIO headers.

Figure 9. Powering the Build HAT using the Raspberry Pi Build HAT power supply.



NOTE

The LEGO® Technic™ motors are very powerful; so to drive them you'll need an external 8V power supply. If you want to read from motor encoders and the SPIKE™ force sensor, you can power your Raspberry Pi and Build HAT the usual way, via your Raspberry Pi's USB power socket. The SPIKE™ colour and distance sensors, like the motors, require an external power supply.

Connecting a Motor

Connect a motor to port A on the Build HAT. The LPF2 connectors need to be inserted the correct way up. If the connector doesn't slide in easily, rotate by 180 degrees and try again.

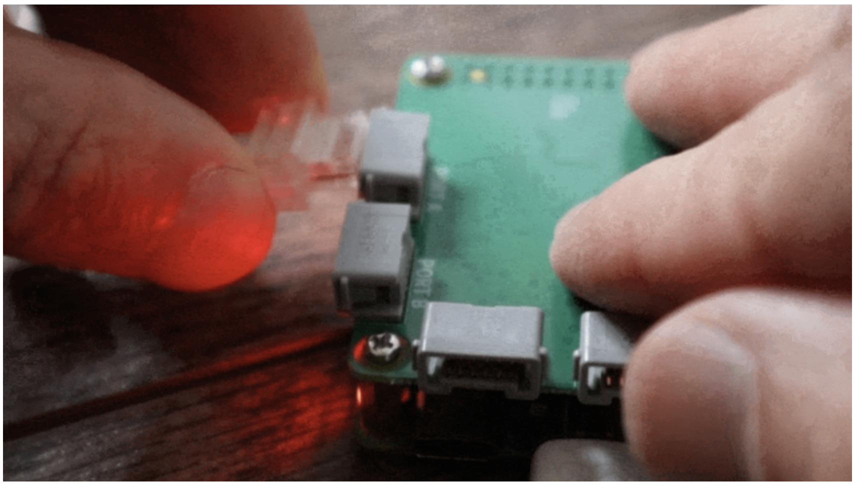


Figure 10. Connecting a motor to Port A of the Build HAT

Installing the Software

Install the Build HAT Python library. Open a Terminal window and type,

```
$ pip3 install buildhat
```

For more information about the Build HAT Python Library see https://buildhat.readthedocs.io/.

Working with Motors

Start the Thonny IDE. Add the program code below:

```
from buildhat import Motor

motor_a = Motor('A')

motor_a.run_for_seconds(5)
```

Run the program by clicking the play/run button. If this is the first time you're running a Build HAT program since the Raspberry Pi has booted, there will be a few seconds pause while the firmware is copied across to the board. You should see the red LED extinguish and the green LED illuminate. Subsequent executions of a Python program will not require this pause.

Your motor should turn clockwise for 5 seconds.

Change the final line of your program and re-run.

```
motor_a.run_for_seconds(5, speed=50)
```

The motor should now turn faster. Make another change:

```
motor_a.run_for_seconds(5, speed=-50)
```

The motor should turn in the opposite (anti-clockwise) direction

Create a new program by clicking on the plus button in Thonny. Add the code below:

```
from buildhat import Motor

motor_a = Motor('A')

While True:
    print("Position: ", motor_a.get_aposition())
```

Run the program. Grab the motor and turn the shaft. You should see the numbers printed in the Thonny REPL changing.

Working with Sensors

Connect a Colour sensor sensor to port B on the Build HAT, and a Force sensor to port C.

If you're not intending to drive a motor, then you don't need an external power supply and you can use a standard USB power supply for your Raspberry Pi.

Create another new program:

```
from signal import pause
from buildhat import ForceSensor, ColorSensor

button = ForceSensor('C')
cs = ColorSensor('B')

def handle_pressed():
    cs.on()
    print(c.get_color())

def handle_released():
    cs.off()
```

Run it and hold a coloured object (LEGO elements are ideal) in front of the colour sensor and press the Force sensor plunger. The sensor's LED should switch on and the name of the closest colour should be displayed in the thonny REPL.

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