

SparkFun Auto pHAT Hookup Guide

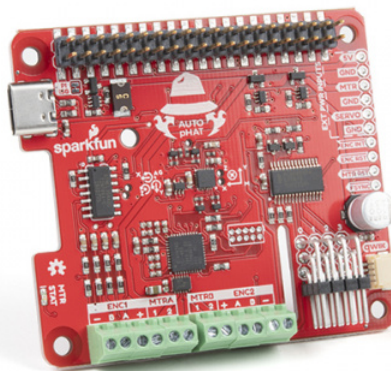
Introduction

Introducing, the Auto pHAT! The ***perfect GIF(t) to get that HAT moving...**



Source: Youtube Doris from Disney's Meet the Robinsons

Terrible pun aside, this product isn't capable of creating DOR-15 (aka Doris), but it will get you started on your robotics adventure.



SparkFun Auto pHAT for Raspberry Pi

© ROB-16328

This device combines a few of our existing products onto a single pHAT. On the Auto pHAT you will find the following components:

- 4 Channel Servo Controller
 - A 9-DoF IMU
 - USB-C Power Input
 - Qwiic Motor Driver
 - Rotary Encoder Input
 - A Qwiic connector
- There are dozens of applicable projects for this product, you can even use it to get started with your rover and robotics applications. Its limits are up to you.

Required Materials

The required materials will depend on your project. However, at minimum, users will need:

- A single board computer (SBC)
 - Must have a 40-pin Raspberry Pi compatible header
- An SD card
- Power supply (or power source)
- Additional accessories:
 - Servos
 - Motors
 - Encoders
 - Chassis and Wheels
 - Header (*optional*)
- Tools:
 - Small Flathead Screw Driver

Single Board Computers

Each of the SBCs that we offer have a unique facet that separates it from the others. There is a 40-pin Raspberry Pi compatible header on each of the SBCs.



Raspberry Pi 3 B+

○ DEV-14643



NVIDIA Jetson Nano Developer Kit (V3)

● DEV-16271



Raspberry Pi 4 Model B (4 GB)

● DEV-15447



Raspberry Pi 4 Model B (2 GB)

○ DEV-15446



Raspberry Pi 3 A+

● DEV-15139



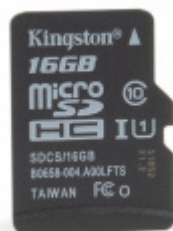
Raspberry Pi Zero W (with Headers)

○ DEV-15470

Note: When using the Raspberry Pi 4 with heat sink case, a compatible header that provides enough clearance and interfaces with the Auto pHAT is required.

SD Cards

These SD cards in our catalog are tested and known to work with all the models of the Raspberry Pi and the Jetson Nano (*excluding the NOOBS card*).



microSD Card - 16GB (Class 10)

● COM-15051



microSD Card with Adapter - 64GB (Class 10)

● COM-14833



microSD Card with Adapter - 32GB (Class 10)
● COM-14832



SparkFun Noobs Card for Raspberry Pi (16GB)
● COM-15052

Note: For first time Raspberry Pi users, we recommend using the NOOBS version as it has the required OS pre-installed.

Power Supplies

Use the appropriate power supply for the SCB you choose. The battery pack and USB-C cable are specifically for the Auto pHAT to supplement the current draw of the motor driver and servo controller.



Wall Adapter Power Supply - 5.1V DC 2.5A (USB Micro-B)
● TOL-13831



Raspberry Pi Wall Adapter Power Supply - 5.1VDC, 3.0A, 15.3W (USB-C)
● TOL-15448



Power Supply - 5V, 4A
● TOL-15352



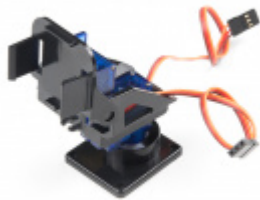
Low Current Lithium Ion Battery Pack - 2.5Ah (USB)
● TOL-15204



USB 3.1 Cable A to C - 3 Foot
● CAB-14743

Servos

The Auto pHAT has 4 available servo channels. This is perfect if for users looking to add a pan-tilt bracket for their camera, a claw, or any other servo or PWM related mechanism (like a robotic arm).



Pan/Tilt Bracket Kit (Single Attachment)
● ROB-14391



Standard Gripper Kit A - Channel Mount
● ROB-13174



Standard Gripper Kit B - Straight Mount
● ROB-13175

Chassis, Motor, and Wheels

The motor driver on the Auto pHAT has 2 H-Bridge drive channels for DC motors.



Hobby Motor - Gear

● ROB-11696



Micro Gearmotor - 90 RPM (6-12V)

● ROB-12285



Hobby Motor and Encoder Kit

● ROB-13260



Planetary Gearmotor - 140RPM

● ROB-15277

Note: Users looking to add brushless DC motors, which are usually driven by an ESC, shouldn't be using the H-Bridge. ESCs are controlled through a PWM signal and required a specific power source. The servo/PWM controller may work, but users should also consider the arming process.

Besides a motor, users will also need a chassis or some kind of structure to assemble all the components on. *You can't really call it a vehicle, if all you have is a motor.*



Robotics Shield Kit for Arduino - Parallax

● ROB-11494



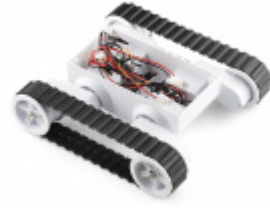
GoPiGo Beginner Starter Kit

● ROB-14801



Circular Robotics Chassis Kit (Three-Layer)

● ROB-14339



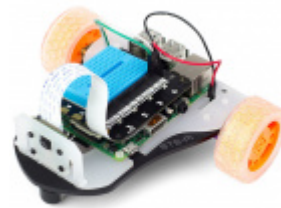
Rover 5 Robot Platform

● ROB-10336



Actobotics Kit - ActoBitty 2

○ ROB-13047



STS-Pi - Build a Roving Robot!

○ DEV-15735

Wheels... these are pretty self explanatory. *If you don't have them, then you can't get rolling (or tracks for "traction").*



Wheel - 65mm (Rubber Tire, Pair)

● ROB-13259



Mecanum Wheels - 65mm, LEGO Compatible (4 Pack)

● ROB-15536

Header

This is an optional item. For users looking to stack HATs, a header might be required for additional clearance between boards or components.

Note: Unfortunately, at this time, we do not have a compatible header. However, we are working on it. Users shouldn't use the Raspberry Pi GPIO Tall Header, as the (male) pins on the header aren't quite long enough

to reach into the (female) socket on the Auto pHAT.

Screw Driver

To tighten and loosen the screw terminals, users will need a small flathead screw driver. The head will need to be ~1.5mm; anything around 2mm will most likely be too large.



Tool Kit - Screwdriver and Bit Set

● TOL-10865



Magnetic Screwdriver Set (20 Piece)

● TOL-15003



iFixit Essential Electronics Toolkit

○ TOL-15256



Electric Hobby Screwdriver Set

● TOL-15548

ADDITIONAL ACCESSORIES

Click the button above to toggle a list of additional accessories that are available from our catalog.

Suggested Reading

Note: First time Raspberry Pi users should also head over to the Raspberry Pi Foundation website and check out their quickstart guides:

- Blog Post: Getting started with your Raspberry Pi
- Raspberry Pi Foundation Getting Stared Guides:
 - Getting started with Raspberry Pi Tutorial
 - Setting up your Raspberry Pi Tutorial
- MagPi Books and Guides:
 - Article: Get started with your new Raspberry Pi
 - The Official Raspberry Pi Beginner's Book (*December 2017*)
 - Get Started with Raspberry Pi (*November 2019*)

- The Official Raspberry Pi Beginner's Guide: How to use your new computer
 - 1st Edition (*December 2018*)
 - 2nd Edition (*June 2019*)
 - 3rd Edition (*November 2019*)

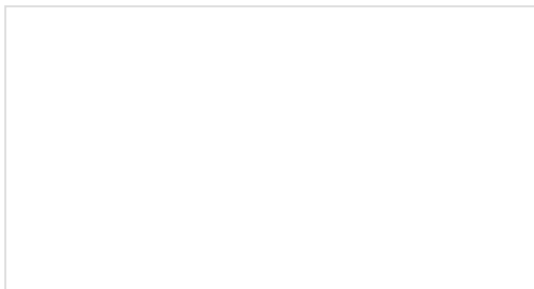
We have also listed a few additional resources for users to familiarize themselves with the Raspberry Pi:

- Using your Raspberry Pi Tutorial
- Documentation:
 - Setup Documentation
 - Installation Documentation
 - Raspbian Documentation
 - SD card Documentation

Note: First time Nvidia Jetson Nano users should also head over to the Nvidia website and check out their guides and tutorials:

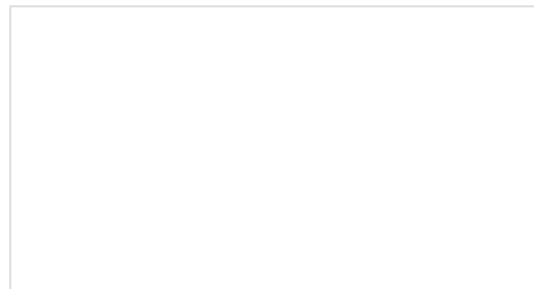
- Support Resources
 - Jetson Nano Getting Started Guide
 - Jetson Download Center
 - Nvidia Jetson Tutorials
 - Jetpack Software Documentation
 - Jetson FAQ
 - Wiki: Nvidia Jetson
 - Wiki: Jetson Nano
- User Manuals:
 - Jetson Nano Developer Kit: User Manual

Below are some of our related tutorials that may be of interest to beginners:



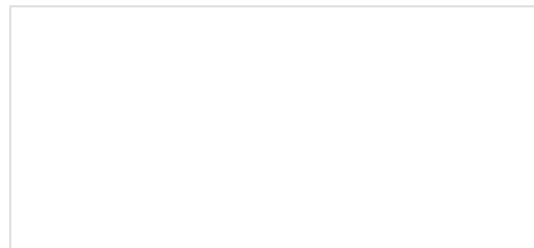
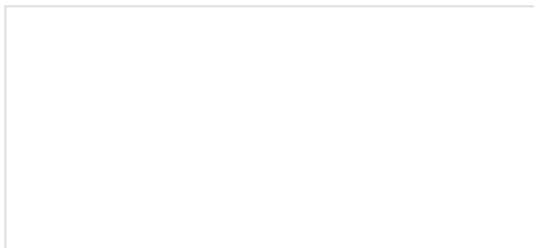
Logic Levels

Learn the difference between 3.3V and 5V devices and logic levels.



I2C


An introduction to I2C, one of the main embedded communications protocols in use today.





Serial Terminal Basics

This tutorial will show you how to communicate with your serial devices using a variety of terminal emulator applications.



SD Cards and Writing Images

How to upload images to an SD card for Raspberry Pi, PCDuino, or your favorite SBC.



Raspberry Pi SPI and I2C Tutorial

Learn how to use serial I2C and SPI buses on your Raspberry Pi using the wiringPi I/O library for C/C++ and spidev/smbus for Python.



Headless Raspberry Pi Setup

Configure a Raspberry Pi without a keyboard, mouse, or monitor.



Python Programming Tutorial: Getting Started with the Raspberry Pi

This guide will show you how to write programs on your Raspberry Pi using Python to control hardware.



How to Use Remote Desktop on the Raspberry Pi with VNC

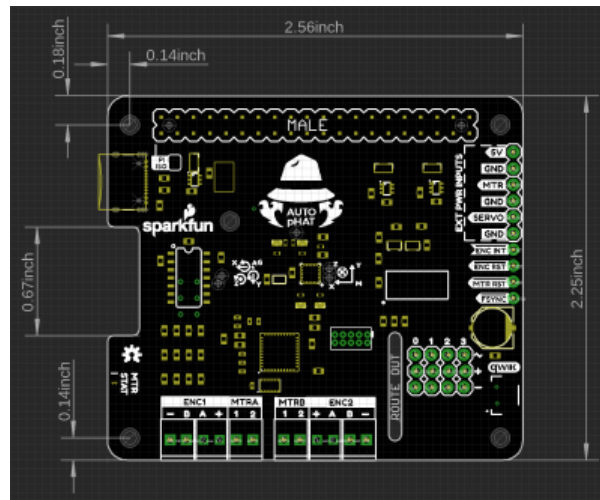
Use RealVNC to connect to your Raspberry Pi to control the graphical desktop remotely across the network.

Hardware Overview

Below, is an overview of the major hardware components on the Auto pHAT.

Dimensions

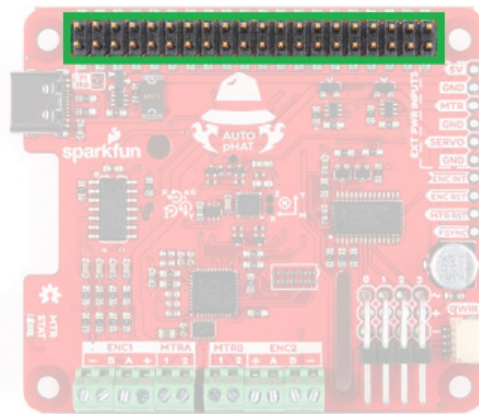
The overall dimensions of the Auto pHAT are 57mm x 65mm. For more details, users can check out the layout in the Eagle files. The board also features two cut-outs for the camera and display ribbon connections.



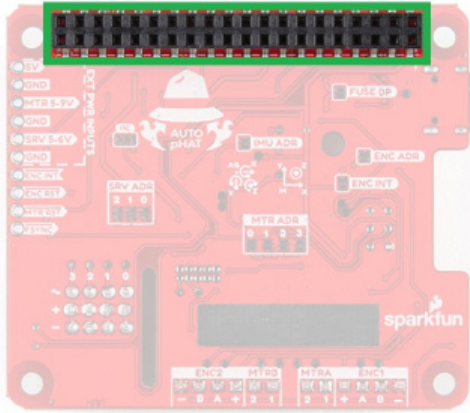
Dimensions of the Auto pHAT. (Click to enlarge)

GPIO Connections

As the Auto pHAT is also intended to integrate with other HATs, it is important to know all of the pins being utilized by the hardware on the Auto pHAT. (*Click the following links, for more information on the GPIO mapping of the Raspberry Pi or Jetson Nano.)

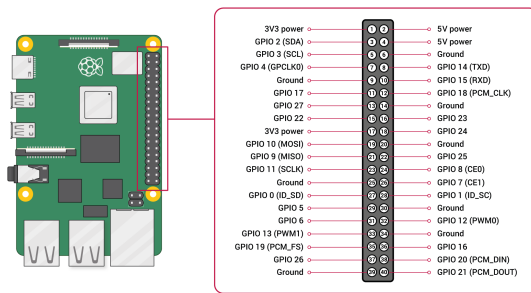


GPIO header connection on the top of the Auto pHAT.



*GPIO header connection on the bottom of the Auto pHAT.
(Click to enlarge)*

Raspberry Pi GPIO Map



Standard GPIO layout on the Raspberry Pi.

Power Connections

Power to the Auto pHAT is supplied through the GPIO pins; both 5V and 3.3V are utilized.

Pin #	GPIO
1	3.3V
17	3.3V
2	5V
4	5V
6	GND
9	GND
Pin #	GPIO
14	GND

20	GND
30	GND
34	GND
39	GND

Qwiic (I2C)

IMU (I2C)

Pin #	GPIO	Function
3	GPIO 02 (SDA)	Qwiic (SDA)
5	GPIO 03 (SCL)	Qwiic (SCL)
26	GPIO 7	Interrupt

Encoder (I2C)

Pin #	GPIO	Function
3	GPIO 02 (SDA)	Qwiic (SDA)
5	GPIO 03 (SCL)	Qwiic (SCL)
7	GPIO 4	Interrupt

Motor Driver (I2C)

Pin #	GPIO	Function
3	GPIO 02 (SDA)	Qwiic (SDA)
5	GPIO 03 (SCL)	Qwiic (SCL)

Servo Controller (I2C)

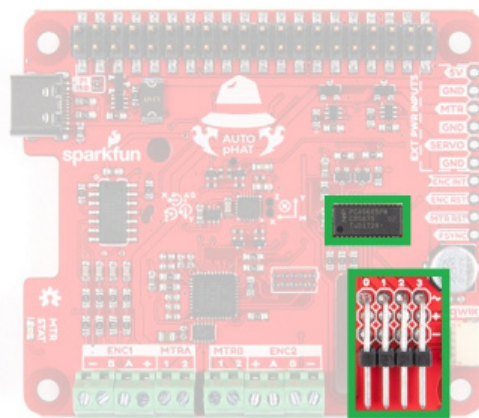
Pin #	GPIO	Function
3	GPIO 02 (SDA)	Qwiic (SDA)
5	GPIO 03 (SCL)	Qwiic (SCL)

Qwiic Connector

Pin #	GPIO	Function
3	GPIO 02 (SDA)	Qwiic (SDA)
5	GPIO 03 (SCL)	Qwiic (SCL)

Servo Controller

The servo controller utilizes the same PCA9685 IC used on the Pi Servo pHAT; however, only the first 4 PWM channels are broken out. The PCA9685 provides I²C control over the 16-channels of 12-bit pulse width modulation (PWM); although only the first 4-channels are available on the Auto pHAT. The default I²C address for the servo controller on the Auto pHAT is **0x40**.

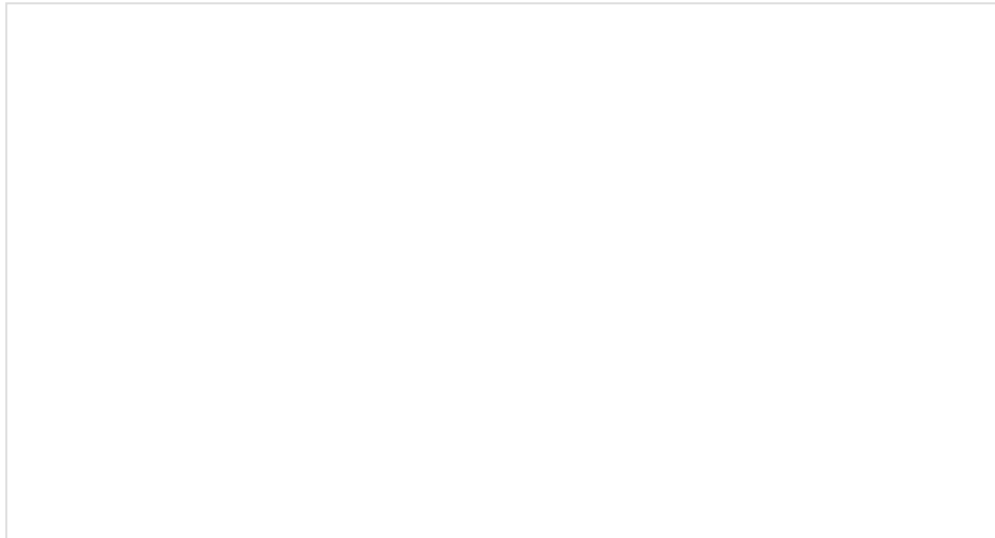


The PCA9685 16-channel PWM controller IC and output headers.

Characteristic	Description
Operating Voltage (V_{DD})	2.3 V to 5.5 V (Hardwired: 5V)
Operating Temperature	-40°C to 85°C
PWM Outputs	16 Totem pole outputs (Default: Open-Drain) Sink 25 mA or Source 10 mA (at 5V) Shared PWM frequency Supports hot insertion
PWM Frequency	24Hz to 1526 Hz (Default (1Eh): 200Hz)
PWM Resolution	12-bit (4096 steps of control)
Duty Cycle	0% to 100% (adjustable)
Oscillator	Internal: 25 MHz (Hardwired) External: 50 MHz (max.) input (unavailable)

I ² C Address	<p>8 available hardware configurable addresses</p> <ul style="list-style-type: none">• Configuration Jumpers: 0x40 to 0x47• Default: 0x40 <p>4 programmable addresses to allow simultaneous groups control of multiple devices:</p> <ul style="list-style-type: none">• 1- General <i>All Call</i> address.• 3- <i>Sub Call</i> addresses.
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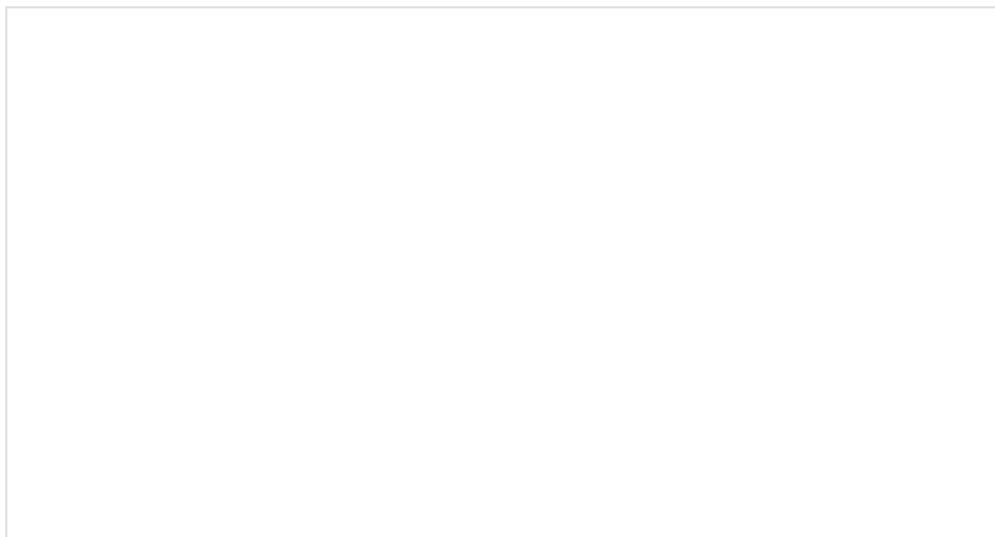
Note: For more details on the PCA9685 and its utilization as a servo controller, check out the following hookup guides on the Pi Servo pHATs:



Pi Servo Hat Hookup Guide

SEPTEMBER 14, 2017

This hookup guide will show you how to connect and use the Pi Servo Hat in a project.



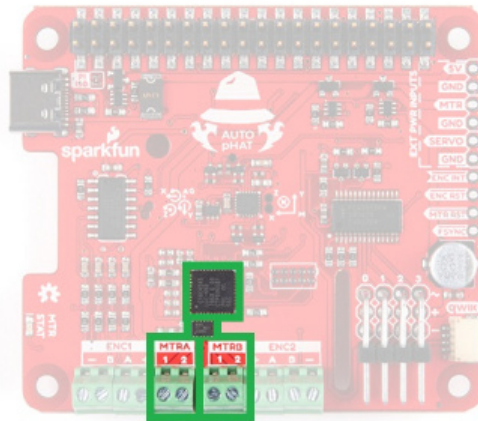
Pi Servo pHAT (v2) Hookup Guide

JULY 11, 2019

This hookup guide will get you started with connecting and using the Pi Servo pHAT on a Raspberry Pi.

Motor Driver

The motor driver consists of the same PSoC4245 and DRV8835 as the Serial Controlled Motor Driver and Qwiic Motor Driver. The DRV8835 H-Bridge provides two drive outputs, each capable of 1.2A at steady state. The default I²C address for the motor driver on the Auto pHAT is **0x5D**.

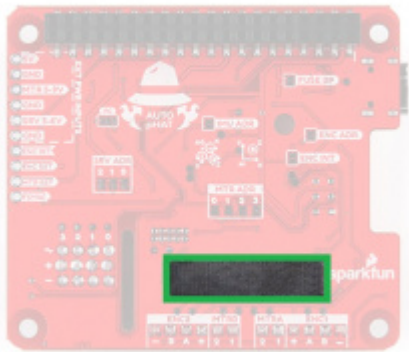


The PSoC4245 microcontroller, DRV8835 H-Bridge, and screw terminal outputs.

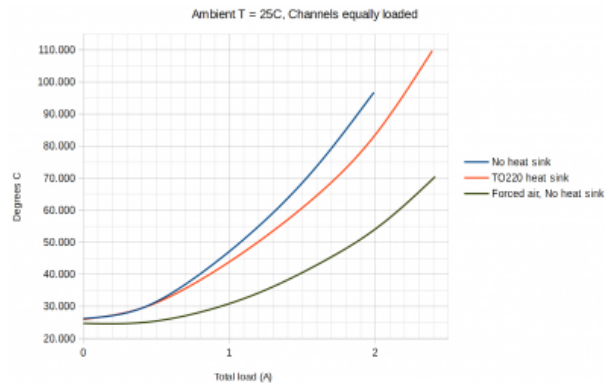
Characteristic	Description
Operating Voltage (V_{DD})	3 V to 11 V (Hardwired: 5V)
Drive Channels	2 Channels
Drive Strength	1.5A per channel (max.) 1.2A (steady state)
Drive Control	127 levels of control Direction inversion on a per motor basis Global Drive enable
I ² C Address	10 available hardware configurable addresses <ul style="list-style-type: none">• Configuration Jumpers: 0x58 to 0x61• Default: 0x5D

Thermal Management

An important consideration for the motor driver is the thermal load due to the current draw of the motors. In order to dissipate the heat, users can use our Theragrip Thermal Tape to attach Small Heat Sinks across the thermally conductive area on the bottom of the board. As the thermal plane doesn't promote natural convection well, users can add a fan to help dissipate the energy, as well.



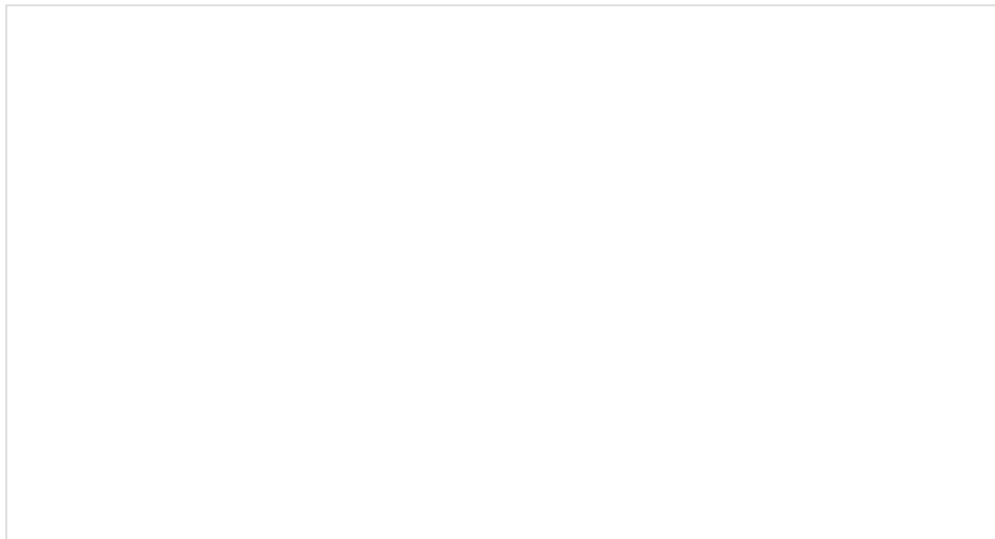
Thermally conductive area on the bottom of the Auto pHAT.



Temperature to total driver load curve.

(Click to enlarge)

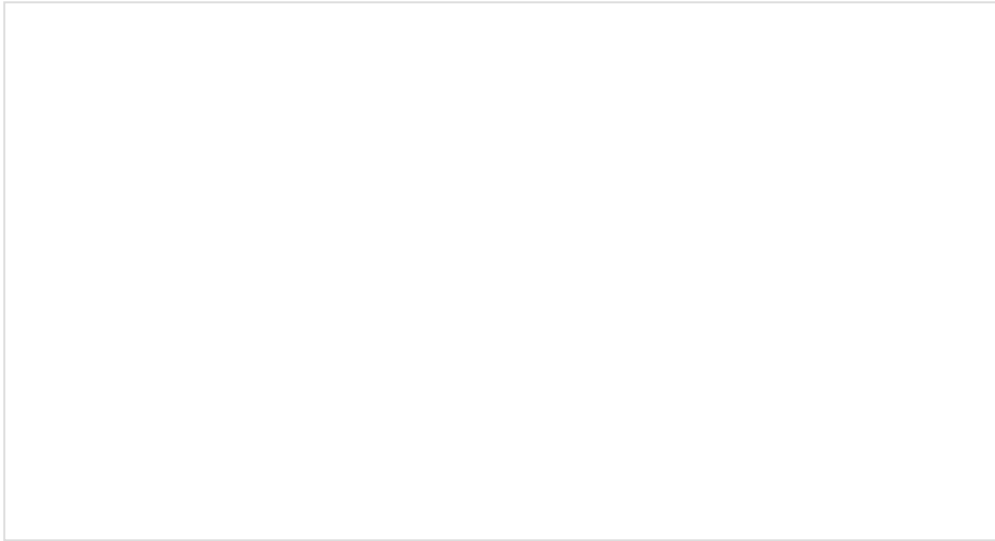
Note: For more details on the Serial Controller Motor Driver or Qwiic Motor Driver and its utilization, check out the following hookup guides on the Pi Servo pHATs:



Serial Controlled Motor Driver Hookup Guide

NOVEMBER 17, 2016

Hookup guide for the Serial Controlled Motor Driver



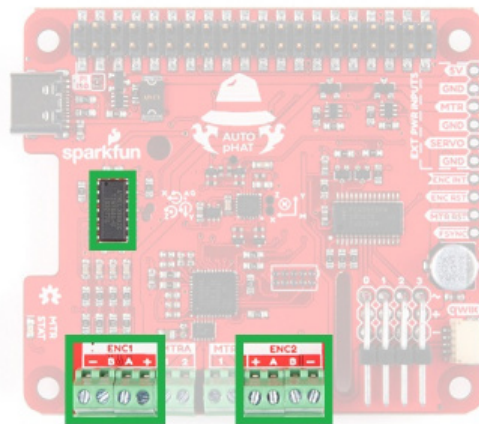
Hookup Guide for the Qwiic Motor Driver

SEPTEMBER 19, 2019

Drive things "qwiic"-ly with the SparkFun Qwiic Motor Driver!

Encoder Reader

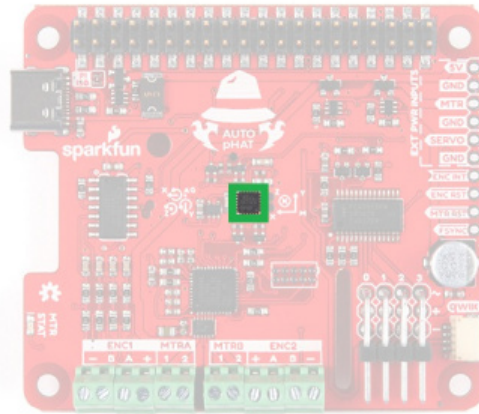
At the heart of the encoder reader is an ATtiny84, which is utilized on our pseudo I²C devices. The encoder reader is based off of the Qwiic Twist, but is capable of reading two, separate quadrature encoders. The default I²C address for the servo controller on the Auto pHAT is **0x73**.



The ATtiny84 dual encoder reader and screw terminal inputs.

9-DoF IMU

The 9-DoF (degree of freedom) IMU is the same ICM20948 IC used on the 9DoF IMU Breakout. It provides 10 unique measurements: 3 axes of acceleration, rotational rate, and magnetic strength data, as well as, internal temperature. Users should note the location of the IMU and the orientation of the axes (labeled on the board), when taking measurements. The default I²C address for the IMU on the Auto pHAT is **0x69**.

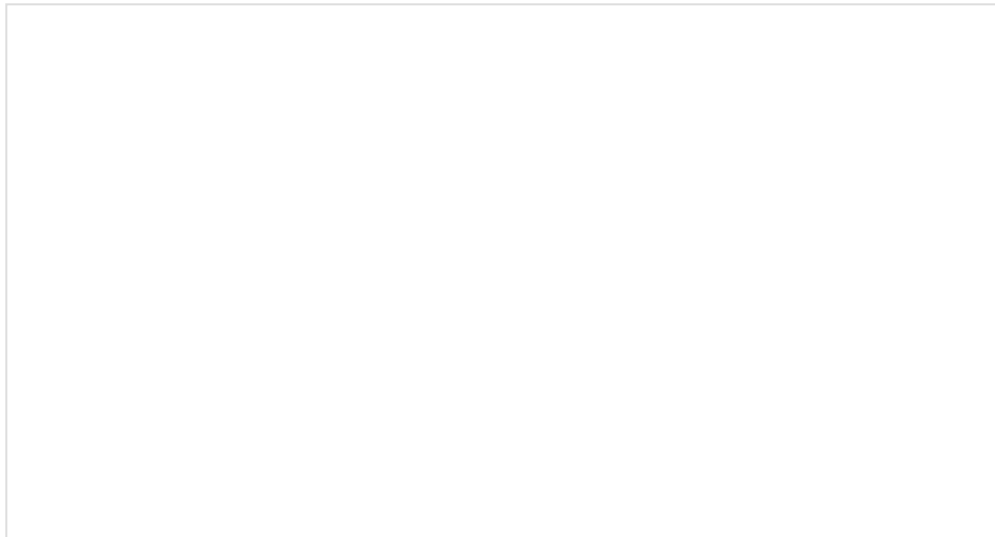


The ICM20948 9-DoF IMU.

Characteristic	Description
Operating Voltage (V_{DD})	1.71 V to 3.6 V (Hardwired: 1.8V)
Operating Temperature	-40°C to 85°C
Gyroscope	<p>Full Scale Ranges:</p> <ul style="list-style-type: none"> • ± 250 dps • ± 500 dps • ± 1000 dps • ± 2000 dps <p>Sensitivity:</p> <ul style="list-style-type: none"> • $\pm(1/131)$ dps • $\pm(1/65.5)$ dps • $\pm(1/32.8)$ dps • $\pm(1/16.4)$ dps <p>Output Data Rate: 562.5, 1125, 9000 Hz</p>

Accelerometer	<p>Full Scale Ranges:</p> <ul style="list-style-type: none"> • ± 2 G • ± 4 G • ± 8 G • ± 16 G <p>Sensitivity:</p> <ul style="list-style-type: none"> • $\pm(1/16384)$ G • $\pm(1/8192)$ G< • $\pm(1/4096)$ G< • $\pm(1/2048)$ G< <p>Output Data Rate: 562.5, 1125, 4500 Hz</p>
Magnetometer	<p>Full Scale Range: ± 4900 μT</p> <p>Sensitivity: .15 μT</p> <p>Output Data Rate: 100 Hz</p>
I ² C Address	<p>2 hardware configurable addresses:</p> <ul style="list-style-type: none"> • 0x69: Jumper closed (Default) • 0x68: Jumper open

Note: For more details on the ICM-20948 and its utilization as an IMU, check out the following hookup guide:

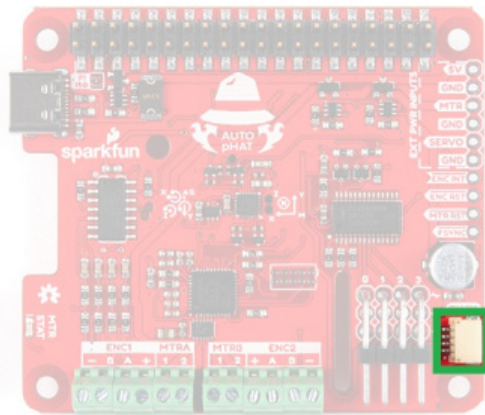


SparkFun 9DoF IMU (ICM-20948) Breakout Hookup Guide

JUNE 27, 2019

How to use the SparkFun 9DoF ICM-20948 breakout board for your motion sensing projects. This breakout is ideal for wearable sensors and IoT applications.

A connector is provided for attaching other Qwiic devices.



Qwiic connector.

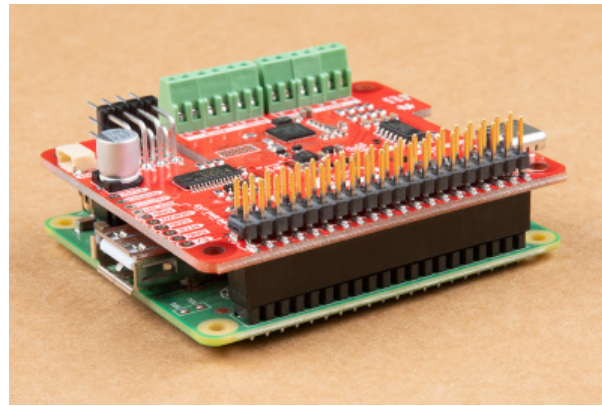
Note: While most of our Qwiic devices should be compatible with a single board computer (SBC), not all have a supported Python package. Users who are unfamiliar with our Qwiic connect system, can check out the video below:

SparkFun's Qwiic Connect System

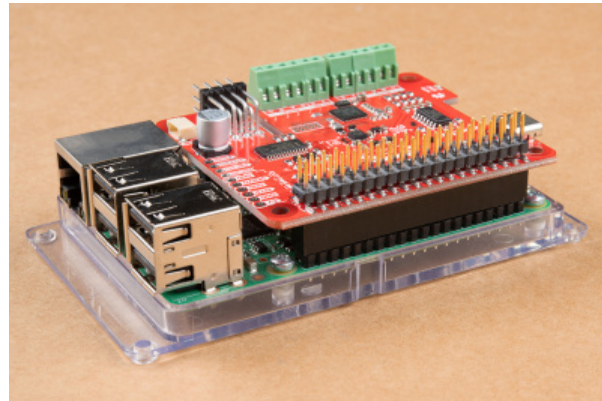


Hardware Assembly

Assembly for the Auto pHAT is fairly straight forward. It plugs directly into the GPIO pins of a Raspberry Pi. Most importantly, users need pay attention to the orientation of the pHAT and double check that the pin are lined up properly. below are a few examples for users to follow.



Auto pHAT on Raspberry Pi 3 Model A+.



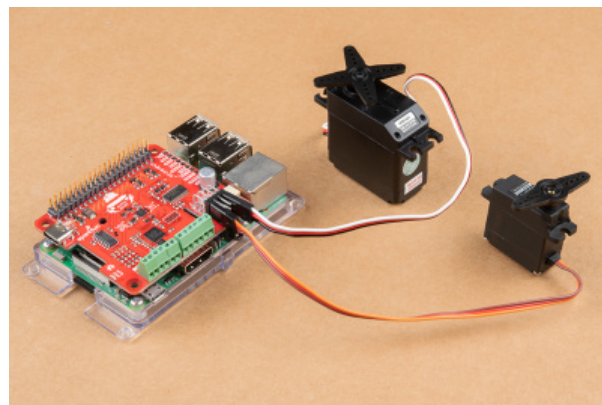
*Auto pHAT on Raspberry Pi 3 Model B.
(Click images to enlarge)*

Attaching Accessories

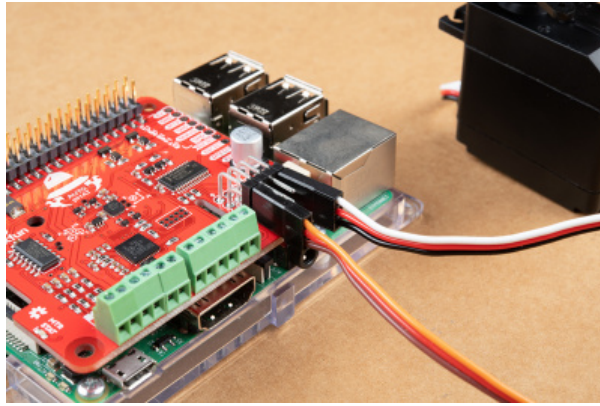
Users will want to attach additional accessories to the Auto pHAT.

Servos

Servos are attached to the 3x4 right angle header. The channels and pins are indicated on the top and right of the header, when reading the silk screen. Below is an example with servos connected to channels 0 and 3. Users should pay close attention to the orientation of the servo connector, in order to match up the pin connections properly.

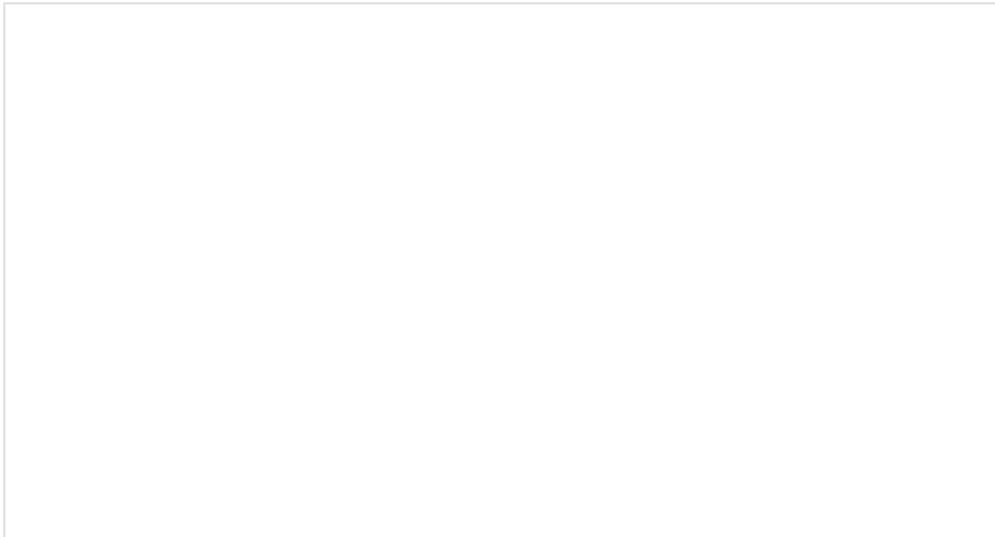


Servos attached to channels 0 and 3.



*Verify that the connector is in the proper orientation.
(*Hint: The signal wire is the uppermost header.)
(Click images to enlarge)*

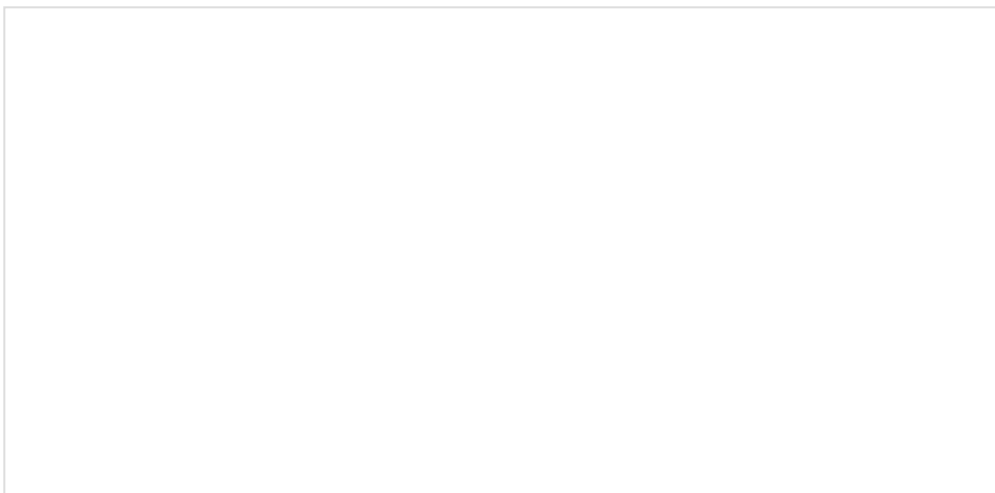
Note: Users who are unfamiliar with servos and their operation should check out our hobby servo and basic servo control tutorials. Additionally, here is a quick reference for common servo wiring colors.



Hobby Servo Tutorial

MAY 26, 2016

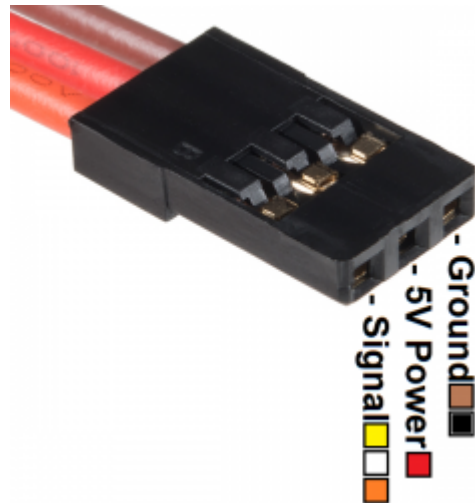
Servos are motors that allow you to accurately control the rotation of the output shaft, opening up all kinds of possibilities for robotics and other projects.



Basic Servo Control for Beginners

FEBRUARY 25, 2020

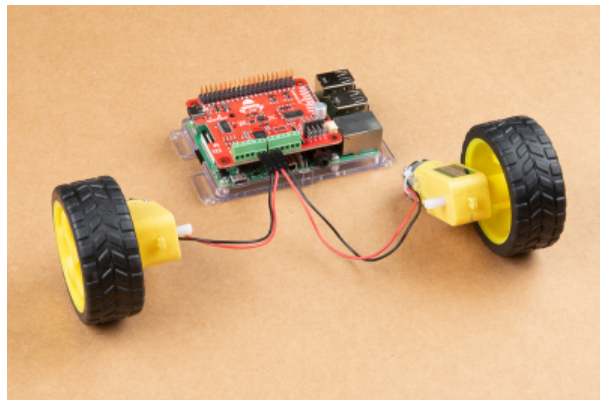
An introductory tutorial demonstrating several ways to use and interact with servo motors!



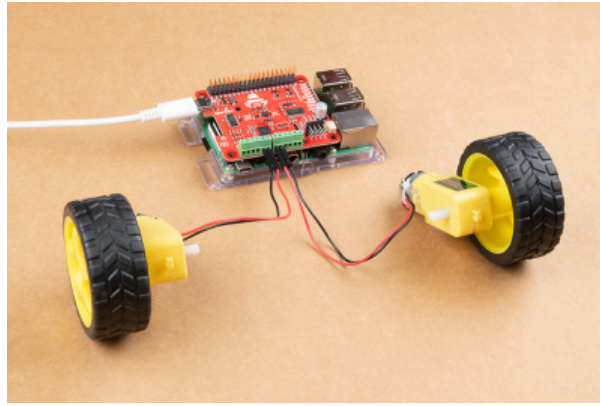
Annotated image of servo wiring harness. (Click to enlarge)

Motors

DC motors should be connected to the inner screw terminals indicated by MTRA and MTRB on the silk screen. Below, is an example of a pair of motors connected to the Auto pHAT. The orientation of the wires (between 1 or 2) shouldn't matter as the drive direction can be configured in software.

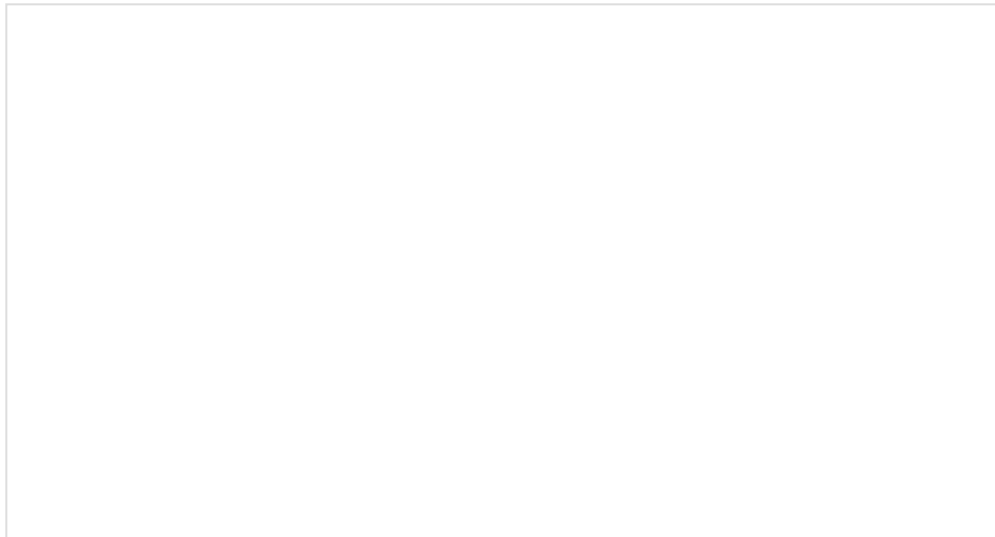


DC hobby motors (with wheels attached) connected to the Auto pHAT.



*An external power source provided by the USB-C connector.
(Click images to enlarge)*

Note: Users unfamiliar with DC motors should check out our motors tutorial.



Motors and Selecting the Right One

DECEMBER 12, 2013

Learn all about different kinds of motors and how they operate.

Quadrature Encoders

Connecting quadrature encoders to the Auto pHAT is relatively simple with the screw terminals. Users should use the silk screen on the board (+ , A , B , and -) to match the connections for the encoder. The datasheet for the encoders should be used if the connections aren't apparent or labeled on the product.

Note: This section is in progress while we await the arrival of the encoder embedded motors.

Note: Users who are unfamiliar with quadrature encoders and their operation should check out our Adventures in Science blog post on encoders.

[Adventures in Science: How to Use Rotary Encoders](#)



Clearance Issues

Another consideration is the clearance of the pHAT from other components. Users can cover the header and screw terminal through hole pins with an insulator to avoid shorting the pins. Additionally, if the clearance between the pHAT and other components (including things like a the heat sink case for the Raspberry Pi 4) becomes an issue, a header should be used to increase the spacing.

Note: The details for this section are in progress while we await the arrival of the compatible header.

Desktop

To configure the Raspberry Pi for use with the Auto pHAT, the PIXEL desktop is recommended. It will be the most convenient for users, but users can still use other methods like SSH to remotely access the Raspberry Pi. To utilize the desktop, users will need to add peripherals like a monitor and keyboard.



Pi 3 Model B setup to access the PIXEL desktop. (Click to enlarge)

Software Configuration

Enable the I²C Bus

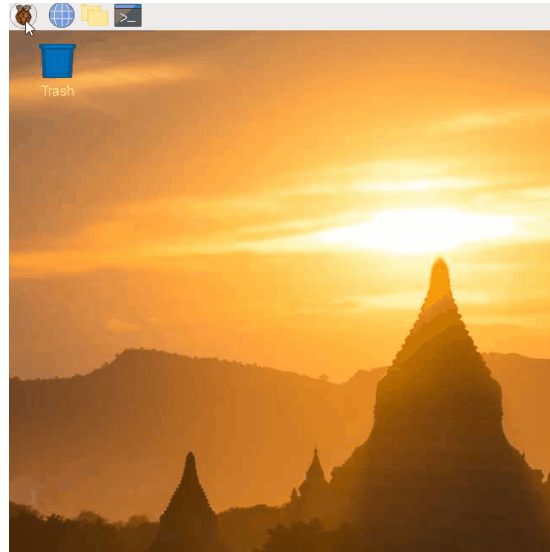
Configuring an OS for the Auto pHAT is relatively simple; the I²C interface will need to be enabled.

Nvidia Jetson

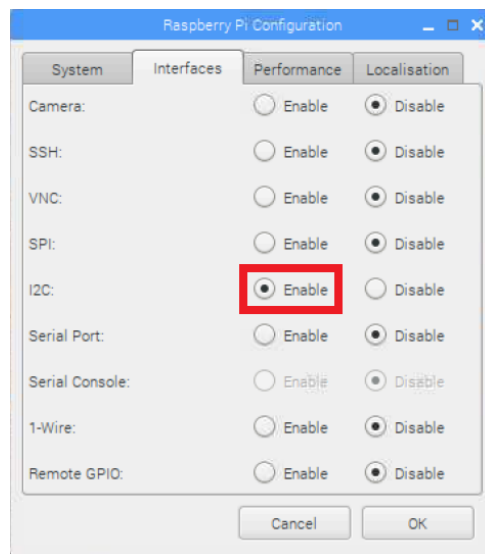
The I²C bus on the Nvidia Jetson is enabled by default; no configuration is necessary.

Raspberry Pi

On the Raspberry Pi, this is easily accomplished within the Raspberry Pi PIXEL desktop. Using the graphical Raspberry Pi Configuration application from the Preferences menu will be the most user friendly option. Users can also make changes through the console based `raspi-config` application.



Raspberry Pi Configuration application. (Click to enlarge)



From the `Interfaces` tab, enable the I2C interface. (Click to enlarge)

Once done, click the `OK` button. Reboot the Raspberry Pi when prompted.

Install the Python Packages

Note: This tutorial assumes you are using the latest version of Python 3. If this is your first time using Python or I²C hardware on a Raspberry Pi, please checkout our tutorial on Python Programming with the Raspberry Pi and the Raspberry Pi SPI and I2C Tutorial.

We've written a Python packages to easily get setup and utilize the Auto pHAT. There are two methods for installing the Python packages:

1. Install the all inclusive SparkFun Qwiic Python package.
2. Independently install the various Python packages:
 - pi-servo-hat
 - sparkfun-qwiic-pca9685
 - sparkfun-qwiic-scmd
 - sparkfun-qwiic-dual-encoder-reader
 - sparkfun-qwiic-icm20948

The all inclusive SparkFun Qwiic Python package, is recommended as is also installs the required I²C driver as well.

Note: Don't forget to double check that the hardware I²C connection is enabled on your Raspberry Pi or other single board computer.

SparkFun Qwiic Package

This repository is hosted on PyPi as the `sparkfun-qwiic` package . On systems that support PyPi installation via `pip3` (use `pip` for Python 2) is simple, using the following commands:

For **all users** (note: the user must have **sudo** privileges):

```
sudo pip3 install sparkfun-qwiic
```

For the **current user**:

```
pip3 install sparkfun-qwiic
```

Upgrading the Python Package

In the future, changes to the Python package might be made. Updating the installed packages has to be done individually for each package (i.e. sub-modules and dependencies won't update automatically and must be updated manually). For example, with the `sparkfun-qwiic-scmd` Python package use the following command (use `pip` for Python 2):

For **all users** (note: the user must have **sudo** privileges):

```
sudo pip3 install --upgrade sparkfun-qwiic-scmd
```

For the **current user**:

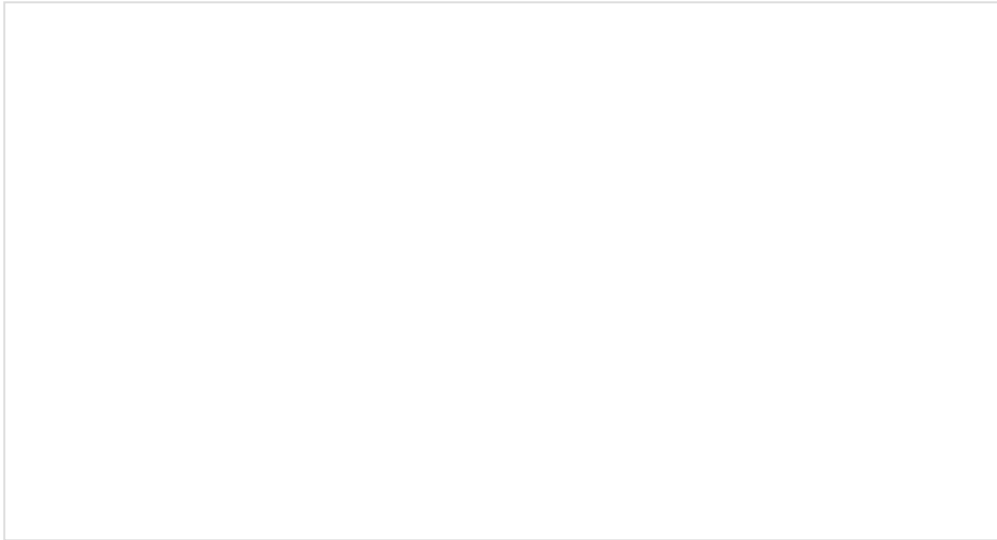
```
pip3 install --upgrade sparkfun-qwiic-scmd
```

Python Package Examples

Servo Controller

Documentation and examples for utilizing the servo controller is hosted on ReadtheDocs.

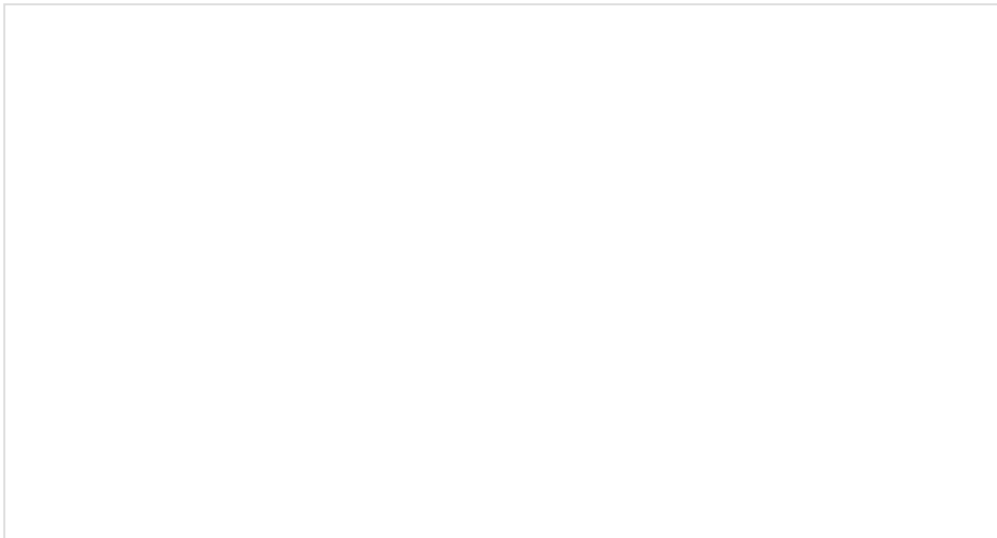
Note: The tutorials below, include other examples for the utilization of the `sparkfun-pi-servo-hat` Python package.



Pi Servo pHAT (v2) Hookup Guide

JULY 11, 2019

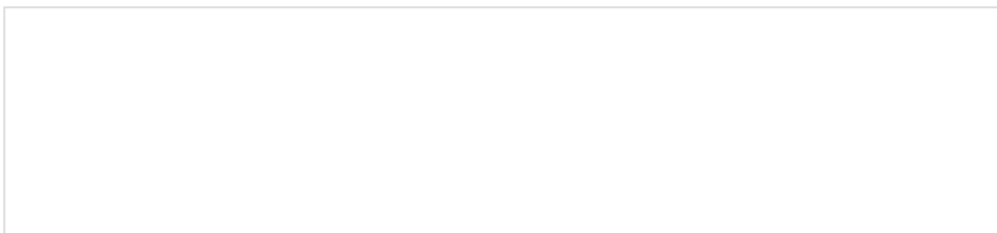
This hookup guide will get you started with connecting and using the Pi Servo pHAT on a Raspberry Pi.



Basic Servo Control for Beginners

FEBRUARY 25, 2020

An introductory tutorial demonstrating several ways to use and interact with servo motors!



Setting Up the Pi Zero Wireless Pan-Tilt Camera

SEPTEMBER 14, 2017

This tutorial will show you how to assemble, program, and access the Raspberry Pi Zero as a headless wireless pan-tilt camera.

Demo Example

This example is pulled from the examples in the ReadtheDocs documentation. It should be used with a 90 degree (range of rotation) servo on channel 0 of the Auto pHAT. It will swing the servo arm between 0° and 90°, in a loop.

```

#!/usr/bin/env python
#-----
# Pi Servo Hat - Example 1
#-----
#
# Written by SparkFun Electronics, June 2019
# Author: Wes Furuya
#
# Compatibility:
#   * Original: https://www.sparkfun.com/products/14328
#   * v2: https://www.sparkfun.com/products/15316
#
# Do you like this library? Help support SparkFun. Buy a board!
# For more information on Pi Servo Hat, check out the product page
# linked above.
#
# This program is distributed in the hope that it will be useful, but
# WITHOUT ANY WARRANTY without even the implied warranty of
# MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU
# General Public License for more details.
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#
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# TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE
# SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.
#=====

"""
This example should be used with a 90 degree (range of rotation) servo
on channel 0 of the Pi Servo Hat.

```

The extended code (commented out), at the end of the example could be used to test the full range of the servo motion. However, users should

be wary as they can damage their servo by giving it a position outside the standard range of motion.

```
"""
```

```
import pi_servo_hat
import time

# Initialize Constructor
test = pi_servo_hat.PiServoHat()

# Restart Servo Hat (in case Hat is frozen/locked)
test.restart()

# Test Run
#####
# Moves servo position to 0 degrees (1ms), Channel 0
test.move_servo_position(0, 0)

# Pause 1 sec
time.sleep(1)

# Moves servo position to 90 degrees (2ms), Channel 0
test.move_servo_position(0, 90)

# Pause 1 sec
time.sleep(1)

# Sweep
#####
while True:
    for i in range(0, 90):
        print(i)
        test.move_servo_position(0, i)
        time.sleep(.001)
    for i in range(90, 0, -1):
        print(i)
        test.move_servo_position(0, i)
        time.sleep(.001)

#####
# Code below may damage servo, use with caution
# Test sweep for full range of servo (outside 0 to 90 degrees).
# while True:
#     for i in range(-23, 100):
#         print(i)
#         test.move_servo_position(0, i)
#         time.sleep(.001)
#     for i in range(100, -23, -1):
#         print(i)
#         test.move_servo_position(0, i)
#         time.sleep(.001)
```


Documentation and examples for utilizing the motor driver is hosted on [ReadtheDocs](#).

Demo Example

This example is pulled from the examples in the [ReadtheDocs](#) documentation. It should be used with a DC motor on MTRX of the Auto pHAT. It will increase and decrease the speed between the 20 and 254 levels, in a loop.

```

#!/usr/bin/env python
#-----
# A simple test to speed up and slow down 1 motor.
#-----
#
# Written by Mark Lindemer
# SparkFun Electronics, April 2020
#
# This python library supports the SparkFun Electroncis qwiic
# qwiic sensor/board ecosystem on a Raspberry Pi (and compatable) single
# board computers.
#
# More information on qwiic is at https://www.sparkfun.com/qwiic
#
# Do you like this library? Help support SparkFun. Buy a board!
#
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# SOFTWARE.
#=====
# Example 1
#
from __future__ import print_function
import time
import sys
import math
import qwiic_scmd

myMotor = qwiic_scmd.QwiicScmd()

def runExample():
    print("Motor Test.")
    R_MTR = 0
    L_MTR = 1
    FWD = 0

```

```

BWD = 1

if myMotor.connected == False:
    print("Motor Driver not connected. Check connections.", \
          file=sys.stderr)
    return
myMotor.begin()
print("Motor initialized.")
time.sleep(.250)

# Zero Motor Speeds
myMotor.set_drive(0,0,0)
myMotor.set_drive(1,0,0)

myMotor.enable()
print("Motor enabled")
time.sleep(.250)

while True:
    speed = 20
    for speed in range(20,255):
        print(speed)
        myMotor.set_drive(R_MTR,FWD,speed)
        time.sleep(.05)
    for speed in range(254,20, -1):
        print(speed)
        myMotor.set_drive(R_MTR,FWD,speed)
        time.sleep(.05)

if __name__ == '__main__':
    try:
        runExample()
    except (KeyboardInterrupt, SystemExit) as exErr:
        print("Ending example.")
        myMotor.disable()
        sys.exit(0)

```

Encoder Reader

Documentation and examples for utilizing the encoder reader is hosted on [ReadtheDocs](#).

Demo Example

This example is pulled from the examples in the [ReadtheDocs](#) documentation. It should be used with quadrature encoders attached to both `ENC1` and `ENC2` on the Auto pHAT. It will read and print out the encoder position; the ticker counter range rolls up to **32767** ticks.

```

#!/usr/bin/env python
#-----
# ex1_qwiic_dual_encoder_reader.py
#
# Simple Example demonstrating how to read encoder counts for the Qwiic Dual Encoder Reader (as
# part of the SparkFun Auto pHAT)
#-----
#
# Written by SparkFun Electronics, May 2019
#
# This python library supports the SparkFun Electroncis qwiic
# qwiic sensor/board ecosystem on a Raspberry Pi (and compatable) single
# board computers.
#
# More information on qwiic is at https://www.sparkfun.com/qwiic
#
# Do you like this library? Help support SparkFun. Buy a board!
#
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# LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM,
# OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE
# SOFTWARE.
#=====
# Example 1
#
from __future__ import print_function
import qwiic_dual_encoder_reader
import time
import sys

def runExample():

    print("\nSparkFun Qwiic Dual Encoder Reader Example 1\n")
    myEncoders = qwiic_dual_encoder_reader.QwiicDualEncoderReader()

    if myEncoders.connected == False:

```

```

        print("The Qwiic Dual Encoder Reader device isn't connected to the system. Please check
your connection", \
            file=sys.stderr)
        return

myEncoders.begin()

while True:

    print("Count1: %d, Count2: %s" % (myEncoders.count1, \
        myEncoders.count2, \
        ))

    time.sleep(.3)

if __name__ == '__main__':
    try:
        runExample()
    except (KeyboardInterrupt, SystemExit) as exErr:
        print("\nEnding Example 1")
        sys.exit(0)

```

9-DoF IMU

Documentation and an example for utilizing the IMU is hosted on [ReadtheDocs](#).

Demo Example

This example is pulled from the examples in the [ReadtheDocs](#) documentation. It display the raw data in the following order: `a_x`, `a_y`, `a_z`, `g_x`, `g_y`, `g_z`, `m_x`, `m_y`, and `m_z`.

```

#!/usr/bin/env python
#-----
# ex1_qwiic_ICM20948.py
#
# Simple Example for the Qwiic ICM20948 Device
#-----
#
# Written by SparkFun Electronics, March 2020
#
# This python library supports the SparkFun Electronics qwiic
# qwiic sensor/board ecosystem on a Raspberry Pi (and compatible) single
# board computers.
#
# More information on qwiic is at https://www.sparkfun.com/qwiic
#
# Do you like this library? Help support SparkFun. Buy a board!
#
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# LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM,
# OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE
# SOFTWARE.
#=====
# Example 1
#

from __future__ import print_function
import qwiic_icm20948
import time
import sys

def runExample():

    print("\nSparkFun 9DoF ICM-20948 Sensor Example 1\n")
    IMU = qwiic_icm20948.QwiicIcm20948()

    if IMU.connected == False:
        print("The Qwiic ICM20948 device isn't connected to the system. Please check your connec

```

```

tion", \
        file=sys.stderr)
    return

IMU.begin()

while True:
    if IMU.dataReady():
        IMU.getAgmt() # read all axis and temp from sensor, note this also updates all instance variables
        print(\
            '{: 06d}'.format(IMU.axRaw)\
            , '\t', '{: 06d}'.format(IMU.ayRaw)\
            , '\t', '{: 06d}'.format(IMU.azRaw)\
            , '\t', '{: 06d}'.format(IMU.gxRaw)\
            , '\t', '{: 06d}'.format(IMU.gyRaw)\
            , '\t', '{: 06d}'.format(IMU.gzRaw)\
            , '\t', '{: 06d}'.format(IMU.mxRaw)\
            , '\t', '{: 06d}'.format(IMU.myRaw)\
            , '\t', '{: 06d}'.format(IMU.mzRaw)\
            )
        time.sleep(0.03)
    else:
        print("Waiting for data")
        time.sleep(0.5)

if __name__ == '__main__':
    try:
        runExample()
    except (KeyboardInterrupt, SystemExit) as exErr:
        print("\nEnding Example 1")
        sys.exit(0)

```

Challenge: Now that you are familiar with the basics, flex that robotics muscle. Try to implement a traction control or an anti-lock braking system (ABS) to show off your prowess.

Troubleshooting

Raspberry Pi

For comprehensive information or troubleshooting issues, on the Raspberry Pi, users should check out the Raspberry Pi Foundation website and their forum.

As a general guideline, users should use the following resources when looking for technical information or assistance that is specifically related to the Raspberry Pi itself:

1. Raspberry Pi FAQ
 - FAQ Troubleshooting Section
2. Raspberry Pi Beginner's Subforum
3. Raspberry Pi Documentation and Help Guides
 - Troubleshooting Guide

4. Raspberry Pi Forum

- **STICKY** - Booting Issues
- See other **STICKY** topics in the Troubleshooting section of the forum

Nvidia Jetson Nano

For comprehensive information or troubleshooting issues, on the Nvidia Jetson, users should check out the Nvidia website and their forum.

As a general guideline, users should use the following resources when looking for technical information or assistance that is specifically related to the Jetson Nano itself:

1. Jetson Support Resources
2. Jetson Nano Getting Started Guide
3. Developer Kit User Manual
4. Jetson Nano Wiki
5. Nvidia FAQ
6. Jetson Forum
7. Jetpack Documentation

For users looking for technical assistance, click on the link. There you will find, basic troubleshooting tips and instructions to get started with posting a topic in our forum. Our technical support team will do their best to assist you.

Resources and Going Further

Product Information

- Schematic
- Eagle Files
- GitHub Product Repository
- Servo Controller:
 - PCA9685 Datasheet
 - Pi Servo Hat Python Package
 - PCA9685 Python Package
- Motor Driver:
 - Serial Controlled Motor Driver Datasheet
 - Qwiic SCMD Python Package
- Encoder Reader:
 - ATtiny84 Datasheet
 - Firmware
 - Dual Encoder Reader Python Package
- 9-DoF IMU:
 - ICM20948 Datasheet
 - Qwiic 9DoF IMU (ICM20948) Python Package

Nvidia Jetson Resources:

- Jetson Download Center
- Nvidia Forum: Jetson Nano
 - Jetson Forum: List of All Resources
- Wiki: Nvidia Jetson:

- Jetson Nano Wiki

Jetson Support Resources

- Jetson Nano Getting Started Guide
- Nvidia Jetson Tutorials
- Nvidia FAQ
- Community Projects
- User Manuals:
 - Developer Kit User Manual
 - Jetpack Software Documentation

Raspberry Pi Resources:

- Raspberry Pi Foundation Downloads
- Raspberry Pi Foundation Forum

Raspberry Pi Help Guides & Documentation:

Help Guides:

- Setting up your Raspberry Pi
- Using your Raspberry Pi
- Add-ons Guide
- Troubleshooting Guide
- Videos

Documentation:

- Setup/Quickstart
- Installation
- Configuration
- Remote Access
- Linux