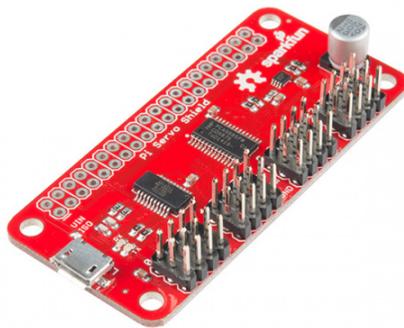




Pi Servo Hat Hookup Guide

Introduction

The SparkFun Pi Servo Hat allows your Raspberry Pi to control up to 16 servo motors via I2C connection. This saves GPIO and lets you use the onboard GPIO for other purposes. Furthermore, the Pi Servo Shield adds a serial terminal connection which will allow you to bring up a Raspberry Pi without having to hook it up to a monitor and keyboard.



SparkFun Pi Servo HAT

© DEV-14328

Required Materials

Here's what you need to follow along with this tutorial. We suggest purchasing a blank microSD card rather than a NOOBS ready card, since the NOOBS ready cards may not have a new enough OS to support the Pi Zero W.



microSD Card with Adapter -
16GB (Class 10)

© COM-13833



Break Away Headers -
Straight

© PRT-00116



SparkFun Pi Servo HAT
© DEV-14328



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



**Raspberry Pi GPIO Tall
Header - 2x20**
© PRT-14017



Raspberry Pi Zero W
© DEV-14277

In addition, you'll want some kind of servo motor to test the setup. Try testing the examples provided later in the tutorial with the generic sub-micro servo first.



**Servo - Generic (Sub-Micro
Size)**
© ROB-09065

Required Tools

No special tools are required to follow this product assembly. You will need a soldering iron, solder, and general soldering accessories.



Soldering Iron - 30W (US, 110V)

🕒 TOL-09507

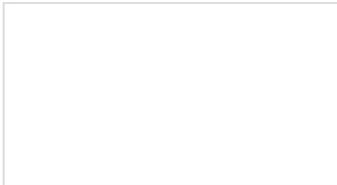


Solder Lead Free - 15-gram Tube

🕒 TOL-09163

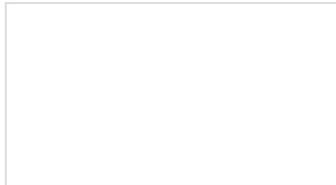
Suggested Reading

You may want to review these tutorials before undertaking this one.



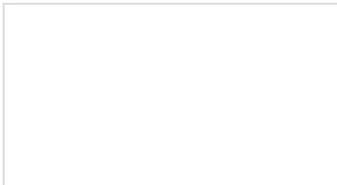
How to Solder: Through-Hole Soldering

This tutorial covers everything you need to know about through-hole soldering.



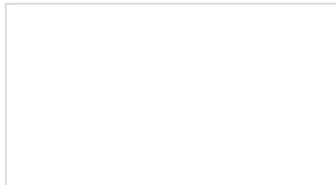
Raspberry Pi SPI and I2C Tutorial

How to use the serial buses on your Raspberry Pi.



Hobby Servo Tutorial

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.



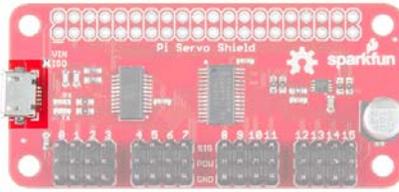
Getting Started with the Raspberry Pi Zero Wireless

Learn how to setup, configure and use the smallest Raspberry Pi yet, the Raspberry Pi Zero - Wireless.

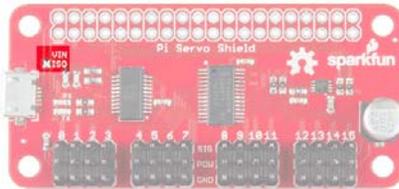
Hardware Overview

There are only a few items of interest on the board, as it is a hat designed to be minimally difficult to use.

USB Micro B Connector - This connector can be used to power the servo motors only, or to power the servo motors as well as the Pi that is connected to the hat. It can also be used to connect to the Pi via serial port connection to avoid having to use a monitor and keyboard for setting up the Pi.



Power supply isolation jumper - This jumper can be cleared (it is closed by default) to isolate the servo power rail from the Pi 5V power rail. Why would you want to do that? If there are several servos, or large servos with a heavy load on them, the noise created on the power supply rail by the servo motors can cause undesired operation in the Pi, up to a complete reset or shutdown. Note that, so long as the Pi is powered, the serial interface will still work regardless of the state of this jumper.

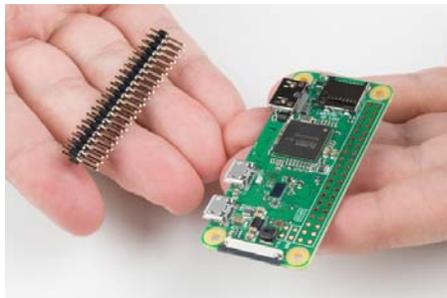


Servo motor pin headers - These headers are spaced out to make it easier to attach servo motors to them. They are pinned out in the proper order for most hobby-type servo motor connectors.



Hardware Assembly

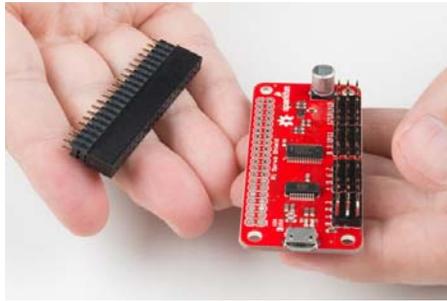
We suggest soldering the male headers onto the Pi Zero W.



My favorite trick for this type of situation is to solder down one pin, then melt the solder on that pin with the iron held in my right hand and use my left hand to adjust the header until it sits flat as shown below. Make sure that you are soldering with the header's shorter side and the longer pins are on the component side. After tacking down one pin, finish soldering all the pins down to the Pi Zero W.



Repeat the steps with the female header and the Pi Servo Hat.



Make sure to insert the short pins from the bottom of the board and add solder to the component side so that the Pi Servo Hat stacks on top of the Pi Zero W's male header pins. You will also need to make sure that the header is sitting level before soldering down all the pins.



Once the headers have been soldered, stack the Pi Servo Hat on the Pi Zero W. Then connect a hobby servo to a channel "0" based on the servo that you are using. Try looking at the hobby servo's datasheet or referring to some of the standard servo connector pinouts listed in this tutorial. Using a sufficient 5V wall adapter, we can power the Pi Zero W. Plug the wall adapter into a wall outlet for power and connect the micro-B connector labeled as the "PWR IN" port on the Pi Zero W.

Software - Python

We'll go over in some detail here how to access and use the pi servo hat in Python.

Full example code is available in the product GitHub repository.

Set Up Access to SMBus Resources

First point: in most OS level interactions, the I²C bus is referred to as SMBus. Thus we get our first lines of code. This imports the smbus module, creates an object of type `SMBus`, and attaches it to bus "1" of the Pi's various SMBuses.

```
import smbus
bus = smbus.SMBus(1)
```

We have to tell the program the part's address. By default, it is 0x20, so set a variable to that for later use.

```
addr = 0x20
```

Next, we want to enable the PWM chip and tell it to automatically increment addresses after a write (that lets us do single-operation multi-byte writes).

```
bus.write_byte_data(addr, 0, 0x20)
bus.write_byte_data(addr, 0xfe, 0x1e)
```

Write Values to the PWM Registers

That's all the setup that needs to be done. From here on out, we can write data to the PWM chip and expect to have it respond. Here's an example.

```
bus.write_word_data(addr, 0x06, 0)
bus.write_word_data(addr, 0x08, 1250)
```

The first write is to the "start time" register for channel 0. By default, the PWM frequency of the chip is 200Hz, or one pulse every 5ms. The start time register determines when the pulse goes high in the 5ms cycle. All channels are synchronized to that cycle. Generally, this should be written to 0. The second write is to the "stop time" register, and it controls when the pulse should go low. The range for this value is from 0 to 4095, and each count represents one slice of that 5ms period (5ms/4095), or about 1.2us. Thus, the value of 1250 written above represents about 1.5ms of high time per 5ms period.

Servo motors get their control signal from that pulse width. Generally speaking, a pulse width of 1.5ms yields a "neutral" position, halfway between the extremes of the motor's range. 1.0ms yields approximately 90 degrees off center, and 2.0ms yields -90 degrees off center. In practice, those values may be slightly more or less than 90 degrees, and the motor may be capable of slightly more or less than 90 degrees of motion in either direction.

To address other channels, simply increase the address of the two registers above by 4. Thus, start time for channel 1 is 0x0A, for channel 2 is 0x0E, channel 3 is 0x12, etc. and stop time address for channel 1 is 0x0C, for channel 2 is 0x10, channel 3 is 0x14, etc. See the table below.

Channel #	Start Address	Stop Address
Ch 0	0x06	0x08
Ch 1	0x0A	0x0C
Ch 2	0x0E	0x10
Ch 3	0x12	0x14
Ch 4	0x16	0x18
Ch 5	0x1A	0x1C
Ch 6	0x1E	0x20
Ch 7	0x22	0x24
Ch 8	0x26	0x28
Ch 9	0x2A	0x2C

Ch 10	0x2E	0x30
Ch 11	0x32	0x34
Ch 12	0x36	0x38
Ch 13	0x3A	0x3C
Ch 14	0x3E	0x40
Ch 15	0x42	0x44

If you write a 0 to the start address, every degree of offset from 90 degrees requires 4.6 counts written to the stop address. In other words, multiply the number of degrees offset from neutral you wish to achieve by 4.6, then either add or subtract that result from 1250, depending on the direction of motion you wish. For example, a 45 degree offset from center would be 207 (45x4.6) counts either more or less than 1250, depending upon the direction you desire the motion to be in.

Software - C++

We'll go over in some detail here how to access and use the pi servo hat in C++. Note that it's much harder than it is in Python, so maybe now's the time to learn Python?

Full example code is available in the product GitHub repository.

Include the Necessary Files

We'll start by going over the files which must be included.

```
#include <unistd.h> // required for I2C device access
#include <fcntl.h> // required for I2C device configuration
#include <sys/ioctl.h> // required for I2C device usage
#include <linux/i2c-dev.h> // required for constant definitions
#include <stdio.h> // required for printf statements
```

Open the I2C Device File

Start by opening the `i2c-1` file in `/dev` for reading and writing.

```
char *filename = (char*)"/dev/i2c-1"; // Define the filename
int file_i2c = open(filename, O_RDWR); // open file for R/W
```

You may wish to check the value returned by the `open()` function to make sure the file was opened successfully. Successful opening of the file results in a positive integer. Otherwise, the result will be negative.

```
if (file_i2c < 0)
{
    printf("Failed to open file!");
    return -1;
}
```

Set Up the Slave Address for the Write

Unlike Python (and Arduino), where the slave address is set on a per-transaction basis, we'll be setting up an "until further notice" address. To do this, we use the `ioctl()` function:

```
int addr = 0x40; // PCA9685 address
ioctl(file_i2c, I2C_SLAVE, addr); // Set the I2C address for u
pcoming
// transactions
```

`ioctl()` is a general purpose function not specifically limited to working with I2C.

Configure the PCA9685 Chip for Proper Operation

The default setup of the PCA9685 chip is not quite right for our purposes. We need to write to a couple of registers on the chip to make things right.

First we must enable the chip, turning on the PWM output. This is accomplished by writing the value 0x20 to register 0.

```
buffer[0] = 0; // target register
buffer[1] = 0x20; // desired value
length = 2; // number of bytes, including address
write(file_i2c, buffer, length); // initiate write
```

Next, we must enable multi-byte writing, as we'll be writing two bytes at a time later when we set the PWM values. This time we don't need to set the `length` variable as it's already correctly configured.

```
buffer[0] = 0xfe;
buffer[1] = 0x1e;
write(file_i2c, buffer, length);
```

Write Values to the PWM Registers

That's all the setup that needs to be done. From here on out, we can write data to the PWM chip and expect to have it respond. Here's an example.

```
buffer[0] = 0x06; // "start time" reg for channel 0
buffer[1] = 0; // We want the pulse to start at time t=0
buffer[2] = 0;
length = 3; // 3 bytes total written
write(file_i2c, buffer, length); // initiate the write

buffer[0] = 0x08; // "stop time" reg for channel 0
buffer[1] = 1250 & 0xff; // The "low" byte comes first...
buffer[2] = (1250>>8) & 0xff; // followed by the high byte.
write(file_i2c, buffer, length); // Initiate the write.
```

The first write is to the "start time" register for channel 0. By default, the PWM frequency of the chip is 200Hz, or one pulse every 5ms. The start time register determines when the pulse goes high in the 5ms cycle. All channels are synchronized to that cycle. Generally, this should be written to 0. The second write is to the "stop time" register, and it controls when the pulse should go low. The range for this value is from 0 to 4095, and each count represents one slice of that 5ms period (5ms/4095), or about 1.2us. Thus, the value of 1250 written above represents about 1.5ms of high time per 5ms period.

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Resources and Going Further

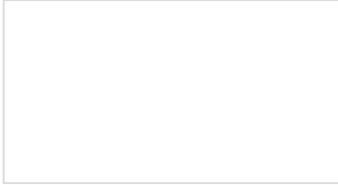
Now that you've successfully got your SparkFun Pi Servo Hat up and running, it's time to incorporate it into your own project!

For more information, check out the resources below:

- [SparkFun Pi Servo Hat Schematic \(PDF\)](#)
- [SparkFun Pi Servo Hat Eagle Files \(ZIP\)](#)
- [PCA9685 Datasheet \(PDF\)](#) - To get a better feel for exactly how PCA9685 works and additional functionality it offers.
- [SparkFun Pi Servo HAT GitHub Repository](#)

- [Setting Up the Pi Zero Wireless Pan-Tilt Camera Tutorial](#) - A kit that uses the Pi Servo Hat in a pan/tilt camera setup.

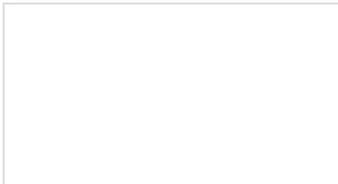
For additional software example using the PCA9685, you can refer to the hookup guide for the Edison PWM Block, which uses the same hardware and is conceptually very similar.



SparkFun Blocks for Intel® Edison - PWM

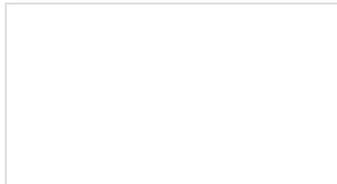
A quick overview of the features of the PWM Block.

Need some inspiration for your next project? Check out some of these related tutorials:



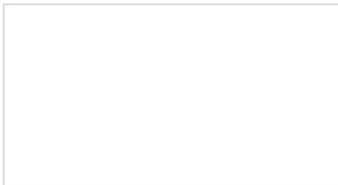
Raspberry Pi Twitter Monitor

How to use a Raspberry Pi to monitor Twitter for hashtags and blink an LED.



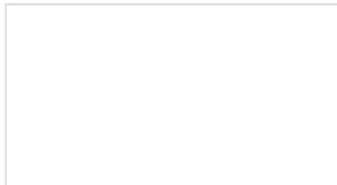
Getting Started with the BrickPi

How to connect Lego Mindstorms to the Raspberry Pi using the BrickPi.



Bark Back Interactive Pet Monitor

Monitor and interact with pets through this dog bark detector project based on the Raspberry Pi!



Getting Started with the Raspberry Pi Zero Wireless

Learn how to setup, configure and use the smallest Raspberry Pi yet, the Raspberry Pi Zero - Wireless.