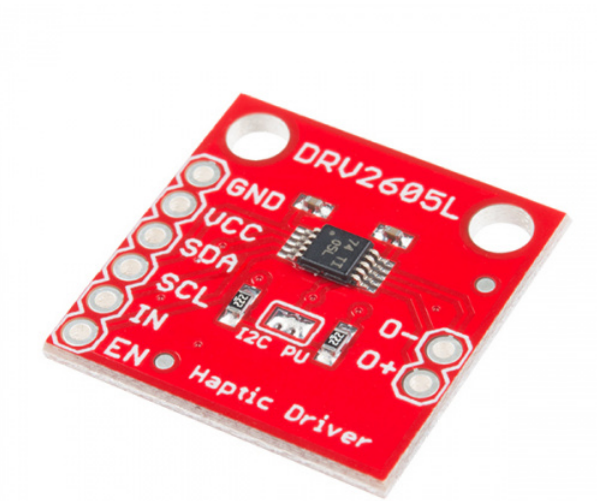
Haptic Motor Driver Hook-Up Guide

Introducing the Haptic Motor Driver

Ready to add some good vibes to your project? Look no further than the Haptic Motor Driver. This board breaks out Texas Instruments' DRV2605L haptic motor driver, which has some seriously cool features. Add meaningful feedback from your devices using the Haptic Motor Driver and an Arduino compatible device. This tutorial will get you up and running, or vibing, in no time with the I^2C library for Arduino and example projects that give you the hardware setup and the code for various modes of operation.



SparkFun Haptic Motor Driver - DRV2605L
ROB-14538

SparkFun Haptic Motor Driver

Features

- Flexible Haptic and Vibration Driver for both ERM and LRA type motors
- I^{2}C Controlled Digital Playback Engine
- Audio to Vibe
- PWM input with 0% to 100% Duty-Cycle Control Range
- Hardware Trigger Input
- Built-in Waveform Sequencer and Trigger

And that is just to name a few. See the DRV2605L data sheet for a complete list.

Required Materials

You'll need a handful of extra parts to get the Haptic Motor Driver up-and-running. Below are the basic components used in this tutorial, if you want to follow along.

SparkFun RedBoard - Programmed with Arduino
DEV-13975

Vibration Motor
ROB-08449

Jumper Wires Premium 6" M/M Pack of 10
PRT-08431

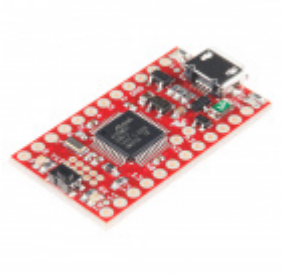
SparkFun Cerberus USB Cable - 6ft
CAB-12016

A microcontroller that supports I^{2}C is required to communicate with the DRV2605L and relay the data to the user by means of vibration. The SparkFun RedBoard or Arduino Uno are popular options for this role, but just about any microcontroller development board should work. (The firmware examples use an Arduino library, if that serves as any extra motivation to use an Arduino.)

Arduino Uno - R3
DEV-11021

SparkFun RedBoard - Programmed with Arduino
DEV-13975

Arduino Pro Mini 328 - 5V/16MHz
DEV-11113



SparkFun SAMD21 Mini Breakout
DEV-13664

Suggested Reading

The DRV2605L is designed for a handful of uses. The Technical Documents provided by Texas Instruments includes application notes, user guides, literature and blogs. The DRV2605L communicates over I^{2}C. We've got a great library to make it easy to use. We're going to be using a breadboard to connect the breakout board to the RedBoard. If these subjects sound foreign to you consider browsing through these tutorials before continuing on.

How to Solder: Through-Hole Soldering

Installing an Arduino Library

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

How do I install a custom Arduino library? It's easy! This tutorial will go over how to install an Arduino library using the Arduino Library Manager. For libraries not linked with the Arduino IDE, we will also go over manually installing an Arduino library.

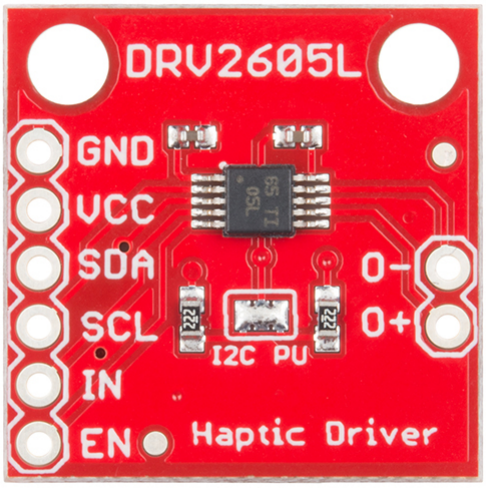
How to Use a Breadboard

Welcome to the wonderful world of breadboards. Here we will learn what a breadboard is and how to use one to build your very first circuit.

I2C

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

Hardware Overview



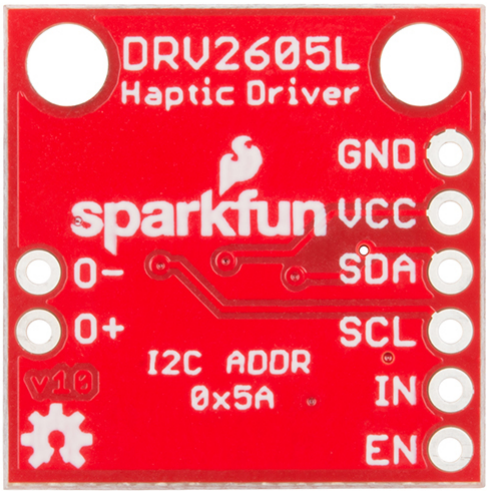
Parametrics

Parameter	Description
Min-Max Source Voltage	**2V - 5.2V.**
Special Features	Integrated Haptic Effects & Smart Loop Architecture.
Input Signal	PWM, Analog, I^2C.

Maximum Output Voltage	10.4V.
Haptic Actuator Type	ERM & LRA type motors only.
Shut Down Current	4uA.
Quiescent Current	0.5mA - Important for your battery powered projects.

Pin Descriptions

The SparkFun Haptic Motor Driver - DRV2605L breakout board provides 6 pins to provide power to the sensor and I^{2}C bus.



Pin Label	Description
GND	Connect to ground.
VCC	Used to power the DRV2605L Haptic Motor Driver. Must be between 2.0 - 5.2V
SDA	I^{2}C data
SCL	I^{2}C clock
IN	Analog and PWM signal input
EN	Enable pin. Connect to VCC for most applications.
O-	Negative motor terminal.
O+	Positive motor terminal.

Setting the Jumpers

On the front of the breakout board is a solder jumper:

- **I2C PU** – This is a 3-way solder jumper that is used to connect and disconnect the I^2C pullup resistors. By default, this jumper is **closed**, which means that both SDA and SCL lines have connected pullup resistors on the breakout board. Use some solder wick to open the jumper if you do not need the pullup resistors (e.g. you have pullup resistors that are located on the I^2C bus somewhere else).

ERM and LRA Motors

The DRV2605L is capable to driving two different types of motors. So what are they? How do they work? How are they different?

Precision Microdrives published application notes on using both Eccentric Rotating Mass, ERM and Linear Resonant Actuator, LRA type motors. The default firmware for the DRV2605L is set for use with ERM type motors. There are six effects libraries for the ERM type and only one for LRA. If you want to get up and running quickly, I recommend our ERM type motor, otherwise you'll be updating several registers in the device and spending much more time with the data sheet.

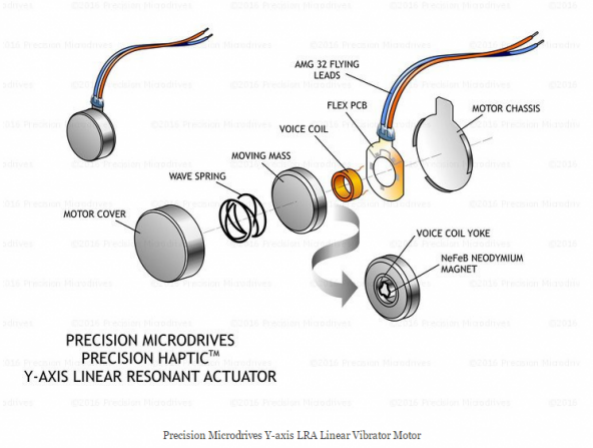


Photo courtesy of https://www.precisionmicrodrives.com/

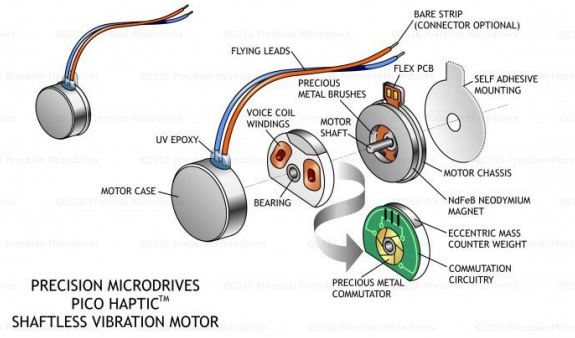


Photo courtesy of https://www.precisionmicrodrives.com/

The difference between the two motors is how the movement of a mass is displaced. LRA vibration motors require an AC signal, driving a sine waveform that is modulated to get multiple effects. ERM vibration motors use a DC motor with a counter weight attached. The DC voltage controls the speed of the motor.

The ERM has an off-centre load, when it rotates the centripetal force causes the motor to move. The rotation is created by applying a current to the armature windings attached to the motor shaft. As these are inside a magnetic field created by the permanent magnets on the inside of the motor's body, a force is created causing the shaft to rotate. To ensure the rotation continues in the same direction, the current in the windings is reversed. This is achieved by using static metal brushes at the motor terminals, which connect to a commutator that rotates with the shaft and windings. The different segments of the commutator connect to the brushes during rotation and the current is reversed, maintaining the direction of rotation.

In a similar method, LRAs use magnetic fields and electrical currents to create a force. One major difference is the voice coil (equivalent of the armature windings) remains stationary and the magnetic mass moves instead. The mass is also attached to a spring, which helps it return to the centre. Driving the magnetic mass up and down causes the displacement of the LRA and thereby the vibration force.[1]

More Suggested Reading

- ERM Vibration Motors
- LRA Vibration Motors
- Haptics
- Solutions for Haptics
- How Devices Provide Haptic Feedback

1: "AB-020 : UNDERSTANDING LINEAR RESONANT ACTUATOR CHARACTERISTICS." Application Note. Https://www.precisionmicrodrives.com. N.p., n.d. Web. 29 Nov. 2016.

Using the SparFun DRV2605L Library

To use the SparkFun Haptic Motor Driver, you will need some supporting software. If you use Arduino, then you are in luck! We created an Arduino Library that makes the DRV2605L easy to use. To add the library from the Arduino IDE simply navigate to Sketch >> include Library >> manage libraries and search for SparkFun Haptic Motor Driver.

The SparkFun DRV2605L library has every register defined, and simple functions can be called to create a custom haptic experience. Every register must be set (or use the default if that works for you). Use the data sheet to help you with the values that need to be written to the registers.

Going through the library header file, you'll see just about every register has a comment with its function and corresponding page number in the data sheet. This board is capable of operating in seven modes and can use either an LRA or ERM type motors. We will explore 2 of the modes – Internal Trigger mode, and PWM mode. From here it shouldn't take much to get the device working in other modes.

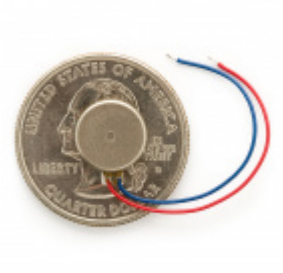
Let's explore each example in detail.

Internal Trigger Mode

The internal trigger mode allows you to play a waveform or a custom waveform sequence from the ROM waveform memory. In this example we will play all 123 waveform effects by loading them in all eight waveform sequencer registers. This simple sketch will also help you become familiar with the effects library so you can start to build your own custom effects sequences. See page 60 of the datasheet for the full list of waveform effects. Each library – listed on page 14 of the datasheet – has its own rated voltage, rise-time and brake-time.

Parts Needed

SparkFun RedBoard - Programmed with Arduino
◉ DEV-13975

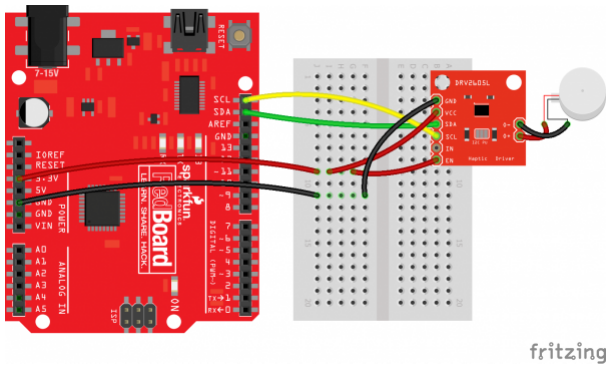


Vibration Motor
◉ ROB-08449

Jumper Wires Premium 6" M/M Pack of 10
◉ PRT-08431

SparkFun Haptic Motor Driver - DRV2605L
○ ROB-14538

Hardware Connection



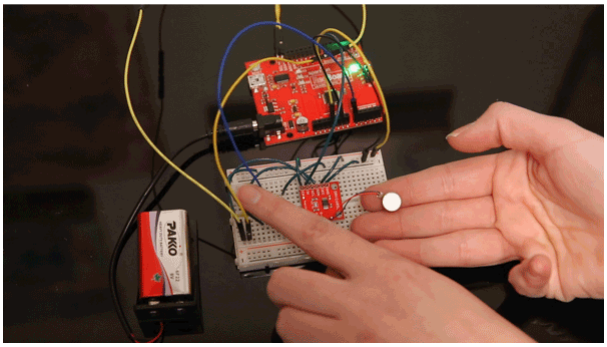
The hardware consists of the standard I^2C connection and the enable (EN) pin must be pulled high.

Arduino Program

```
#include <Sparkfun_DRV2605L.h> //SparkFun Haptic Motor Driver Library
#include <Wire.h> //I2C library

SFE_HMD_DRV2605L HMD; //Create haptic motor driver object

void setup()
{
  HMD.begin();
  Serial.begin(9600);
  HMD.Mode(0); // Internal trigger input mode -- Must use the GO() function to trigger playback.
  HMD.MotorSelect(0x36); // ERM motor, 4x Braking, Medium loop gain, 1.365x back EMF gain
  HMD.Library(2); //1-5 & 7 for ERM motors, 6 for LRA motors

}
void loop()
{
  int seq = 0; //There are 8 sequence registers that can queue up to 8 waveforms
  for(int wave = 1; wave <=123; wave++) //There are 123 waveform effects
  {
     HMD.Waveform(seq, wave);
     HMD.go();
     delay(600); //give enough time to play effect
     Serial.print("Waveform Sequence:      ");
     Serial.println(seq);
     Serial.print("Effect No.:      ");
     Serial.println(wave);

    if (wave%8==0) //Each Waveform register can queue 8 effects
    {
        seq=seq+1;
    }
    if (wave%64==0) // After the last register is used start over
    {
        seq=0;
    }
  }
 }
```

PWM & Analog Input Mode Example: Light Vibes

In this example project, we are going to control an ERM motor based on analog input from a photocell that gets mapped to a range from 0-255 and uses that result to set the pulse width modulation of an output pin connected to the IN/TRIG pin on the Haptic Motor Driver. This project will give haptic effects based on the amount of ambient light in an area.



Waving your hand over the photoresistor turns off the motor, and, when you move your hand away, you can feel the ramping effects as the PWM signal increases with the amount of light detected.

Parts Needed

In addition to the basics like hook-up wire, you'll also need the following parts:

SparkFun RedBoard - Programmed with Arduino
◉ DEV-13975

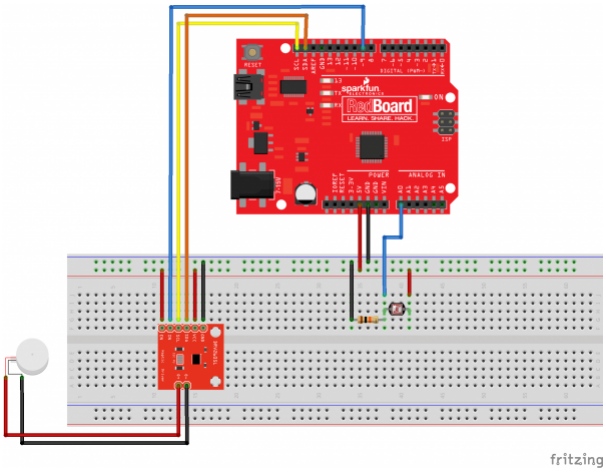
Mini Photocell
◉ SEN-09088

Vibration Motor
◉ ROB-08449

SparkFun Haptic Motor Driver - DRV2605L
○ ROB-14538

Resistor 10k Ohm 1/6th Watt PTH
COM-08374

The Circuit



Arduino Sketch

```
// Control the vibration of an ERM motor
// using PWM and a photoresistor.

#include <Sparkfun_DRV2605L.h>
#include <Wire.h>

SFE_HMD_DRV2605L HMD;
const int analogInPin = A0;  // Analog input pin that the sensor is attached to
const int analogOutPin = 9; // Analog output pin that the Haptic Motor Driver is attached to

int sensorValue = 0;        // value read from the sensor
int outputValue = 0;        // value output to the PWM (analog out)


void setup()
{
  HMD.begin();
  Serial.begin(9600);
  HMD.Mode(0x03); //PWM INPUT
  HMD.MotorSelect(0x0A);
  HMD.Library(7); //change to 6 for LRA motors

}
void loop()
{

 // read the analog in value:
  sensorValue = analogRead(analogInPin);
  // map it to the range of the analog out:
  outputValue = map(sensorValue, 0, 1023, 0, 255);
  // change the analog out value:
  analogWrite(analogOutPin, outputValue);

  // print the results to the serial monitor:
  Serial.print("sensor = ");
  Serial.print(sensorValue);
  Serial.print("\t output = ");
  Serial.println(outputValue);

  // wait 2 milliseconds before the next loop
  // for the analog-to-digital converter to settle
  // after the last reading:
  delay(2);
 }
```

Resources and Going Further

Now that you have been through three of modes of operation, try out the other four and use an LRA motor! How will you add haptics to your next project?

Here are are the numerous resources and documents mentioned through out this tutorial.

- DRV2605L Data Sheet

- Haptic Motor Driver GitHub Repository
- Haptic Motor Driver Schematic

For more motor-related fun, check out these other great SparkFun tutorials:

Big Easy Driver Hookup Guide
How to get started with the SparkFun Big Easy Driver.

Easy Driver Hook-up Guide
Get started using the SparkFun Easy Driver for those project that need a little motion.

Stepoko: Powered by grbl Hookup Guide
Hardware guide for the Stepoko

Spectacle Example: Super Mario Bros. Diorama
A study in building an animated diorama (with sound!) using Spectacle electronics.