

Sensor & Actuator Modules

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Introductory Medical Device Prototyping

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Modules

- ▶ Arduino compatible board & kit
- ▶ LEDs, switches and potentiometers
- ▶ Sensors – environmental & physical monitoring, motion sensing, user interface
- ▶ Special purpose – meter, clock and camera
- ▶ Wireless
- ▶ Actuators – servo & motor

Building Prototypes

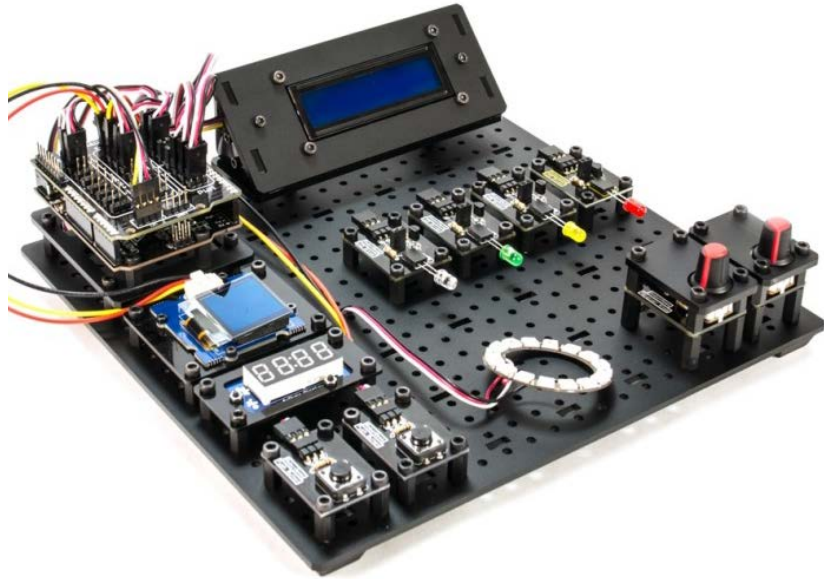
- ▶ Ready-made modules can simplify your prototype construction.
- ▶ Published software *sketches* can serve as a guide or base from which you can write your own program.
- ▶ Modules connect with the microcontroller board via analog, digital or communication ports – SPA, I²C, serial UART and Wifi.
- ▶ The following companies supply various modules, sketches and/or example projects:
 - [Adafruit](#)
 - [Arduino](#)
 - [Digi-Key](#)
 - [EngineersGarage.com](#)
 - [Seeed WIKI – Grove](#)
 - [Phidgets Precision](#)
 - [Microchip](#)
 - [Trossen Electronics–RobotGeek](#)
 - [Sharp](#)
 - [SparkFun](#)
 - *Many other components are available on Amazon and EBay.*

- ▶ Individual parts can be purchased locally at [Axman](#) surplus store on University Ave., or ordered from Digi-key.



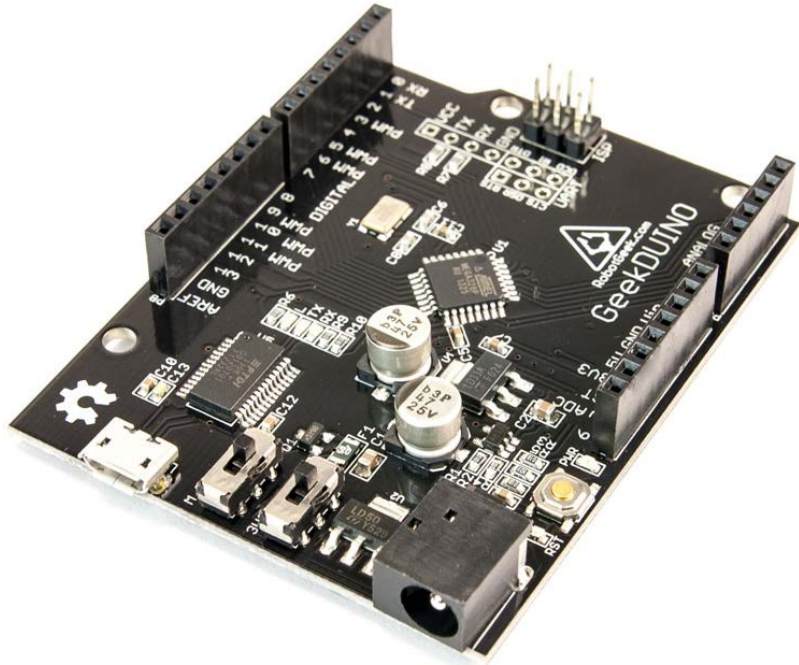
- ▶ Specialized Dupont connectors, crimps, wire and ribbon cable are available from me for module to microcontroller board interconnections.
- ▶ The following slides are illustrative of some of the modules available.

RobotGeek “Workbench” Kits



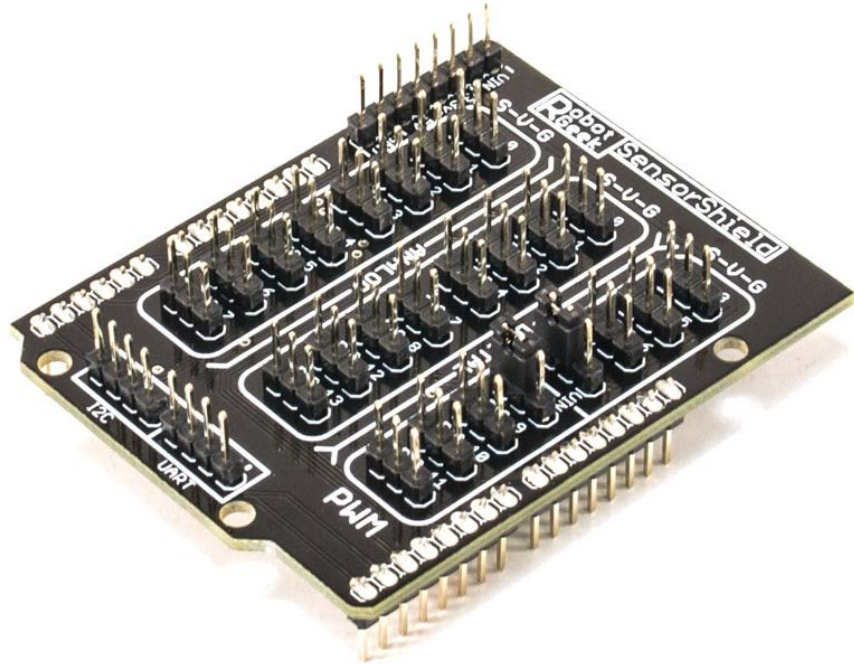
- ▶ Modular style placement of microcontroller, shield and sensors.
- ▶ Surface area: 21 X 22 CM
- ▶ All Robot Geek products and kits conform to a standard 1 X 1 CM hole pattern grid.

RobotGeek Geekduino



- ▶ Compatible with the Arduino Duemilanove and uses the ATmega 328, the same chip as the Arduino Uno.
- ▶ Used with the RobotGeek kits.

RobotGeek Sensor Shield



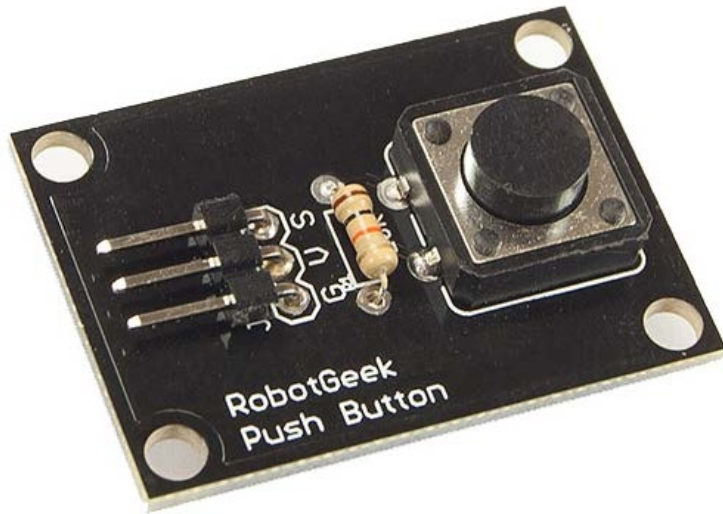
- ▶ Fits atop the Arduino board.
- ▶ 3-Pin connectors to RobotGeek sensors and other sensors, actuators and output boards.
- ▶ 14 Digital I/O Channels
- ▶ 6 Analog Input Channels
- ▶ Power selector jumpers for PWM channels
- ▶ UART and I²C 4-pin connectors
- ▶ Vin, 5v, 3.3v and Ground power breakout

Sensor Cables



- ▶ These cables are .1"(2.54mm) pitch and are 300mm in length with color coded wires.
- ▶ Come in packages of 10.
- ▶ 3-pin compatible with RobotGeek Sensor cables.

RobotGeek Pushbutton



- ▶ Simple pushbutton with pull-up resistor.
- ▶ You will need to add components or software debounce.

RobotGeek Joystick



- ▶ Optional mushroom or stick style controls.
- ▶ Potentiometer-based.
- ▶ Mounting hole pattern is 1 x 1 cm
- ▶ RobotGeek compatible.

RobotGeek Slider



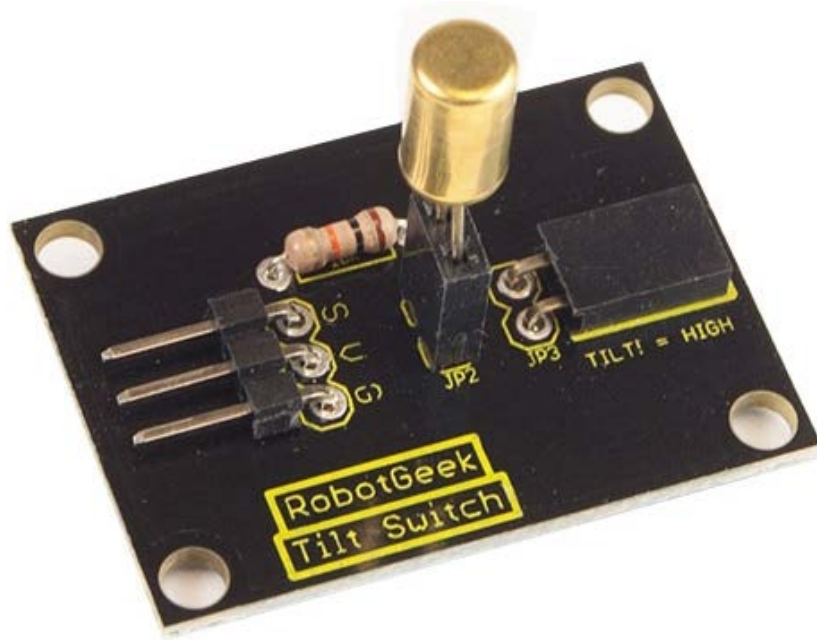
- ▶ Slide potentiometer for projects requiring a linear analog input.

RobotGeek Rotation Knob



- ▶ Potentiometer – a variable resistor with center tap.

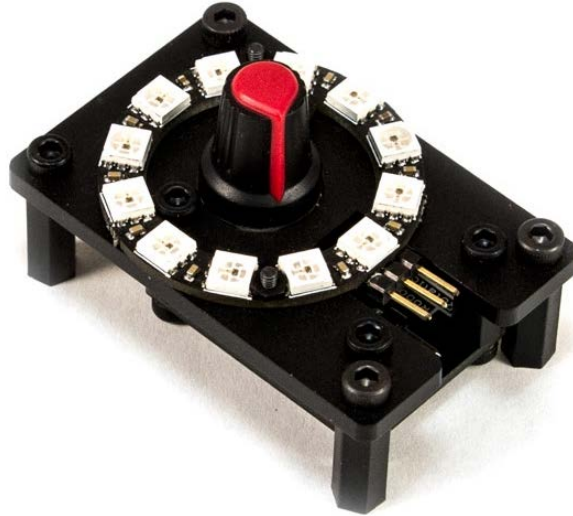
RobotGeek Tilt Switch



- ▶ Uses a digital input and allows determination if the object it is mounted to is tilted.

NeoPixel Lighted Rotary Switch

Git-Hub



Example
.ino file

Watch
.5m

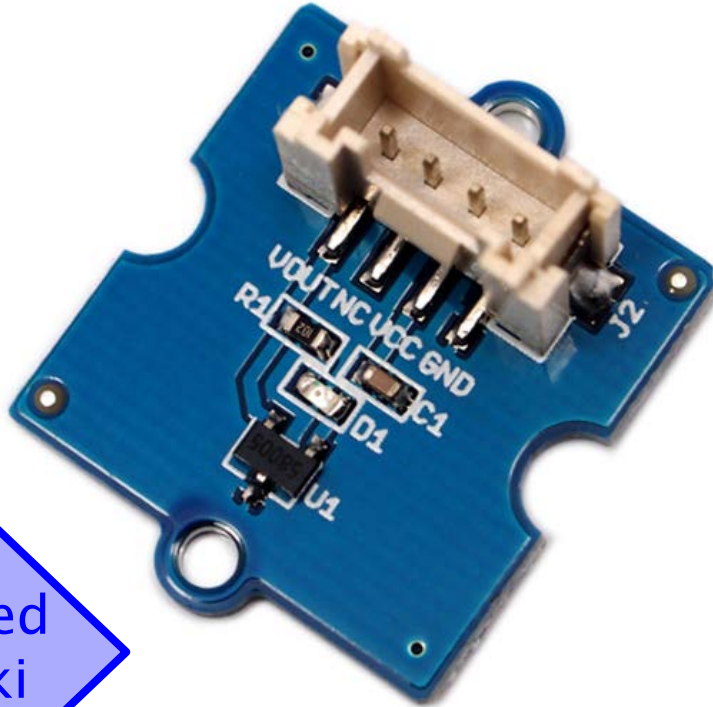
- ▶ RobotGeek Compatible mount.
- ▶ Single-wire-based LED pixels.
- ▶ Analog output of switch position.
- ▶ Uses Adafruit_NeoPixel.h library

Floor Mat Switch



- ▶ Two strips of metal apart with thin squares of foam in-between them every .75 inches.
- ▶ The pairs of metal strips are spaced out 2.5 inches from each other for the length of the mat.
- ▶ When someone steps on the mat their weight presses the two metal strips together creating a closed contact.
- ▶ All the strips are connected down both sides of the mat creating one large switch.
- ▶ Can be trimmed into smaller units.

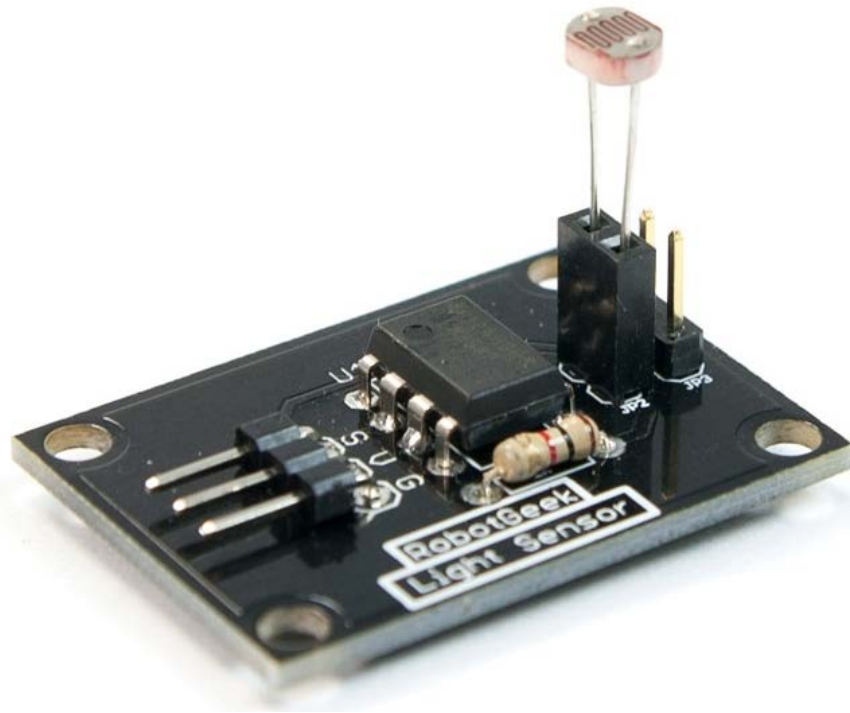
Hall Effect Sensor Switch



seeed
Wiki

- ▶ A Hall effect switch that turns on and off depending on the presence of a magnetic field.
- ▶ 400ns transition period for rise and fall
- ▶ Continuous-time hall effect sensor
- ▶ 20mm by 24mm

RobotGeek Light Sensor



- ▶ Analog output will be proportional to the light intensity.

Light Sensor



- ▶ For use with the Phidgets 8/8/8 kit.
- ▶ Response Time Max: 2ms
- ▶ Peak Sensitivity Wavelength: 625 nm
- ▶ Light Level Min: 1 lux
- ▶ Light Level Max(5v): 1000 lux
- ▶ Light Current Ratio: 1.2
- ▶ Device Current Consumption: 5 mA
- ▶ Output Impedance: 1K ohms
- ▶ Bandwidth / Reaction Time: 50 Hz
- ▶ Minimum / Maximum Voltage: 2.4VDC to 5.5VDC
- ▶ Operating Temp Min: -40°
- ▶ Operating Temp Max: 85°

Robot Geek Temperature Sensor

Git-Hub

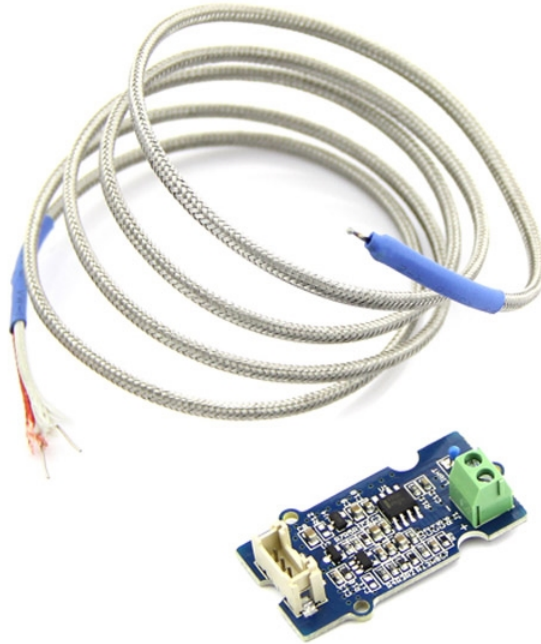


- ▶ RobotGeek compatible.
- ▶ Voltage Input: 2.7 V to 5.5 VDC
- ▶ 10 mV/°C scale factor
- ▶ $\pm 2^\circ\text{C}$ accuracy over temperature
- ▶ $\pm 0.5^\circ\text{C}$ linearity
- ▶ Operating Range: -40°C to $+125^\circ\text{C}$

High Temperature Sensor

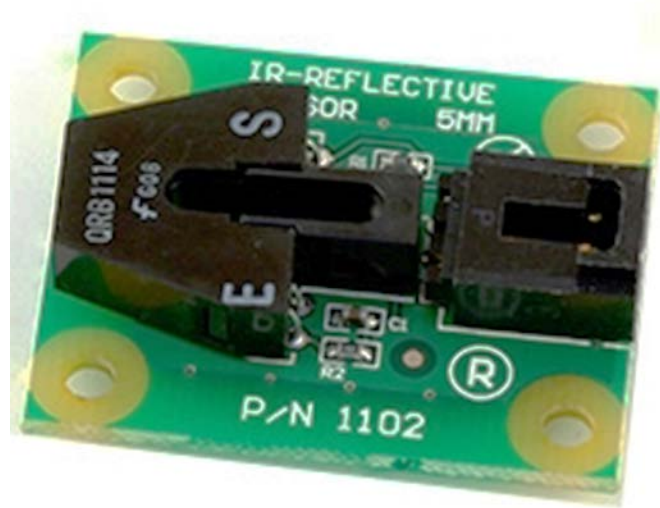
Git-Hub

seed
Wiki



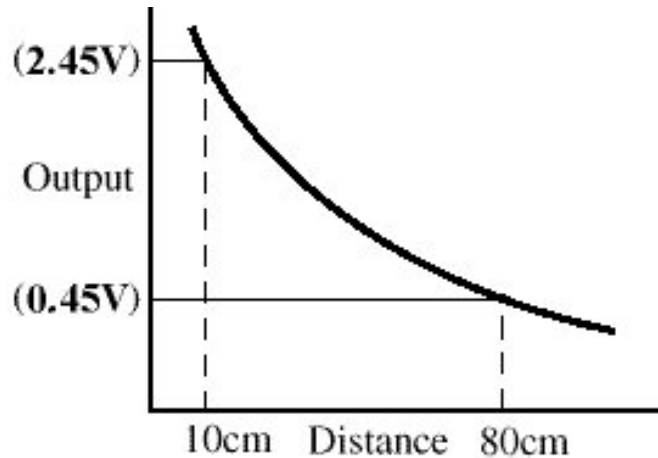
- ▶ Thermocouples are very sensitive, requiring a good amplifier with a cold-compensation reference.
- ▶ K type thermocouple for temperature detection, with a Thermistor
- ▶ The detectable range of this Sensor is -50°C to 600°C (-58°F to 1112°F), and the accuracy is rated at $\pm(2.0\% + 2^{\circ}\text{C})$.

IR Reflective Sensor



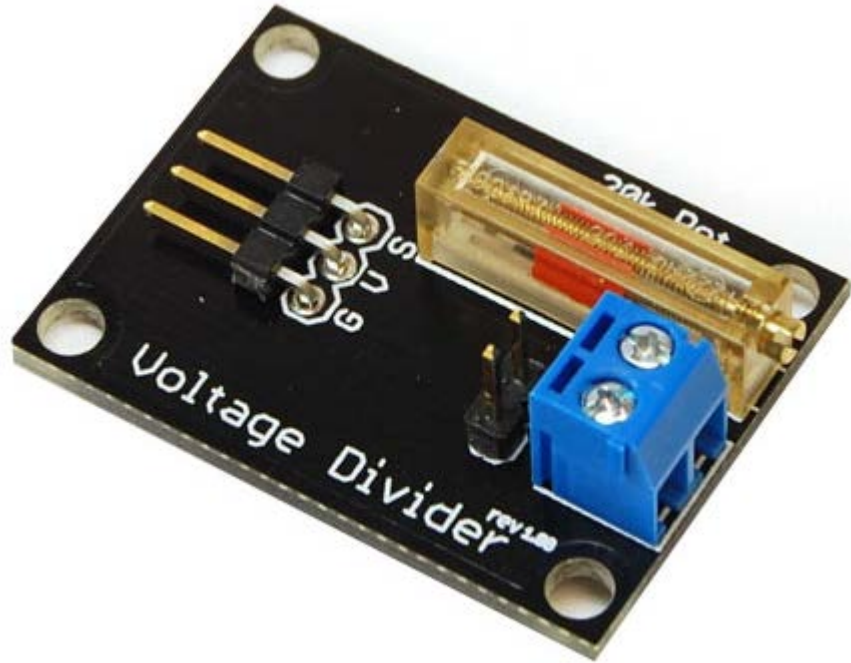
- ▶ Made to connect to the Phidgets 8/8/8 Interface
- ▶ Based on the QRB1114 sensor.
- ▶ It can be used to determine the difference between black (low reflective conditions) and white (high reflective conditions).

Sharp IR Distance Sensor



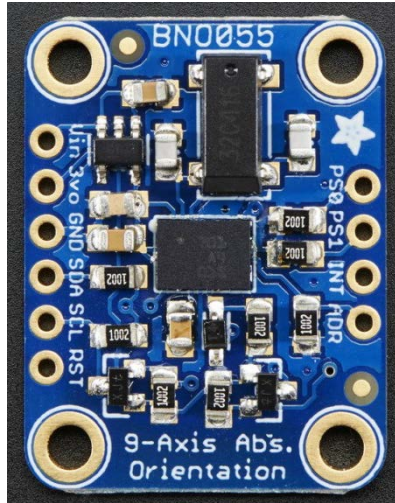
- ▶ Detects distances from 4" to 30" (10cm–80cm).
- ▶ Sharp IR GP2Y0A21YK0F.
- ▶ Graph shows output voltage relative to distance.

RobotGeek Voltage Divider



- ▶ Use with any sensor that has variable resistance.
- ▶ The “fixed” resistor is an adjustable potentiometer on the board.
- ▶ Sensors may plug into the top or connect by wire to the blue terminal block.

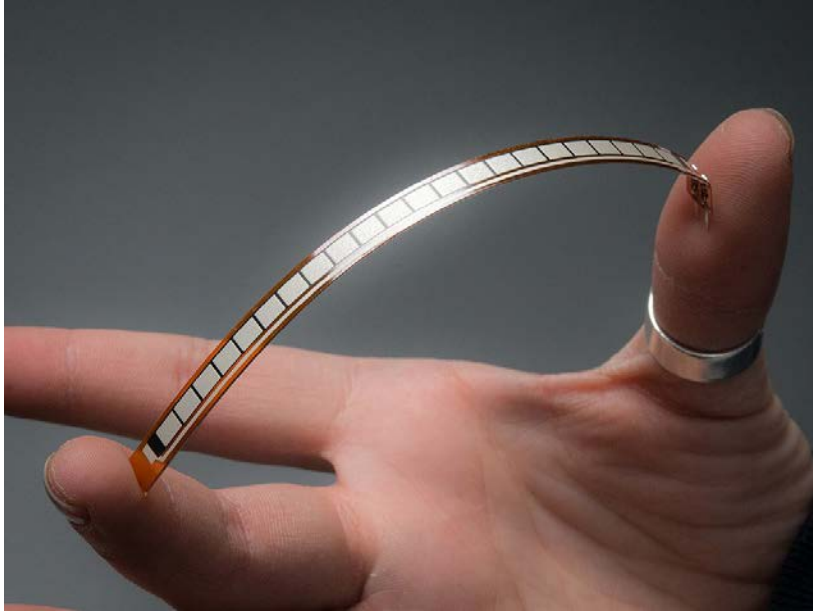
Adafruit 9-DOF Absolute Orientation Sensor BN0055



Adafruit BN0055 Features...

- ▶ Absolute Orientation (Euler Vector, 100Hz) Three axis orientation data based on a 360° sphere
- ▶ Absolute Orientation (Quaternion, 100Hz) Four point quaternion output for more accurate data manipulation
- ▶ Angular Velocity Vector (100Hz) Three axis of 'rotation speed' in rad/s
- ▶ Acceleration Vector (100Hz) Three axis of acceleration (gravity + linear motion) in m/s^2
- ▶ Magnetic Field Strength Vector (20Hz) Three axis of magnetic field sensing in micro Tesla (μT)
- ▶ Linear Acceleration Vector (100Hz) Three axis of linear acceleration data (acceleration minus gravity) in m/s^2
- ▶ Gravity Vector (100Hz) Three axis of gravitational acceleration (minus any movement) in m/s^2
- ▶ Temperature (1Hz) Ambient temperature in degrees celsius

Adafruit Long Flex Sensor

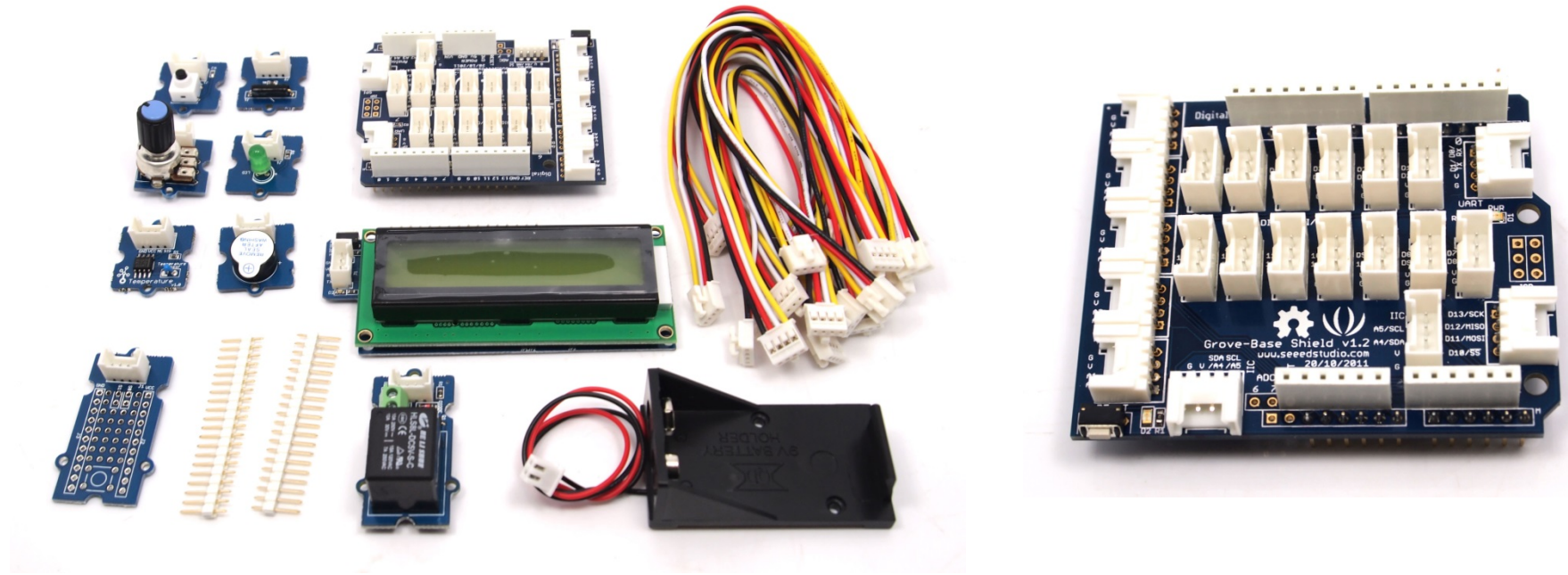


- ▶ Can detect flexing or bending in one direction.
- ▶ Basically resistors that change value based on how much they're flexed.
- ▶ If they're unflexed, the resistance is about $\sim 10\text{K}\Omega$.
- ▶ When flexed all the way the resistance rises to $\sim 20\text{K}\Omega$.

Leap Features...

- ▶ Tracks hands, fingers, and pointable tools
- ▶ Sub-millimeter accuracy and near-zero latency
- ▶ 8 cubic feet of interactive 3D space
- ▶ 150° field of view extending above the device
- ▶ Compact device at 3" long
- ▶ Compatible with Mac, Windows, and Linux via USB
- ▶ SDKs in six programming languages
- ▶ New: Image API provides developers access to raw stereo image

Grove Kit



Grove Modules



- ▶ Button contains a pull-down resistor.
- ▶ LED has a current limiting resistor.
- ▶ Buzzer can be driven either with a digital signal or analog PWM.
- ▶ Potentiometer is 10k ohm.

Groves Environmental Monitoring Modules



Grove - Digital Light Sensor



Grove - Light Sensor



Grove - Temperature and Humidity Sensor



Grove - Barometer Sensor



Grove - Dust Sensor



Grove - Gas Sensor



Grove - Temperature Sensor



Grove - Air Quality Sensor



Grove - Temperature and Humidity Sensor Pro



Grove - Gas Sensor(O₂)



Grove - HCHO Sensor



Grove - Temp&Humi Sensor (SHT31)



Grove - Grove - Barometer Sensor (BMP280)



Grove - Grove - Barometer Sensor(BME280)

Groves Physical Monitoring Modules #1



Grove - Hall Sensor



Grove - Infrared temperature sensor



Grove - Ultrasonic Ranger



Grove - Rotary Angle Sensor



Grove - Serial Camera



Grove - Chest Strap Heart Rate Sensor



Grove - Ear-clip Heart Rate Sensor



Grove - Loudness Sensor



Grove - UV Sensor



Grove - Serial MP3 Player



Grove - 80cm Infrared Proximity Sensor



Grove - Mini Camera



Grove - PH Sensor



Grove - GSR Sensor

Grove Physical Monitoring Modules #2



Grove - Water Sensor



Grove - Magnetic Switch



Grove - Alcohol Sensor



Grove - RTC



Grove - Differential Amplifier



Grove - Electricity Sensor



Grove - Sound Sensor



Grove - IR Distance Interrupt



Grove - Tilt Switch



Grove - Encoder



Grove - I2C Color Sensor



Grove - Sound Recorder



Grove - Moisture Sensor



Grove - PIR Motion Sensor



Grove - Infrared Reflective Sensor

Grove Motion Sensor Modules



Grove - 3-Axis Digital Compass



Grove - 3-Axis Digital Accelerometer($\pm 1.5g$)



Grove - 3-Axis Digital Gyro



Grove - Collision Sensor



Grove - 3-Axis Analog Accelerometer



Grove - 3-Axis Digital Accelerometer($\pm 16g$)



Grove - 6-Axis Accelerometer and Compass V1.0



Grove - Single Axis Analog Gyro

Grove User Interface Modules #1



Grove - Solid State Relay



Grove - OLED Display 128*64



Grove - Serial LCD



Grove - LED Socket Kit



Grove - Button



Grove - Vibration Motor



Grove - LED Bar



Grove - Relay



Grove - Protoshield



Grove - Thumb Joystick



Grove - Infrared Reflective Sensor



Grove - LED Strip Driver



Grove - 4-Digit Display



Grove - OLED Display 96*96



Grove - I2C Motor Driver

Grove User Interface Modules #2



Grove - Slide Potentiometer



Grove - Chainable RGB LED



Grove - PS/2 Adapter



Grove - BlinkM



Grove - I2C Hub



Grove - I2C Touch Sensor



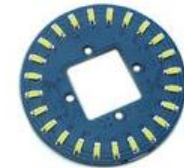
Grove - Screw Terminal



Grove - Buzzer



Grove - Servo



Grove - Circular LED



Grove - Touch Sensor



Grove - Switch(P)



Grove - Variable Color LED



Grove - Piezo Vibration Sensor



Grove - Dry-Reed Relay

Grove User Interface Modules #3



Grove - SPDT Relay(30A)



Grove - 2-Coil Latching Relay



Grove - Speaker



Grove - RJ45 Adapter



Grove - Fingerprint Sensor



Grove - Voltage Divider



Grove - NunChuck



Grove - DMX512



Grove - Flame Sensor



Grove - MOSFET



Grove-Recorder.jpg/400px-Grove-Recorder.jpg

Grove - I2C ADC



Grove - Recorder



Grove - EL Driver



Grove - LED Matrix Driver v1.0

Grove Cables



Grove - Universal 4 Pin Buckled 5cm Cable(5 PCs Pack) [↗](#)



Grove - Universal 4 Pin Unbuckled 20cm Cable(5 PCs Pack) [↗](#)



Grove - Universal 4 Pin Buckled 20cm Cable(5 PCs pack) [↗](#)



Grove - Universal 4 Pin Buckled 30cm Cable(5 PCs Pack) [↗](#)



Grove - Universal 4 Pin Buckled 40cm Cable(5 PCs Pack) [↗](#)



Grove - Universal 4 Pin Buckled 50cm Cable(5 PCs Pack) [↗](#)



Grove - Branch Cable(5PCs pack) [↗](#)



Grove - Branch Cable for Servo (5PCs pack) [↗](#)



Grove - 4 Pin 2.54 Female Jumper Wire(5 PCs pack) [↗](#)



Grove - Electronic brick 3 pin to Grove 4 pin converter cable(5 PCs pack) [↗](#)

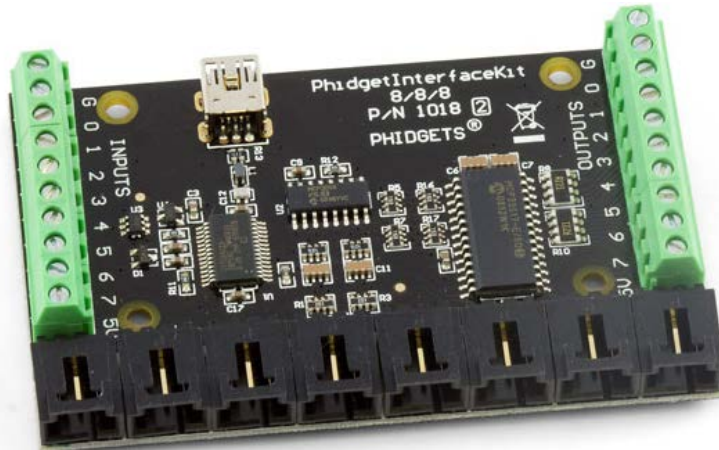


Grove - Electronic brick 4 pin to Grove 4 pin converter cable(5 PCs pack) [↗](#)

These tiny connectors are difficult to build and may need to be ordered separately.

Phidgets Interface Kit 8/8/8

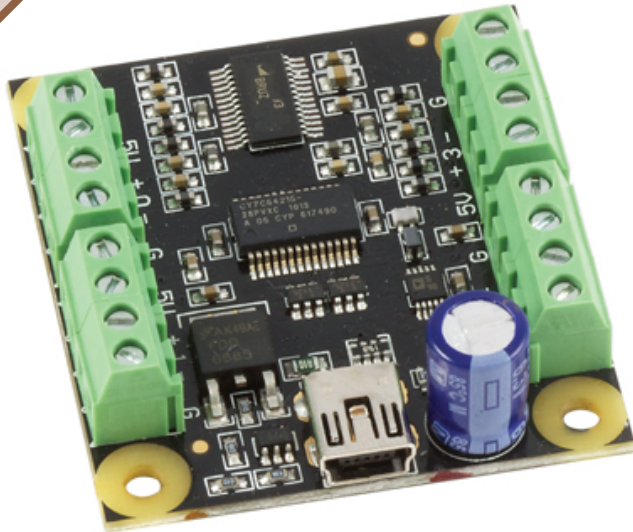
Phidgets



- ▶ 8 Analog Inputs
- ▶ 8 Digital Inputs
- ▶ 8 Digital Outputs
- ▶ The Analog Input can measure a voltage between 0V and 5V.
- ▶ The analog measurement is represented in the software as a value between 0 and 1000, so a sensor value of 1 unit represents a voltage of approximately 5 mV.

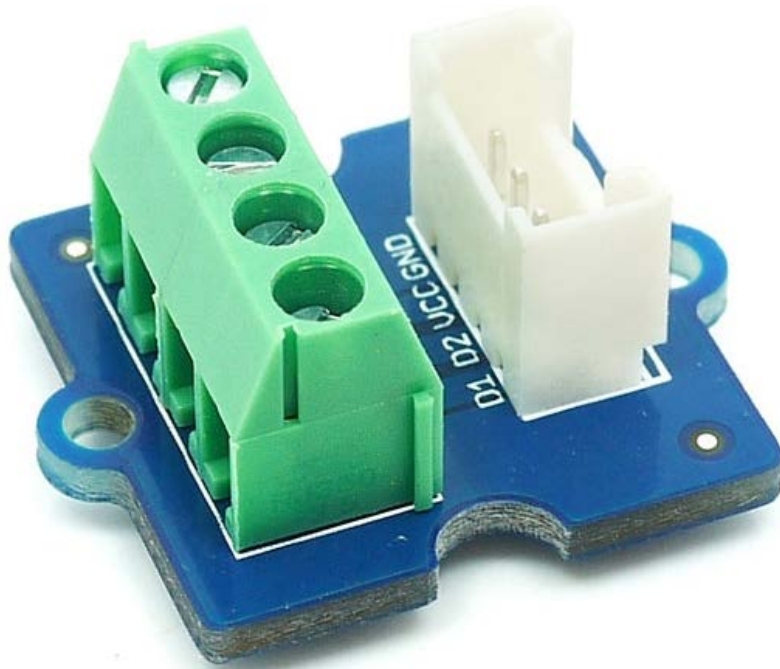
PhidgetBridge Wheatstone Bridge

Phidgets
Libraries



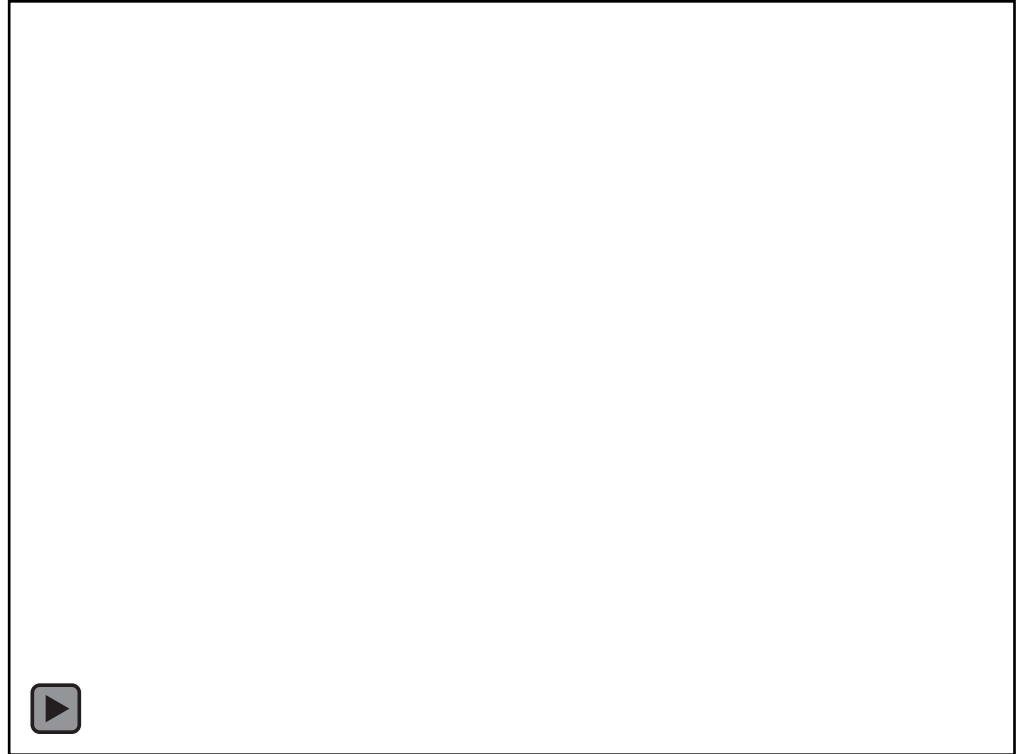
- ▶ Interfaces to up to four Wheatstone Bridge based sensors
- ▶ Great interface for Load Cells and Strain Gauges
- ▶ Mini-USB cable and hardware mounting kit included
- ▶ Can only be used by a device with a USB port / not meant to be used with microcontrollers (such as Arduino)
- ▶ Total current available to Bridge Outputs: 465mA
- ▶ Recommended wire size: 16-26AWG
- ▶ Differential voltage resolution per channel: 24 bits
- ▶ Data rates (affects all channels): 8ms to 1000ms in 8ms increments

Screw Terminal

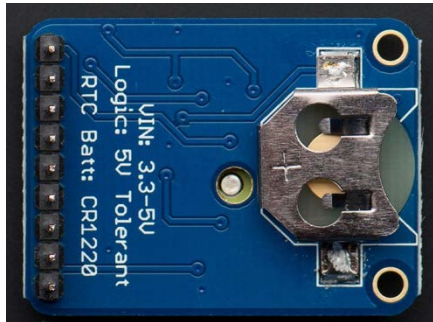
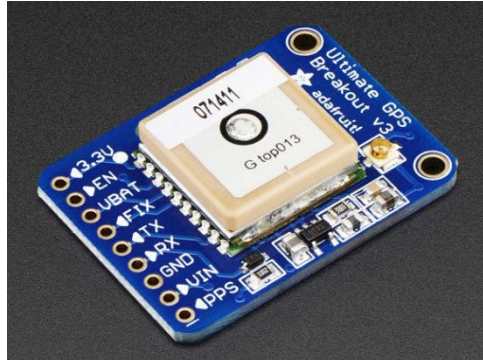


- ▶ Four 3.5mm pitch pins.
- ▶ Rating up to 125V @ 6A.
- ▶ Terminal can accept 30 to 20AWG wire.

Leap Motion Controller

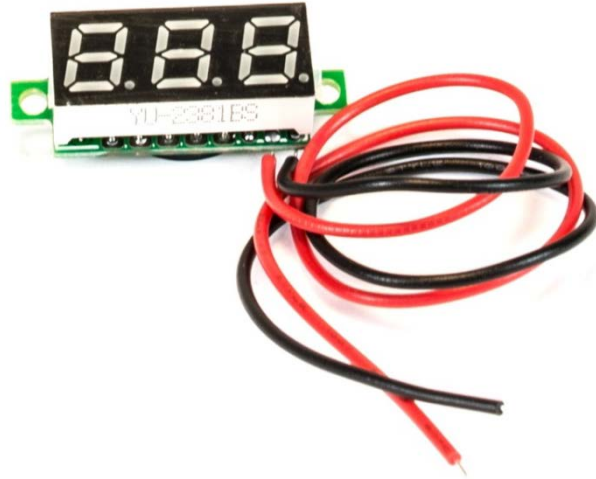


Adafruit Ultimate GPS



- ▶ -165 dBm sensitivity, 10 Hz updates, 66 channels
- ▶ 5V friendly design and only 20mA current draw
- ▶ Breadboard friendly + two mounting holes
- ▶ RTC battery-compatible
- ▶ Built-in data logging
- ▶ PPS output on fix
- ▶ Internal patch antenna + u.FL connector for external active antenna
- ▶ Fix status LED

DC Voltmeter, LED .28"



There are many voltage, current and power meters, even small oscilloscopes available on EBay. Radio City carries a number of these locally.

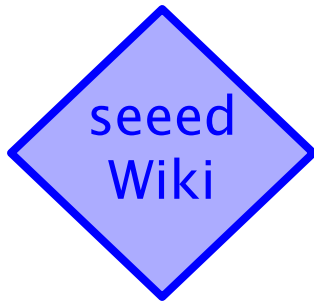
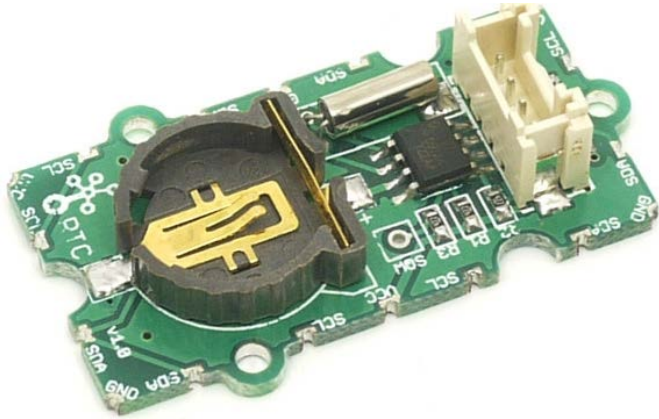
- ▶ Voltage range: 2.4~ 30V
- ▶ Work current: under 30mA
- ▶ Size: 30x11.7x9.2 mm
- ▶ Measure speed: 200ms/one time
- ▶ Accuracy : 3%.

Adafruit Panel Temperature Meter



- ▶ Separate thermistor bulb can be attached to any object.
- ▶ 4.5V to 30V DC input
- ▶ 0.1V precision
- ▶ 3–4mA draw

Grove Real Time Clock (RTC)



- ▶ Real-Time Clock (RTC) Counts Seconds, Minutes, Hours, Date of the Month, Month, Day of the week, and Year with Leap-Year Compensation Valid Up to 2100.
- ▶ 56-Byte, Battery-Backed, Nonvolatile (NV)RAM for Data Storage.
- ▶ I2C Serial Interface.
- ▶ 5V DC supply.
- ▶ Programmable Square-Wave Output Signal.
- ▶ Automatic Power-Fail Detect and Switch Circuitry.
- ▶ Consumes Less than 500nA in Battery-Backup Mode with Oscillator Running.

Pixy CMUcam5



cmucam
.org

- ▶ Vision sensor that can quickly track colored objects and report back their X/Y position to your Arduino or other microcontroller
- ▶ Communicates via SPI (default), I²C, UART serial, analog or digital.
- ▶ Capable of tracking hundreds of objects at 50 times per second.
- ▶ At any time the pixy can remember up to 7 distinct colors or 'signatures.'

XBee 1mW Communication Module



XBee 1mW



XBee Explorer Regulated



XBee Explorer USB

- ▶ Zigbee 802.15.4 wireless communication.
- ▶ Send sensory data to your pc from 300 ft.
- ▶ 2.4GHz

Grove Wireless Modules



Grove - 315MHz Simple RF Link Kit



Grove - Serial RF Pro



Grove - GPS



Grove - 125KHz RFID Reader



Grove - Serial Bluetooth



Grove - 433MHz Simple RF Link Kit



Grove - XBee Carrier



Grove - Infrared Receiver

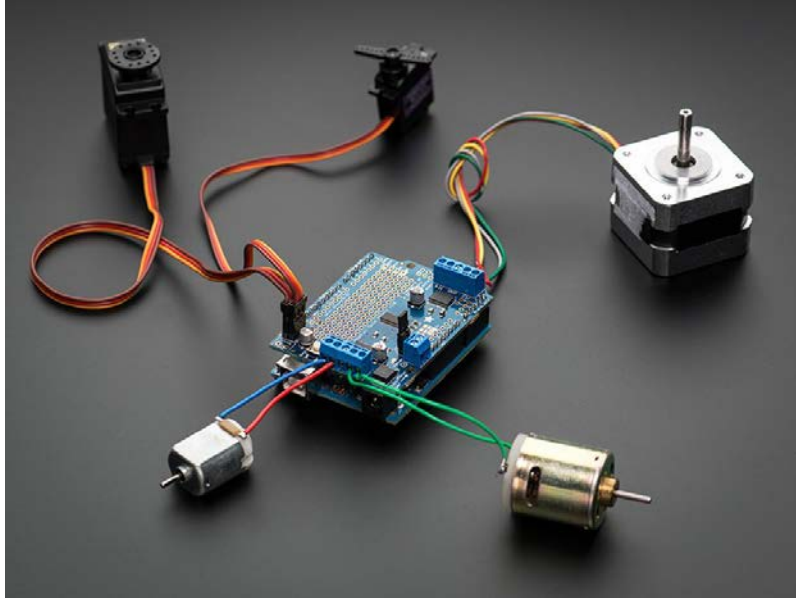


Grove - Infrared Emitter



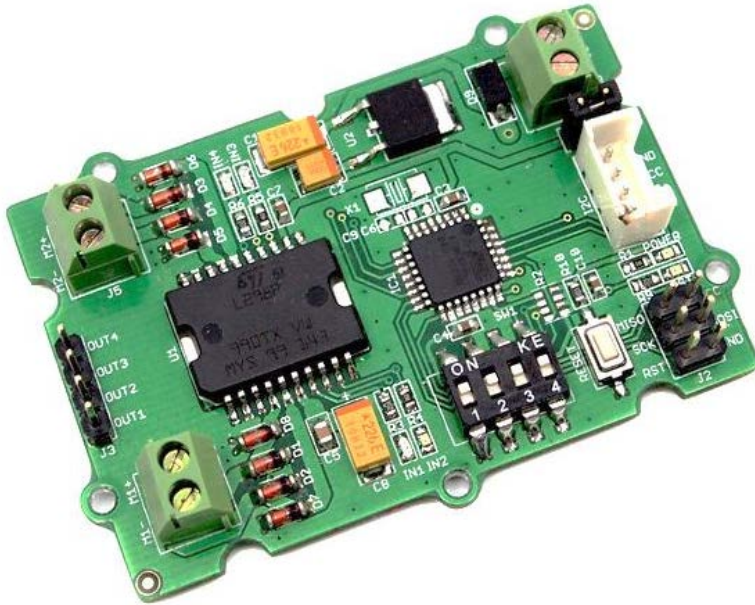
Grove - Bee Socket

Adafruit Motor/Stepper/Servo Shield for Arduino



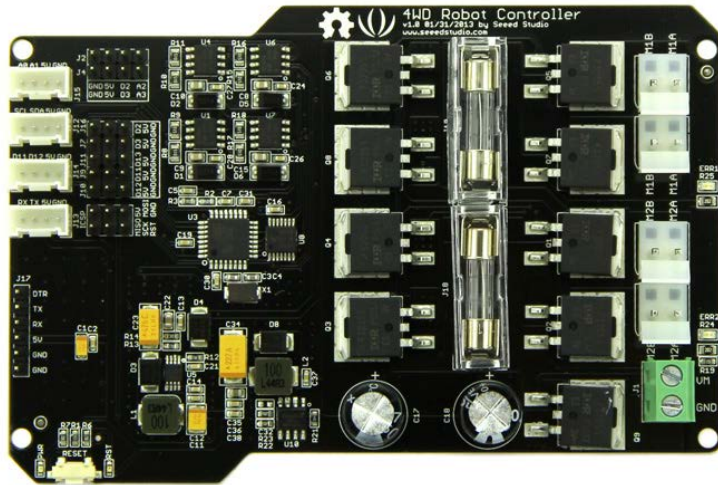
- ▶ 2 connections for 5V 'hobby' servos connected to the Arduino's high-resolution dedicated timer – no jitter!
- ▶ 4 H-Bridges: TB6612 chipset provides 1.2A per bridge (3A for brief 20ms peaks) with thermal shutdown protection, internal kickback protection diodes. Can run motors on 4.5VDC to 13.5VDC.
- ▶ Up to 4 bi-directional DC motors with individual 8-bit speed selection (so, about 0.5% resolution).
- ▶ Up to 2 stepper motors (unipolar or bipolar) with single coil, double coil, interleaved or micro-stepping.

Grove – I²C Motor Driver



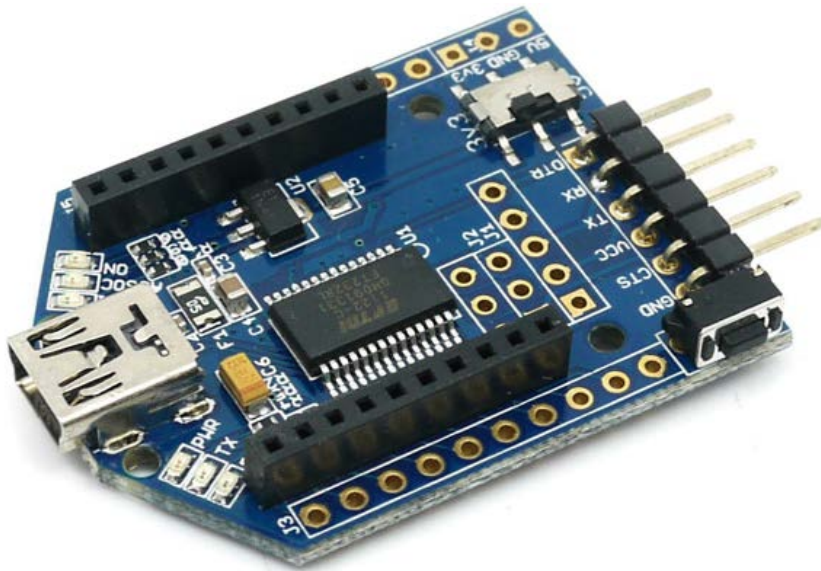
- ▶ Directly control stepper motor or DC motor.
- ▶ Dual channel H-bridge driver chip (L298N) that can handle current up to 2A per channel.
- ▶ I²C communication.
- ▶ Version 1.3 shown.

Hercules Dual Motor Controller



- ▶ Full bridge drive circuit based on MOSFET supports two independent channels, each channel up to 15A
- ▶ LED shows fuse protection status
- ▶ Several Grove ports, conveniently connect with servo, encoder and sensors
- ▶ Atmege328 controller, Arduino compatible
- ▶ Dual 15A 6–20V Motor Controller is a high current motor drive control board. Dual 15A 6–20V Motor Controller is a high current motor drive control board.
- ▶ Includes micro controller processor, motor drive circuit, charging circuit and protection circuit.

UartSBee V4



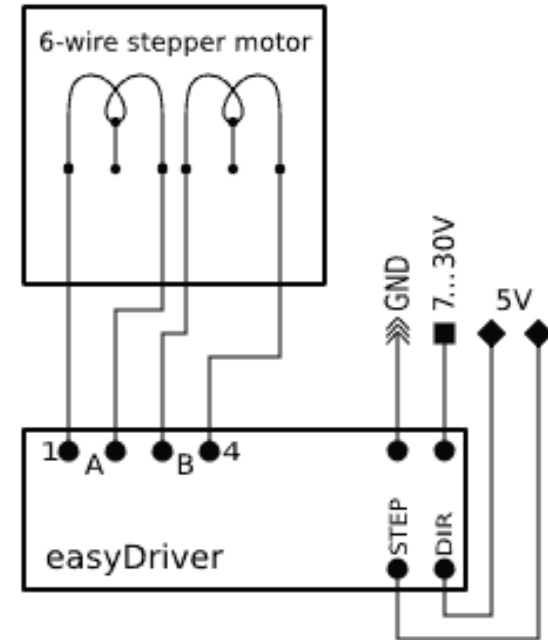
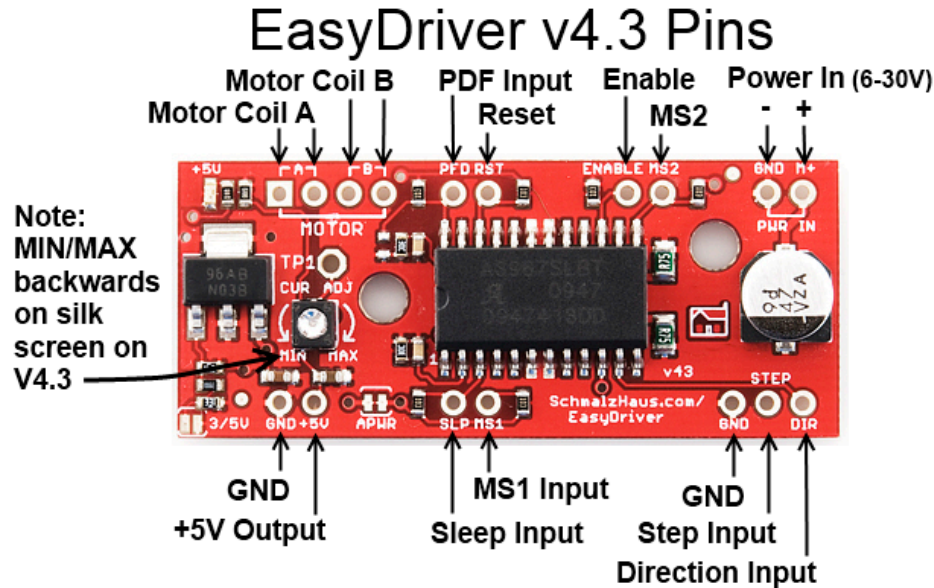
- ▶ FTDI cable compatible **USB to Serial** adapter equipped with BEE socket(20pin 2.0mm).
- ▶ The integrated **FT232RL** can be used for programming or communicating with MCUs.
- ▶ Useful for connecting the Hercules dual motor controller to your pc.

Stepper Motor Driver v2.3

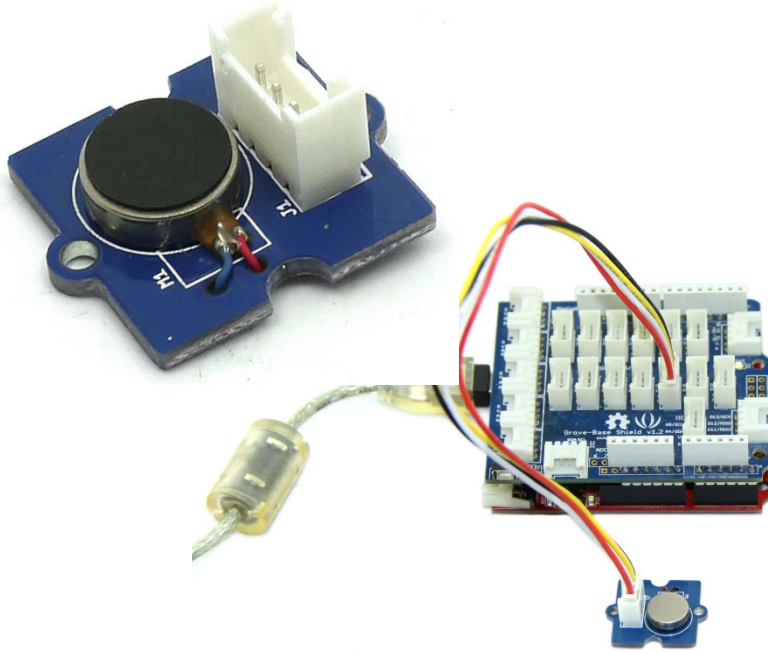


- ▶ One stepper motor, as well as receive input from two limit switches.
- ▶ It is based around the Allegro A3982 Stepper Motor Driver with Translator.
- ▶ The A3982 is capable of driving up to 2A per coil.
- ▶ Surface mount components require solder paste and hot plate to assemble.

Grove EasyDriver



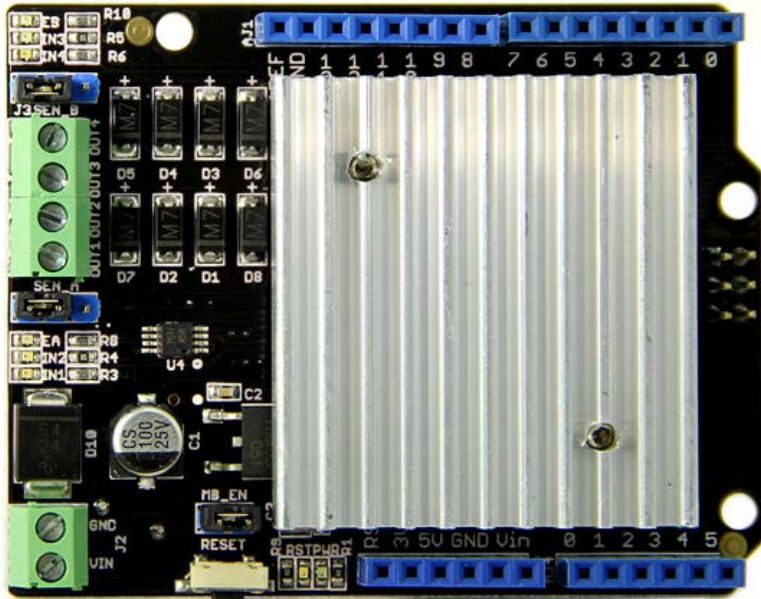
Grove – Vibration Motor



Grove – Base Shield on an Arduino

- ▶ Mini vibration motor suitable as a non-audible indicator.
- ▶ When the input is HIGH, the motor will vibrate just like your cell phone on silent mode.

Grove Motor Shield



- ▶ Driver module for motors that allows you to use Arduino to control the working speed and direction of the motor.

Adafruit Plastic Water Solenoid Valve



- ▶ 1/2" Nominal NPS
- ▶ Working Pressure: 0.02 Mpa – 0.8 Mpa
- ▶ Working Temperature: 1 °C – 75 °C
- ▶ Response time (open): ≤ 0.15 sec
- ▶ Response time (close): ≤ 0.3 sec
- ▶ Actuating voltage: 12VDC (but we found it would work down to 6V)
- ▶ Actuating life: ≥ 50 million cycles
- ▶ Weight: 4.3 oz
- ▶ Dimensions: 3" x 2.25" x 2"

Summary

- ▶ Arduino compatible board & kit
- ▶ LEDs, switches and potentiometers
- ▶ Sensors – environmental & physical monitoring, motion sensing & user interface
- ▶ Special purpose – meter, clock and camera
- ▶ Wireless data recording
- ▶ Actuators – servo & motor