SunFounder Components

www.sunfounder.com

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CONTENTS

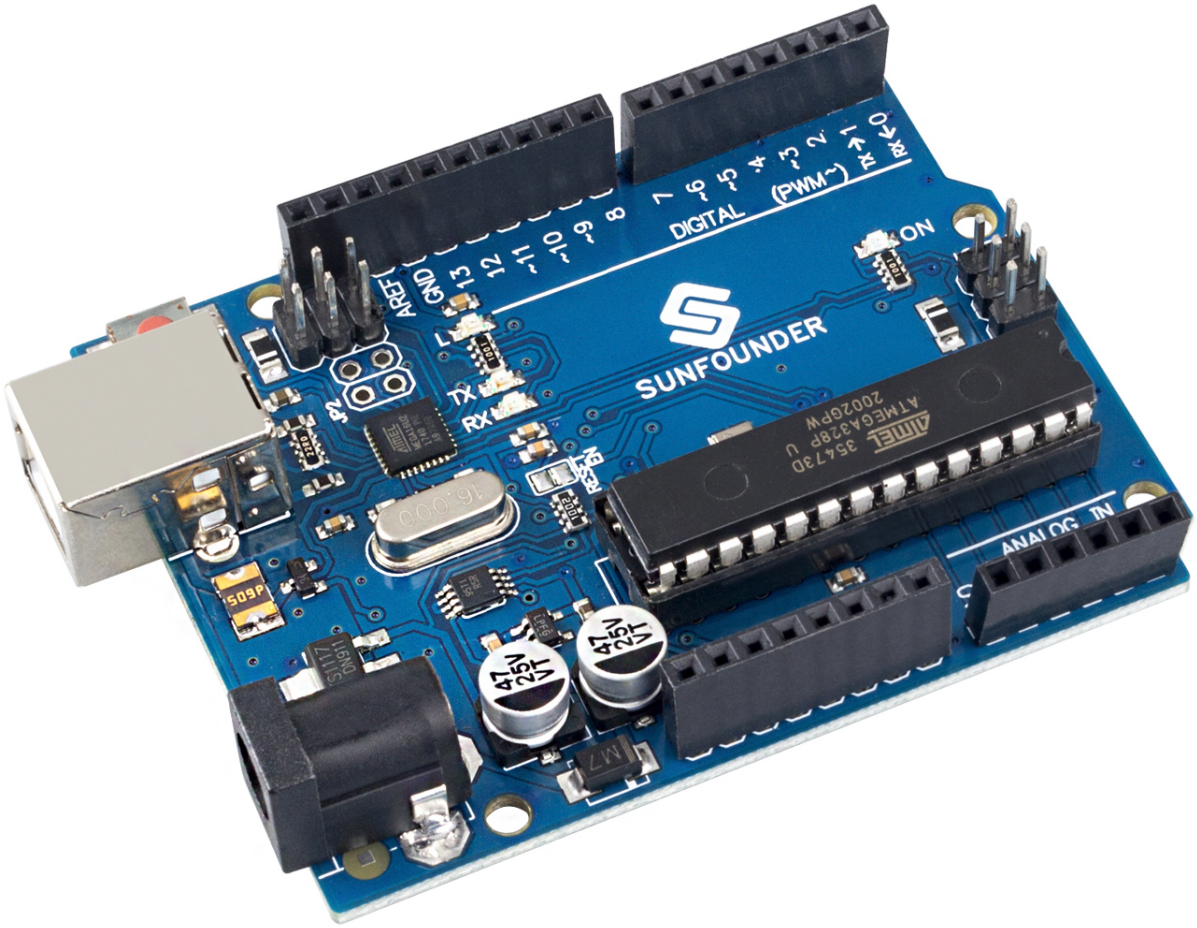
Below is the introduction to each component, which contains the operating principle of the component and the corresponding projects.

Control Board

CHAPTER

ONE

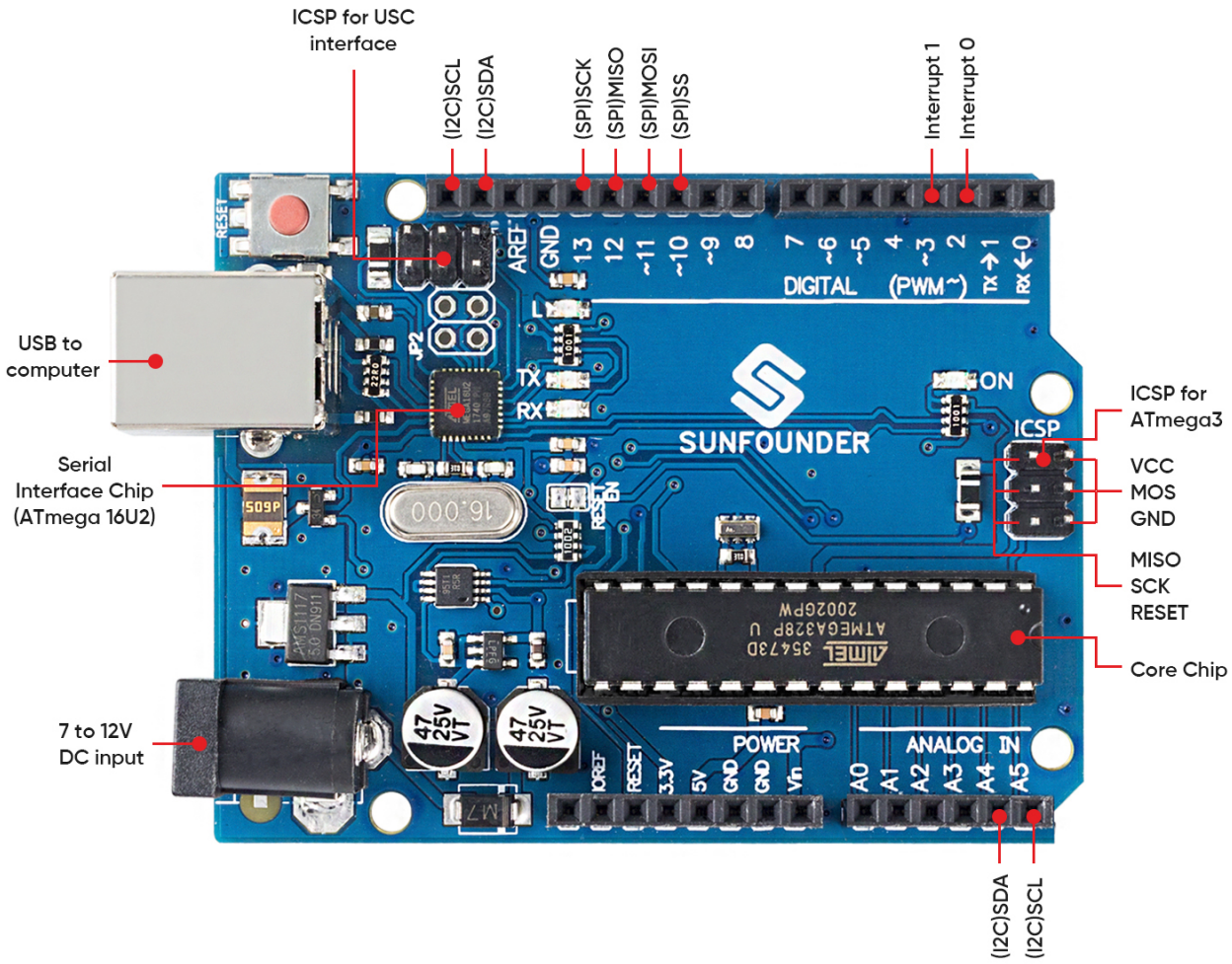
SUNFOUNDER R3 BOARD



Note: The SunFounder R3 board is a mainboard with almost the same functions as the Arduino Uno, and the two boards can be used interchangeably.

SunFounder R3 board is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

Technical Parameters



- MICROCONTROLLER: ATmega328P
- OPERATING VOLTAGE: 5V
- INPUT VOLTAGE (RECOMMENDED): 7-12V
- INPUT VOLTAGE (LIMIT): 6-20V
- DIGITAL I/O PINS: 14 (0-13, of which 6 provide PWM output(3, 5, 6, 9-11))
- PWM DIGITAL I/O PINS: 6 (3, 5, 6, 9-11)
- ANALOG INPUT PINS: 6 (A0-A5)
- DC CURRENT PER I/O PIN: 20 mA
- DC CURRENT FOR 3.3V PIN: 50 mA
- FLASH MEMORY: 32 KB (ATmega328P) of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328P)
- EEPROM: 1 KB (ATmega328P)
- CLOCK SPEED: 16 MHz
- LED_BUILTIN: 13
- LENGTH: 68.6 mm

- WIDTH: 53.4 mm
- WEIGHT: 25 g
- I2C Port: A4(SDA), A5(SCL)

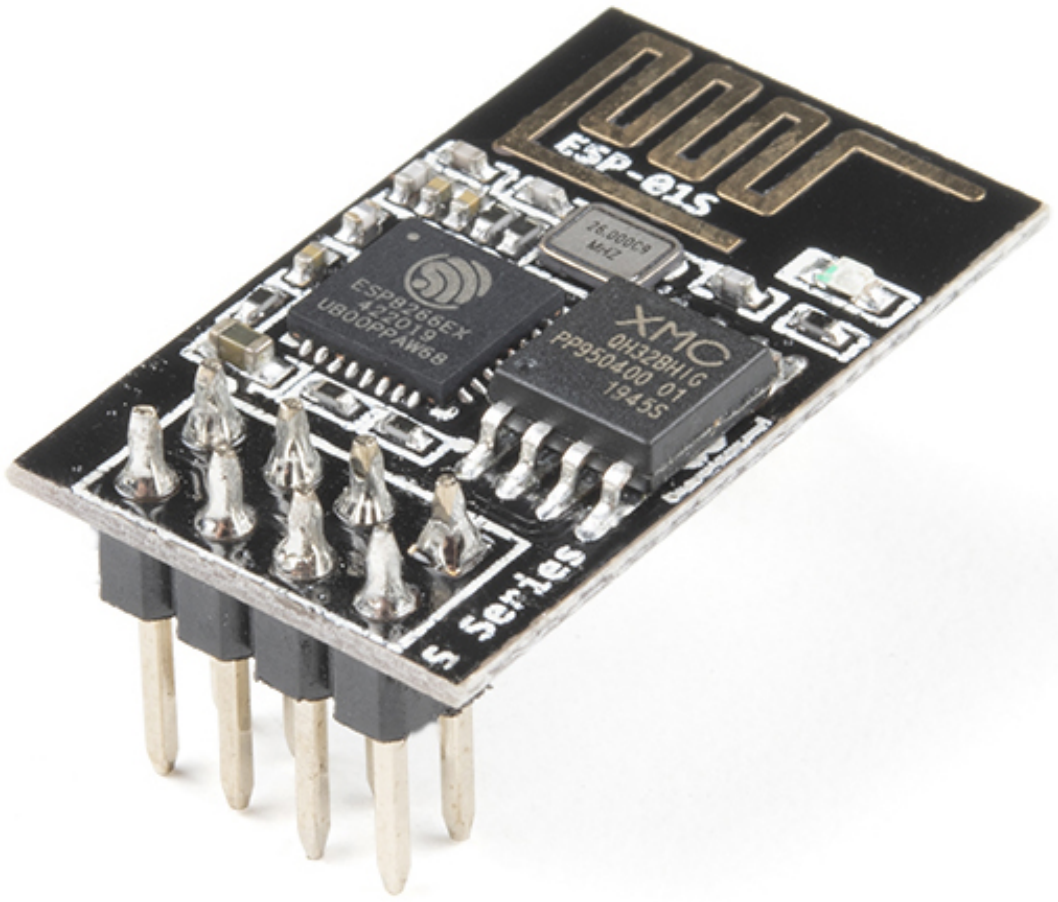
What's More

- Arduino IDE
- Arduino Programming Language Reference
- install_arduino
- ATmega328P Datasheet

CHAPTER

TWO

ESP8266 MODULE



The ESP8266 is a low-cost Wi-Fi microchip, with built-in TCP/IP networking software, and microcontroller capability, produced by Espressif Systems in Shanghai, China.

The chip first came to the attention of Western makers in August 2014 with the ESP-01 module, made by a third-party manufacturer Ai-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. However, at first, there was almost no English-language documentation on the chip and the commands it accepted. The very low price and the fact that there were very few external components on the module, which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, the chip, and the software on it, as well as to translate the Chinese documentation.

Pins of ESP8266 and their functions:

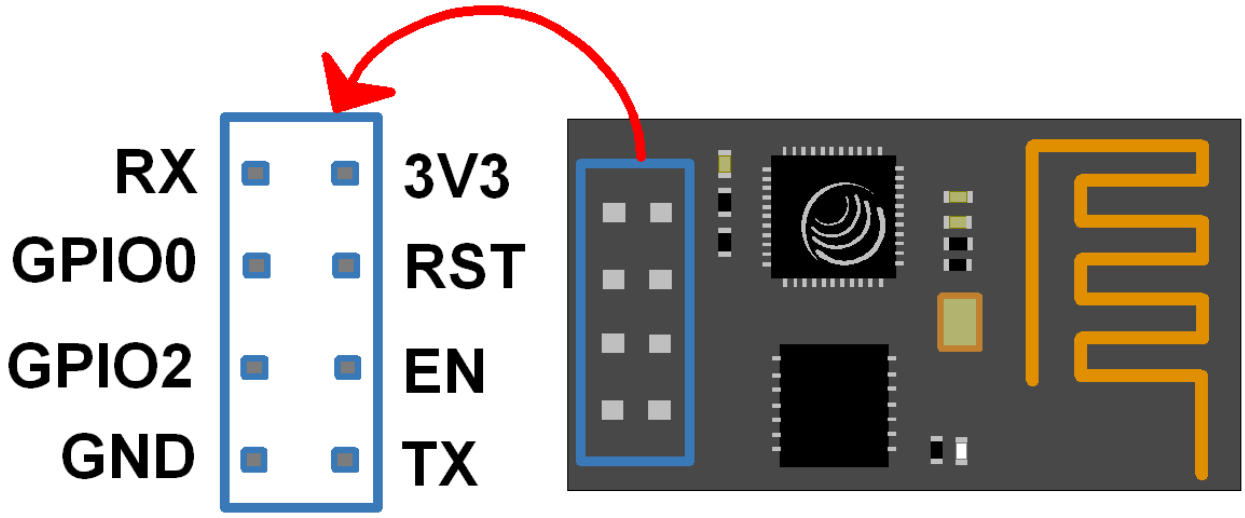
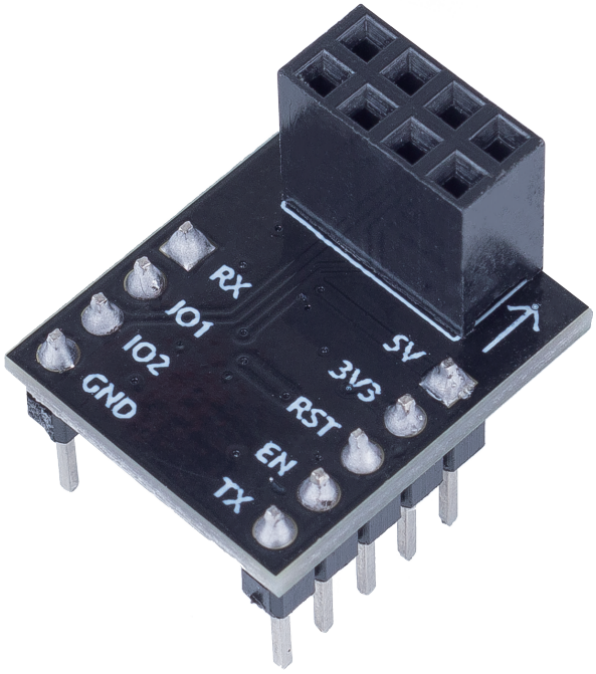


Table 1: ESP8266-01 Pins

Pin	Name	Description
1	TXD	UART_TXD, sending; General Purpose Input/Outpu: GPIO1; Pull-down is not allowed when startup.
2	GND	GND
3	CU_PD	Working at high level; Power off when low level is supplied.
4	GPIO2	It should be high level when power on, hardware pull-down is not allowed; Pull-up by default;
5	RST	External Reset signal, reset when low level is supplied; work when high level is supplied (high level by default);
6	GPIO0	WiFi Status indicator; Operation mode selection: Pull-up: Flash Boot, operation mode; Pull-down: UART Download, download mode
7	VCC	Power Supply(3.3V)
8	RXD	UART_RXDReceiving; General Purpose Input/Output: GPIO3;

- ESP8266 - Espressif
- ESP8266 AT Instruction Set

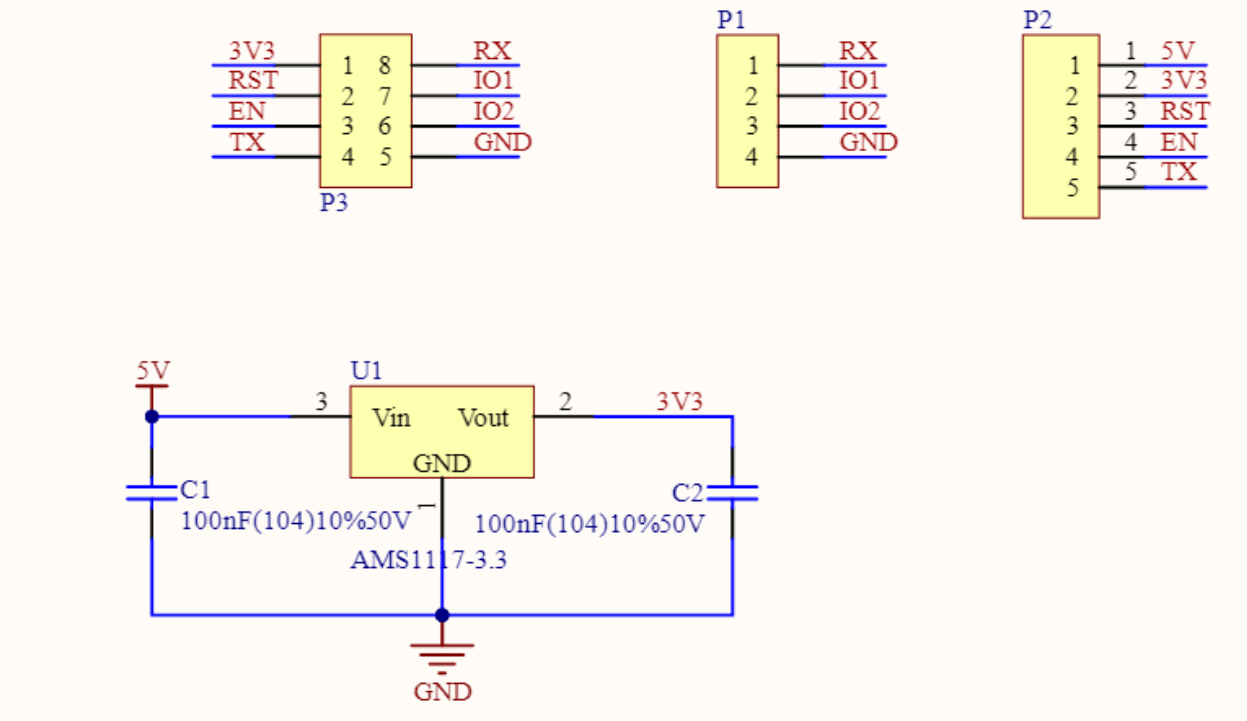
2.1 ESP8266 Adapter



The ESP8266 adapter is an expansion board that allows the ESP8266 module to be used on a breadboard.

It perfectly matches the pins of the ESP8266 itself, and also adds a 5V pin to receive the voltage from the Arduino board. The integrated AMS1117 chip is used to drive the ESP8266 module after dropping the voltage to 3.3V.

The schematic diagram is as follows:



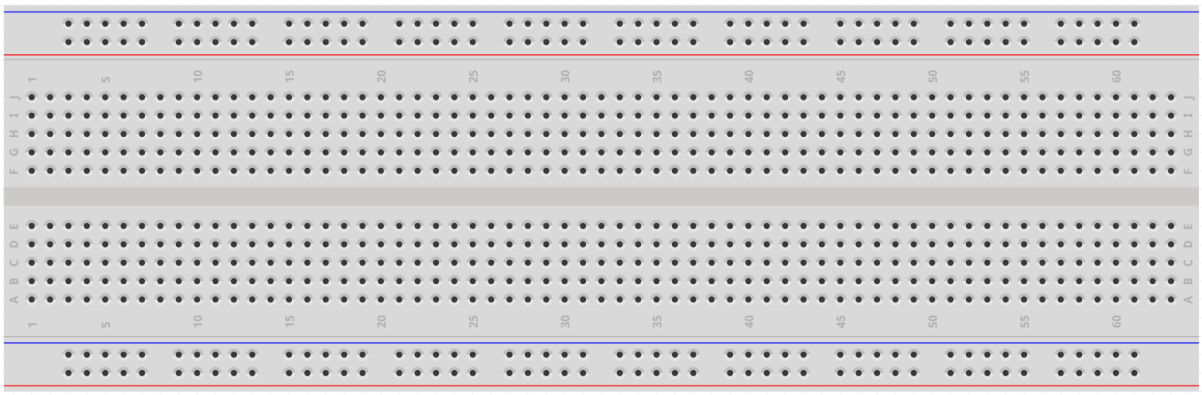
Basic

CHAPTER

THREE

BREADBOARD

What is a “solderless” breadboard?

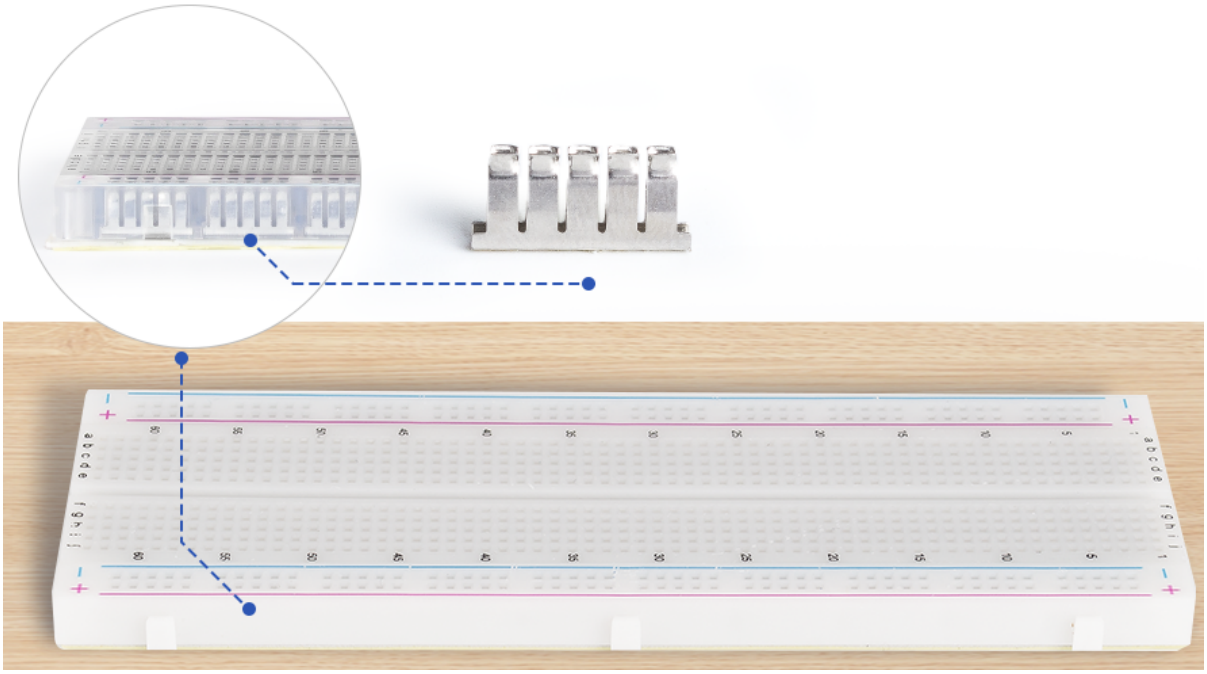


A breadboard is a rectangular plastic board with many small holes in it. These small holes allow you to easily insert electronic components to build circuits. Technically speaking, these breadboards are known as solderless breadboards because they do not require soldering to make connections.

Features

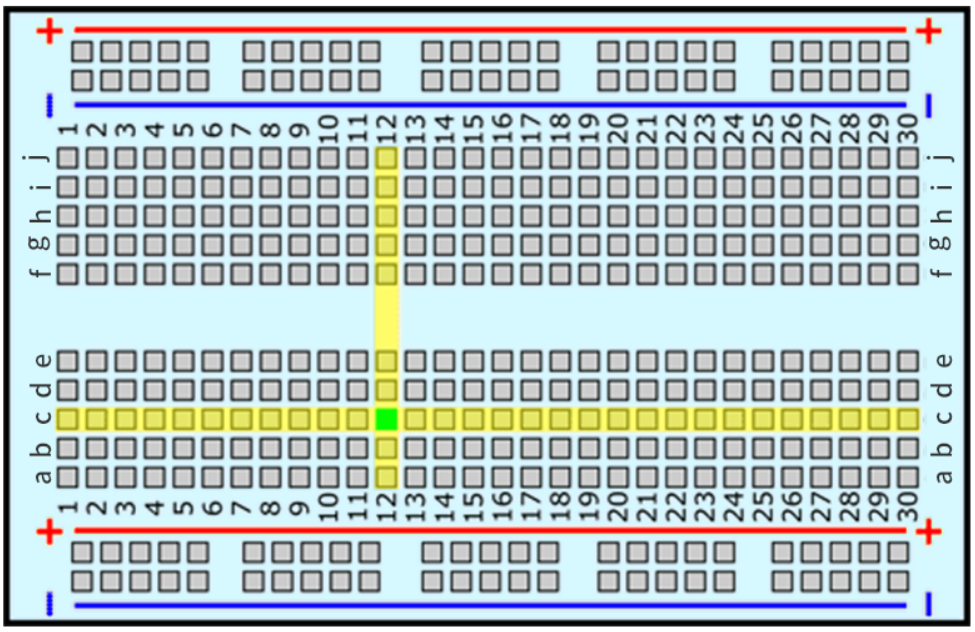
- Size: 163 x 54 x 8 mm
- 830 tie points breadboards: 630 tie-point ic-circuit area plus 2x100 tie-point distribution strips providing 4 power rails.
- Wire size: Suitable for 20-29 AWG wires.
- Material: ABS Plastic Panel, Tin Plated Phosphor Bronze Contact Sheet.
- Voltage / Current: 300V/3-5A.
- With Self-Adhesive Tape on the Back

What is in the breadboard?



The inside of the breadboard is made up of rows of small metal clips. When you insert the leads of a component into the holes of the breadboard, one of the clips catches it. Some breadboards are actually made of clear plastic, so you can see the clips inside.

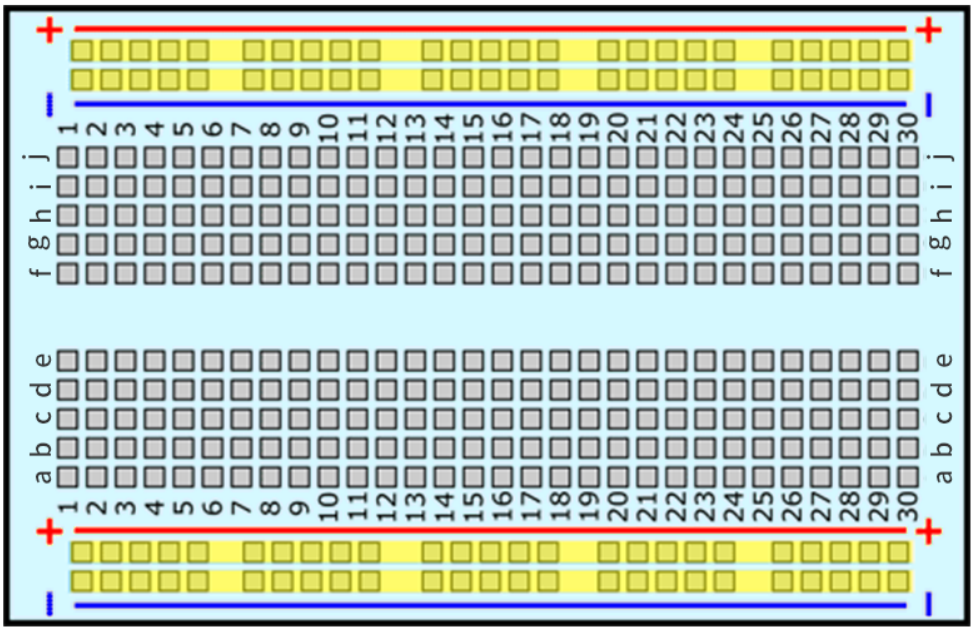
What do the letters and numbers on a breadboard mean?



Most breadboards have some numbers, letters and plus and minus signs on them. Although the labels will vary from breadboard to breadboard, the function is basically the same. These labels allow you to find the corresponding holes more quickly when building your circuit.

The row numbers and column letters help you to precisely locate the holes on the breadboard, for example, hole “C12” is where column C intersects row 12.

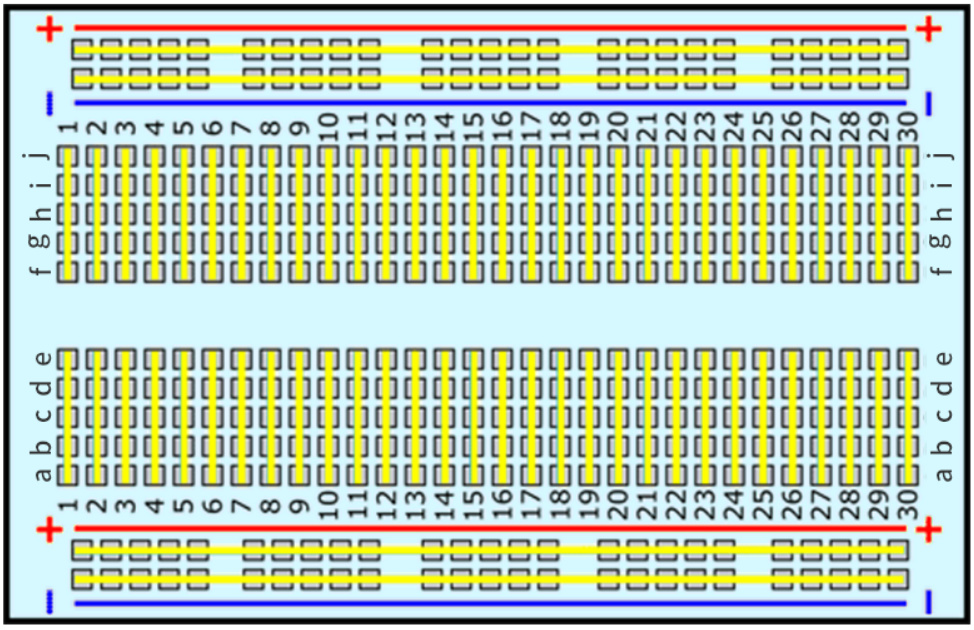
What do the colored lines and plus and minus signs mean?



The sides of the breadboard are usually distinguished by red and blue (or other colors), as well as plus and minus signs, and are usually used to connect to the power supply, known as the power bus.

When building a circuit, it is common to connect the negative terminal to the blue (-) column and the positive terminal to the red (+) column.

How are the holes connected?



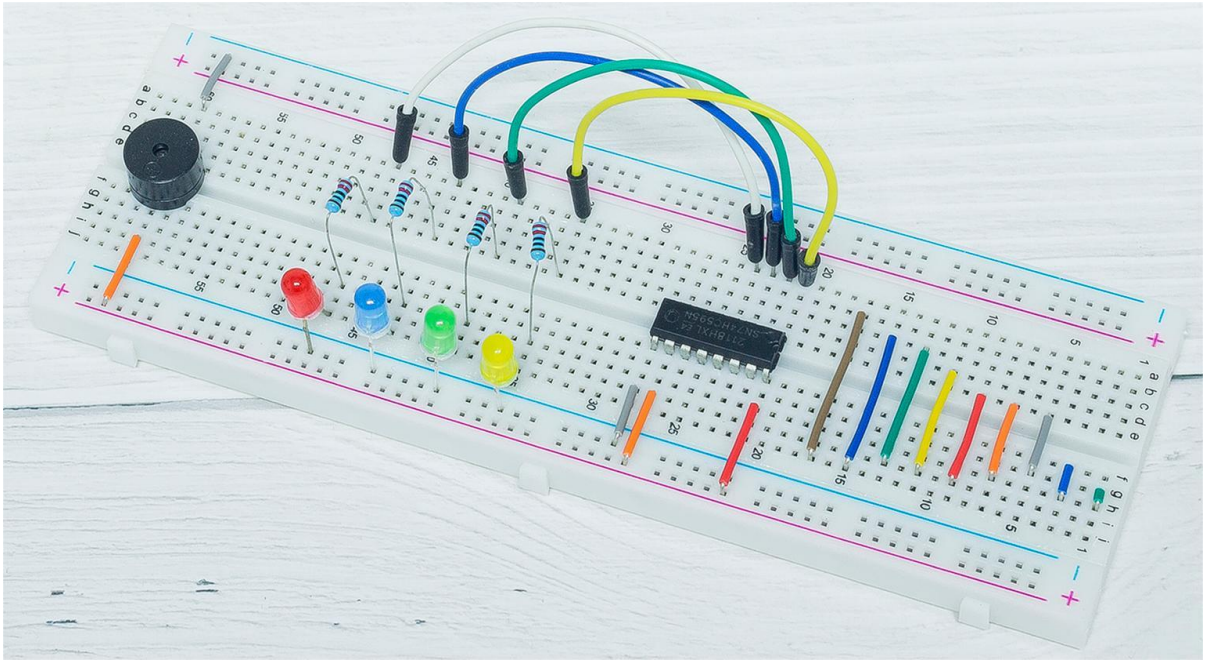
As shown in the diagram, each set of five holes in the middle section, columns A-E or F-J, is electrically connected. This means, for example, that hole A1 is electrically connected to holes B1, C1, D1 and E1.

It is not connected to hole A2 because that hole is in a different row with a separate set of metal clips. It is also not connected to holes F1, G1, H1, I1 or J1 because they are located in the other “half” of the breadboard - the clips are

not connected across the middle gap.

Unlike the middle section, which is grouped by five holes, the buses on sides are electrically connected separately. For example, the column marked blue (-) is electrically connected as a whole, and the column marked red (+) is also electrically connected.

Which electronic parts are compatible with breadboards?



Many electronic components have long metal legs called leads. Almost all components with leads will work with a breadboard. Components such as resistors, capacitors, switches, diodes, etc. can be inserted in any of the rows, but ICs need to be arranged across the middle gap.

CHAPTER

FOUR

RESISTOR

What is a resistor?

Resistor is an electronic element that can limit the branch current. A fixed resistor is a kind of resistor whose resistance cannot be changed, while that of a potentiometer or a variable resistor can be adjusted.

Features

- Tolerance ±1%
- Power (Watts): 0.25W, 1/4W
- Composition Metal Film
- Features Flame Retardant Coating, Safety
- Operating Temperature -55°C ~ 155°C
- Low cost
- Generates less noise than carbon composition resistor
- Wide operating range
- Long-term stability

Electrical Symbol

Two generally used circuit symbols for resistor. Normally, the resistance is marked on it. So if you see these symbols in a circuit, it stands for a resistor.

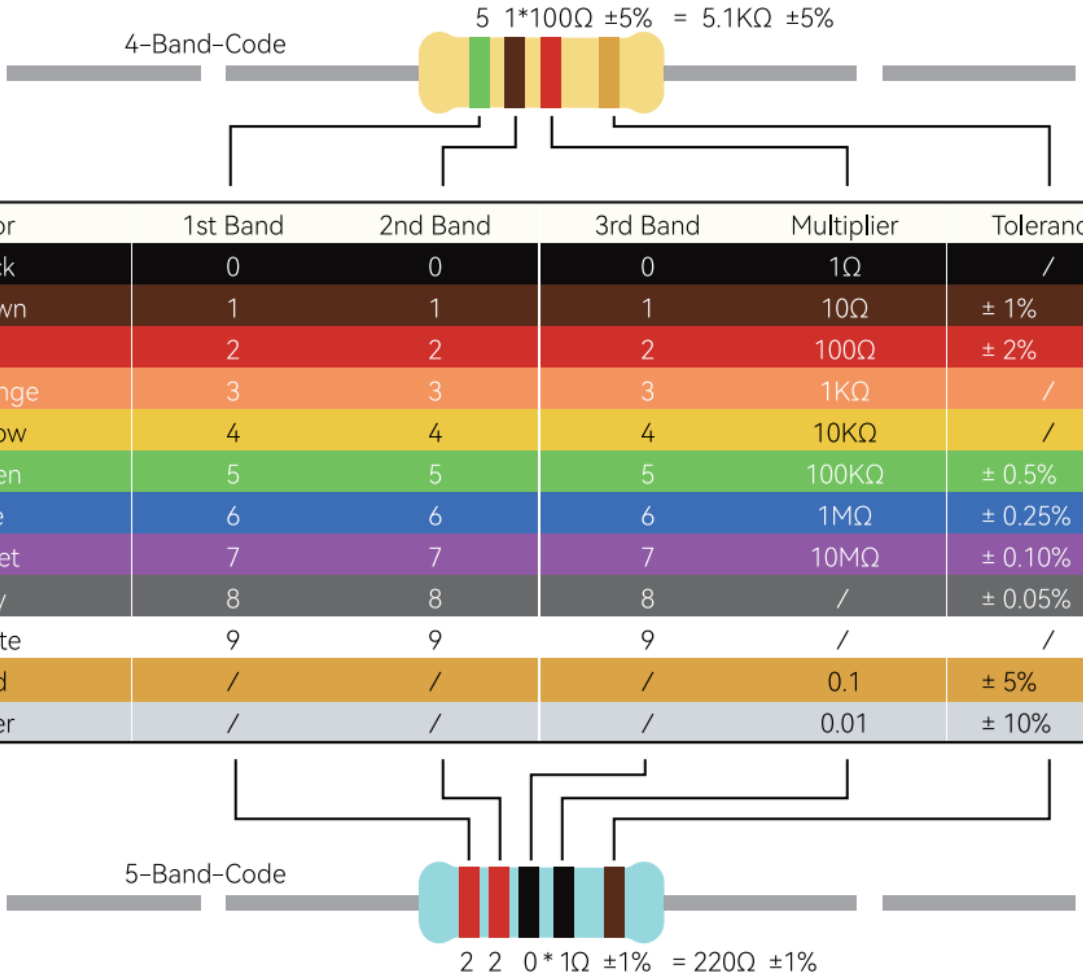
 is the unit of resistance and the larger units include K, M, etc. Their relationship can be shown as follows: 1 M=1000 K, 1 K = 1000 .

How to know the resistance?

When using a resistor, we need to know its resistance first. Here are two methods:

- Observe the bands on the resistor
- Use a multimeter to measure the resistance.

If you are familiar with the color ring table below, it is a quick and easy method by looking at the color band on the resistor. As shown in the table below, if you follow a specific method of calculation after reading the color band, it is easy to get the resistance of the resistor.

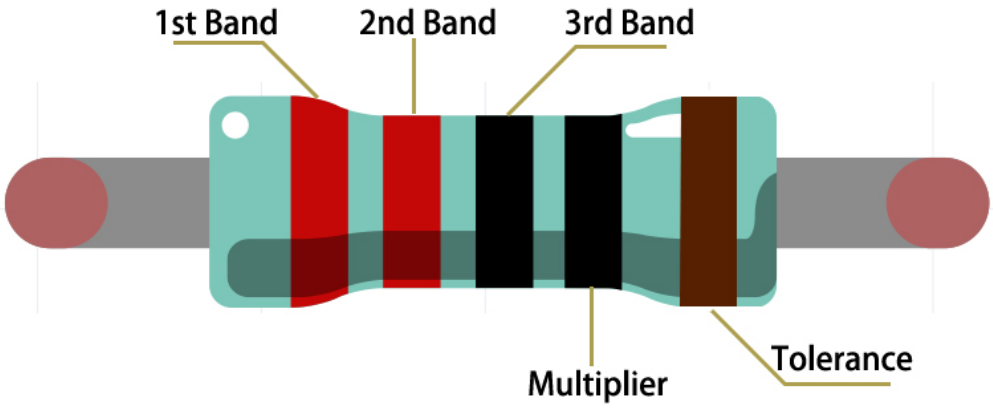


Color	1st Band	2nd Band	3rd Band	Multiplier	Tolerance
Black	0	0	0	1Ω	/
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	/
Yellow	4	4	4	10KΩ	/
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8	/	± 0.05%
White	9	9	9	/	/
Gold	/	/	/	0.1	± 5% (J)
Silver	/	/	/	0.01	± 10% (K)

Normally, when you get a resistor, you may find it hard to decide which end to start for reading the color. The tip is that the gap between the 4th and 5th band will be comparatively larger.

Therefore, you can observe the gap between the two chromatic bands at one end of the resistor; if it's larger than any other band gaps, then you can read from the opposite side.

Let's see how to read the resistance value of a 5-band resistor as shown below.



So for this resistor, the resistance is 2(red) 2(red) 0(black) x 10^0(black) = 220 , and the permissible error is ± 1% (brown).

Due to different resistor manufacturers, the color band may be a bit off, resulting in incorrect readings of the resistance value. In this case, you can also use a multimeter to check the resistance.

SunFounder general resistor color band table

Resistor	Color Band
10	brown black black silver brown
100	brown black black black brown
220	red red black black brown
330	orange orange black black brown
1k	brown black black brown brown
2k	red black black brown brown
5.1k	green brown black brown brown
10k	brown black black red brown
100k	brown black black orange brown
1M	brown black black green brown

Unit Conversion

is the unit of resistance and the larger units include K, M, etc. Their relationship can be shown as follows: 1 M=1000 K, 1 K = 1000 . Normally, the value of resistance is marked on it.

CHAPTER

FIVE

CERAMIC CAPACITOR

What is Ceramic Capacitor?

A fixed value type of capacitor where the ceramic material within the capacitor acts as a dielectric is the Ceramic Capacitor. This capacitor consists of more number of alternating layers of ceramic and also a metal layer which acts as an electrode.

It is widely used in electronic circuits because of its large dielectric constant, large specific capacity, wide operating range, good humidity resistance, high insulation resistance, good heat resistance, and low dielectric loss.

Features

- Capacitance: 10x10^4pF (0.1uF)
- Rated voltage: 50V DC
- **Nominal capacity range: 80000PF~180000PF**

  Test conditions:

  - Measurement voltage: 1±0.2Vrms
  - Frequency: 1KHZ
  - Temperature: 25±2°C(Arbitration temperature)
- Allowable deviation of capacity: +80%-20%
- Loss angle tangent: tg2.5×10-2
- Insulation resistance (IR): 10000M
- Storage: Temperature: 0-40°C, Humidity: <80%RH

Ceramic Capacitor Polarity

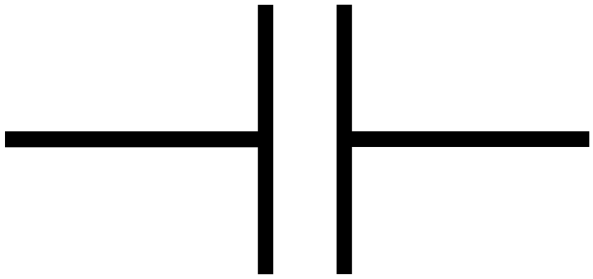
When connecting capacitors in an electric circuit, capacitor polarity is one of the most important factors to consider. Based on their polarity, capacitors can be divided into two groups:

- Polarised capacitor
- Non-polarised capacitor

Capacitors with polarization have two terminals, called anode and cathode. They must be connected in a specific order in the circuit. And when the capacitor is non-polarized, both terminals are the same and can be connected to the circuit at will.

A ceramic capacitor is a non-polarized device that is common in every electrical device.

Following is the symbol for ceramic capacitor:



Read the capacitance value

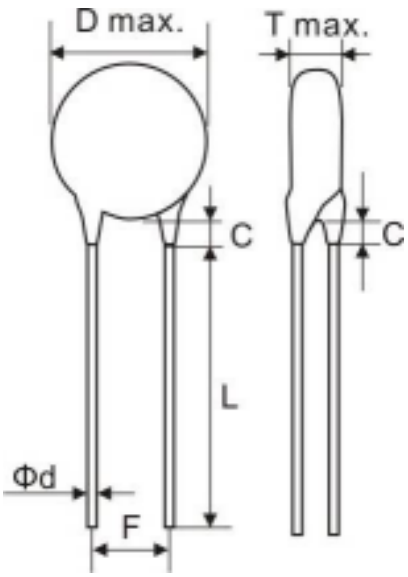
Usually ceramic capacitors have a two to three digit code printed on them.

- The first two digits describe the value of the capacitor and the last digit is a power of 10. After multiplying the first two digits together you get the capacitance value in pF.
- If there are only two digits, it means there is no multiplier, then you only need to read the value of the first two digits in picofarads.

For example:

- 104 = 10 x 10^4=100000pF
- 681 = 68 x 10^1 = 680pF

Size



- Outer diameter D: 5.0±0.3mm
- Lead length L: 14±1mm
- Lead wire width F: 2.5±0.3mm
- Wire diameter: 0.35±0.02mm
- Coating foot length C: 2.5 max

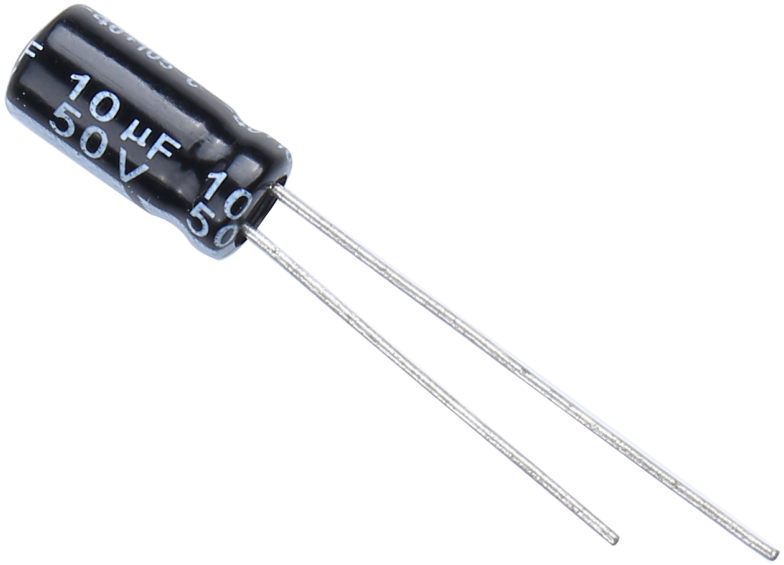
Unit Conversion

1F=10^3mF=10^6uF=10^9nF=10^12pF

CHAPTER

SIX

ELECTROLYTIC CAPACITOR



What is Electrolytic Capacitor?

A capacitor is an electronic component that stores energy in the form of electrical energy when charged, also known as a two-terminal passive component or capacitor, and is measured in Farads (F). It consists of two metal parallel plates which are separated by a gap filled with dielectric. They are of 3 types, they are fixed capacitors, polarized capacitors and variable capacitors. In the case of fixed capacitors with a fixed capacitance value, polarized capacitors have two polarities ("+ve" and "-ve"), while in variable capacitors the capacitance value can be changed according to the application.

This article focuses on electrolytic capacitors in polarized capacitors. Aluminum electrolytic capacitors are polarized capacitors in which the anode (+) terminal is formed by an aluminum foil and an etched surface. The anodizing process produces a thin layer of oxide insulation that is used as a dielectric. The cathode is formed through a second aluminum foil when a non-solid electrolyte masks the rough surface area of the oxide layer.

Features:

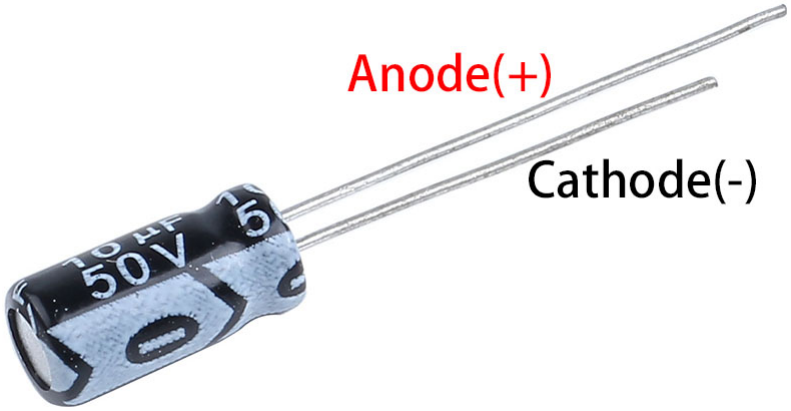
- Nominal Capacitance: 10UF
- Rated Voltage: 50V.
- Size: 5x11mm(0.2 x0.43in)
- Capacitance Tolerance: electrolytic +/-20%
- Operating Temperature Range: -40deg/C ~105+deg/C

Capacitor Polarity Identification

The polarity of capacitors can be identified in several ways as follows.

Based on the height of the capacitor leads we can identify which is negative polarity and which is positive polarity. Capacitor whose terminal is longer is a positive polarity terminal or an anode and the capacitor whose terminal is shorter is a negative polarity or cathode.

And the black arrow points to the negative terminal.



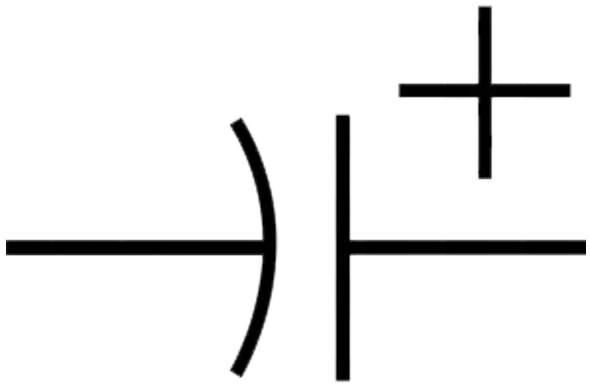
Read the capacitance value

Capacitance, which refers to the amount of charge stored at a given potential difference, is denoted as C, and the international unit is the Farad (F). In general, charges are moved by forces in an electric field. When there is a dielectric between conductors, the movement of charge is impeded and the charge accumulates on the conductor, leading to an accumulation of charge.

Through-hole capacitors are marked with their capacitance value and maximum voltage rating. A capacitor with “10F

50V" printed on it has a nominal capacitance value of 10F and a maximum voltage rating of 50 volts, which should never be exceeded.

Electrical Symbol



Use/Application

A wide range of electrolytic capacitors are used in the following applications

- Used in filtering applications to reduce power supply ripple
- Used as low-pass filters to smooth input and output signals
- Used as a filter in audio amplifier circuits to reduce hum

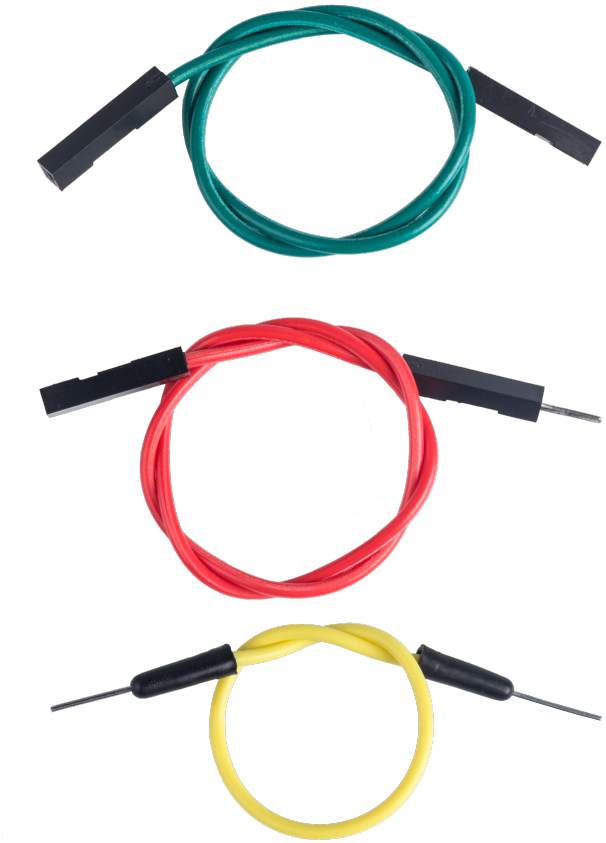
Unit Conversion

1F=10^3mF=10^6uF=10^9nF=10^12pF

CHAPTER

SEVEN

JUMPER WIRES



Wires that connect two terminals are called jumper wires. There are various kinds of jumper wires. Here we focus on those used in breadboard. Among others, they are used to transfer electrical signals from anywhere on the breadboard to the input/output pins of a microcontroller.

Jump wires are fitted by inserting their “end connectors” into the slots provided in the breadboard, beneath whose surface there are a few sets of parallel plates that connect the slots in groups of rows or columns depending on the area. The “end connectors” are inserted into the breadboard, without soldering, in the particular slots that need to be connected in the specific prototype.

There are three types of jumper wire: Female-to-Female, Male-to-Male, and Male-to-Female. The reason we call it Male-to-Female is because it has the outstanding tip in one end as well as a sunk female end. Male-to-Male means both side are male and Female-to-Female means both ends are female.

More than one type of them may be used in a project. The color of the jump wires is different but it doesn't mean their function is different accordingly; it's just designed so to better identify the connection between each circuit.

Chip

CHAPTER

EIGHT

74HC595

Do you ever find yourself wanting to control a lot of LEDs, or just need more I/O pins to control buttons, sensors, and servos all at once? Well, you can connect a few sensors to Arduino pins, but you will soon start to run out of pins on the Arduino.

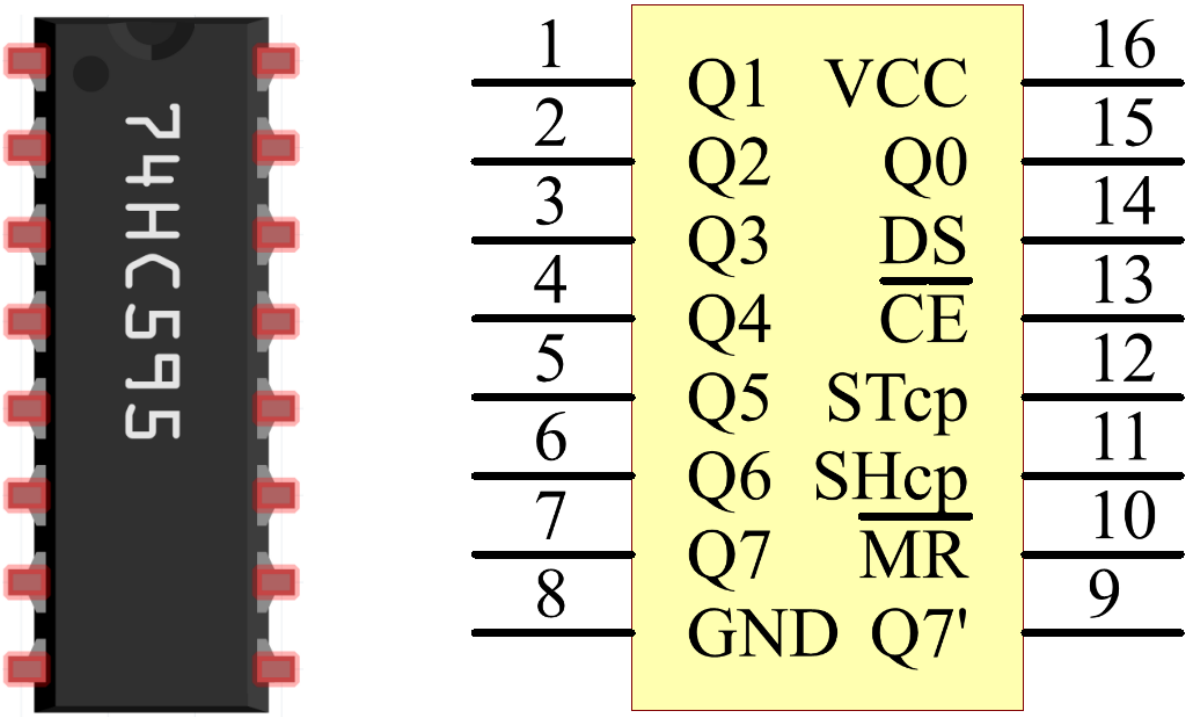
The solution is to use “shift registers”. Shift registers allow you to expand the number of I/O pins you can use from the Arduino (or any microcontroller). The 74HC595 shift register is one of the most famous.

The 74HC595 basically controls eight independent output pins and uses only three input pins. If you need more than eight additional I/O lines, you can easily cascade any number of shift registers and create a large number of I/O lines. All this is done by so-called shifting.

Features

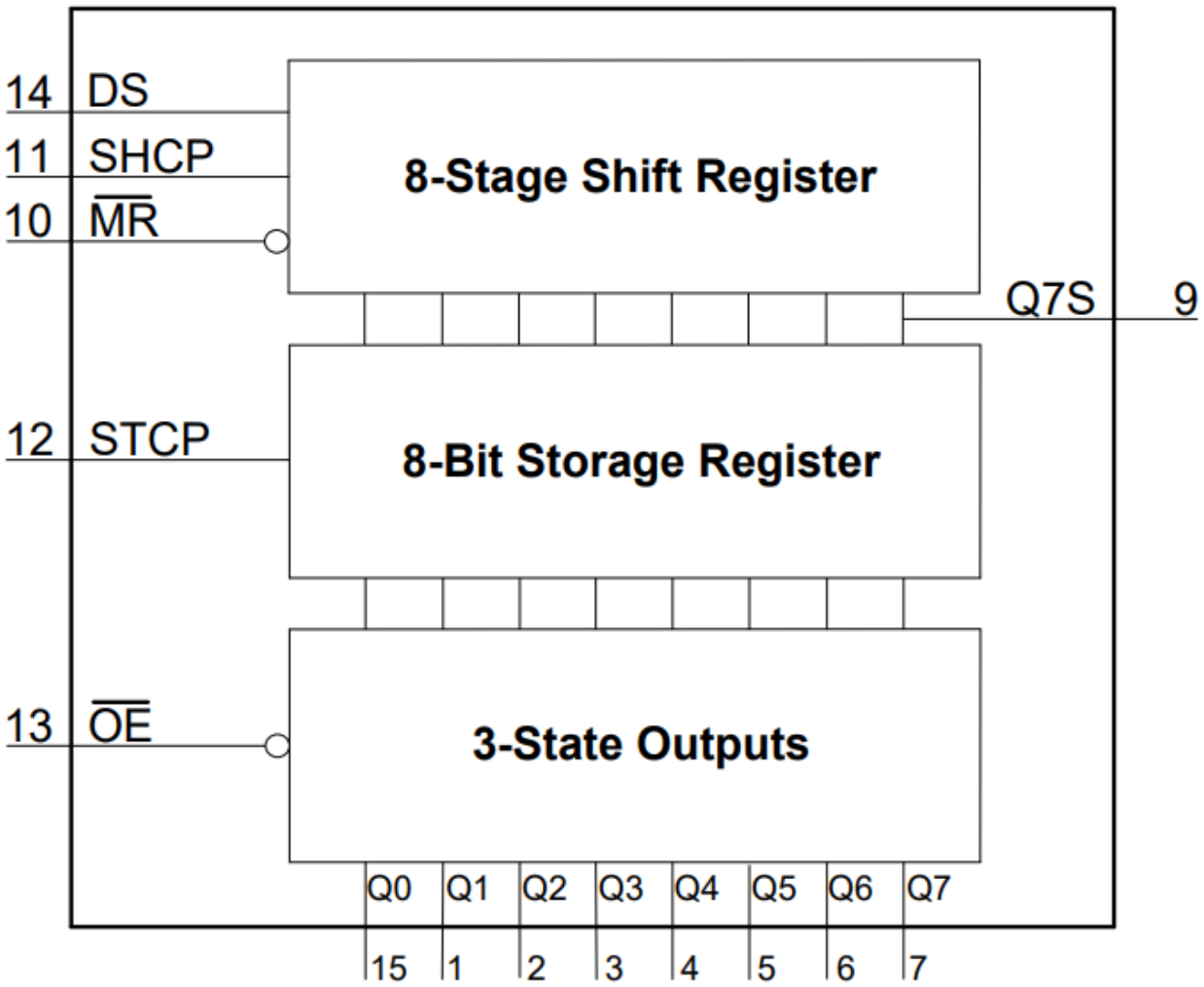
- 8-Bit serial-in, parallel-out shift
- Wide operating voltage range of 2 V to 6 V
- High-current 3-state outputs can drive up to 15LSTTL loads
- Low power consumption, 80-μA max ICC
- Typical tPD = 14 ns
- ±6-mA output drive at 5 V
- Low input current of 1 μA max
- Shift register has direct clear

Pins of 74HC595 and their functions:



- **Q0-Q7**: 8-bit parallel data output pins, able to control 8 LEDs or 8 pins of 7-segment display directly.
- **Q7'**: Series output pin, connected to DS of another 74HC595 to connect multiple 74HC595s in series
- **MR**: Reset pin, active at low level;
- **SHcp**: Time sequence input of shift register. On the rising edge, the data in shift register moves successively one bit, i.e. data in Q1 moves to Q2, and so forth. While on the falling edge, the data in shift register remain unchanged.
- **STcp**: Time sequence input of storage register. On the rising edge, data in the shift register moves into memory register.
- **CE**: Output enable pin, active at low level.
- **DS**: Serial data input pin
- **VCC**: Positive supply voltage.
- **GND**: Ground.

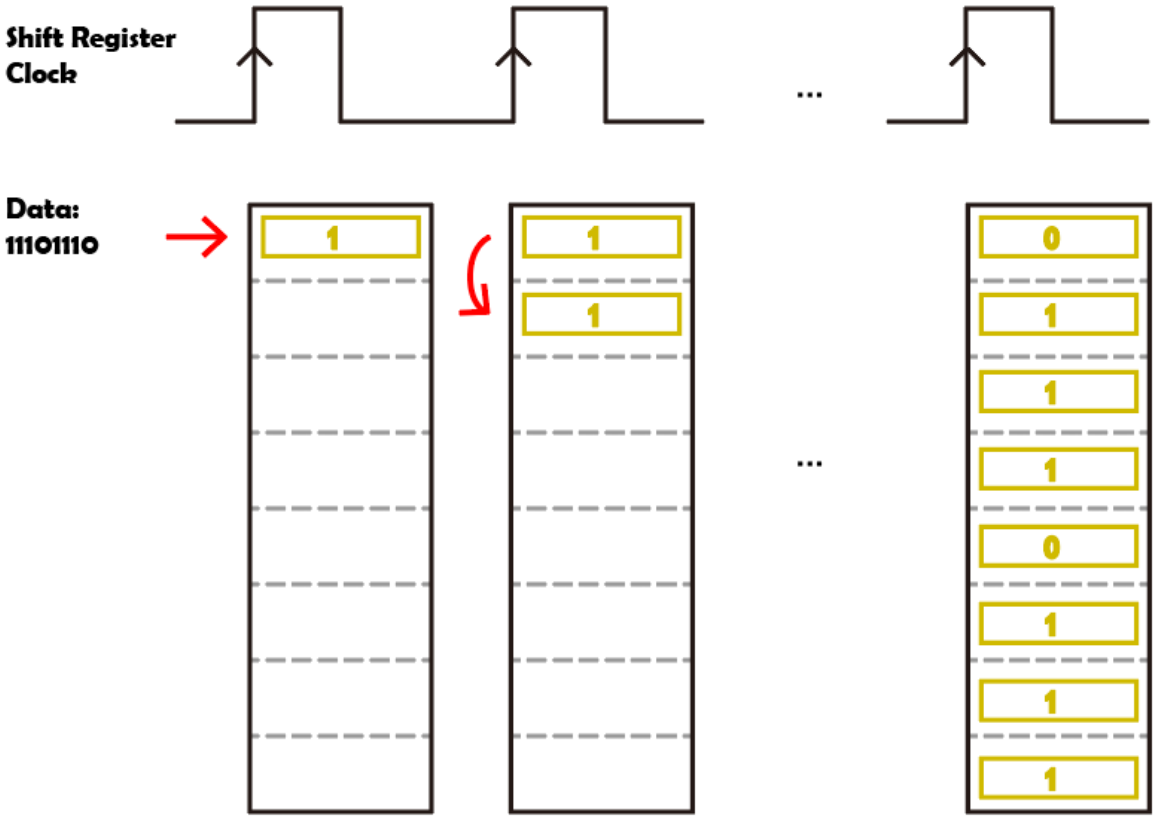
Functional Diagram



Working Principle

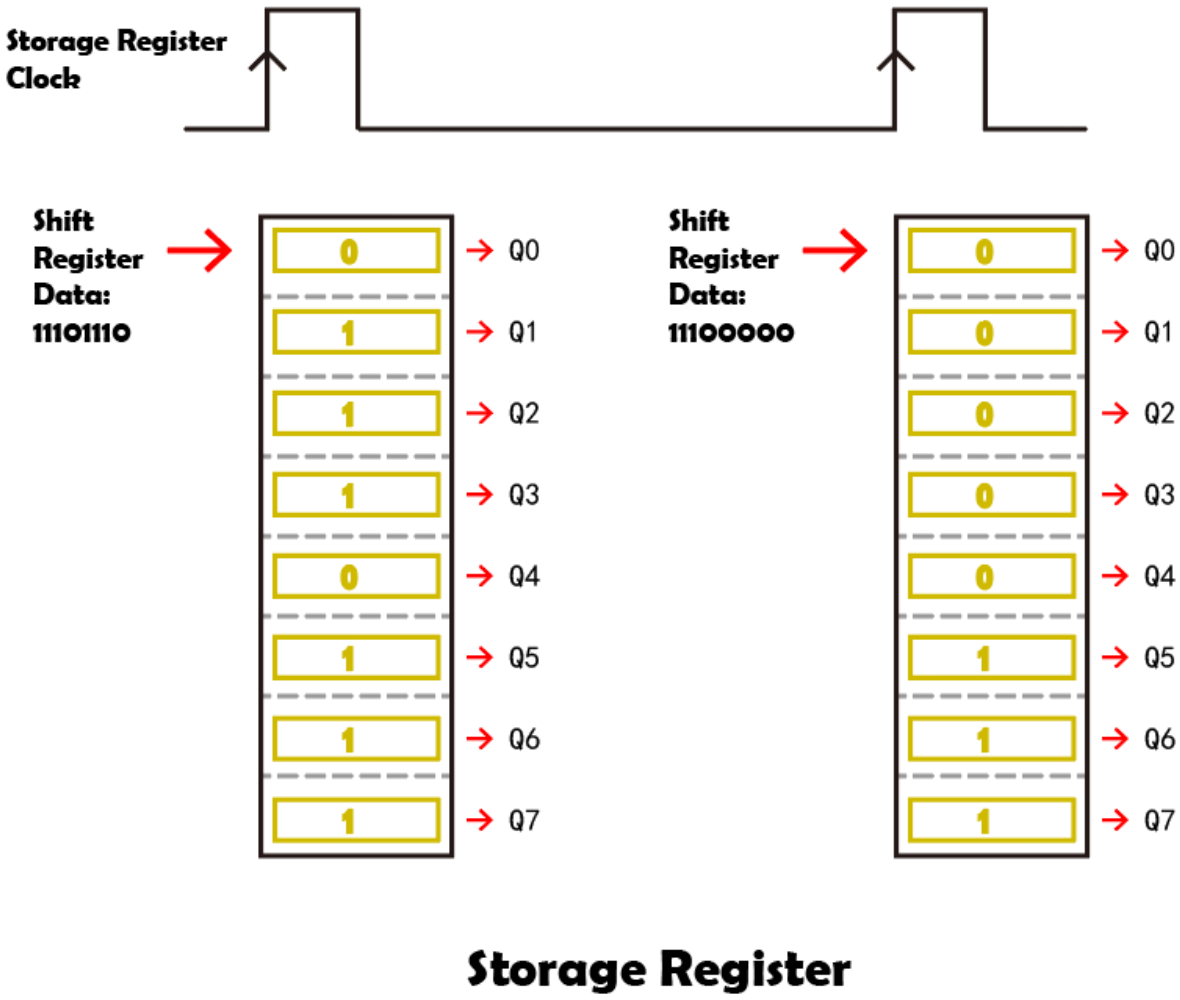
When MR (pin10) is high level and OE (pin13) is low level, data is input in the rising edge of SHcp and goes to the memory register through the rising edge of STcp.

- Shift Register
  - Suppose, we want to input the binary data 1110 1110 into the shift register of the 74hc595.
  - The data is input from bit 0 of the shift register.
  - Whenever the shift register clock is a rising edge, the bits in the shift register are shifted one step. For example, bit 7 accepts the previous value in bit 6, bit 6 gets the value of bit 5, etc.



Shift Register

- Storage Register
  - When the storage register is in the rising edge state, the data of the shift register will be transferred to the storage register.
  - The storage register is directly connected to the 8 output pins, Q0 ~ Q7 will be able to receive a byte of data.
  - The so-called storage register means that the data can exist in this register and will not disappear with one output.
  - The data will remain valid and unchanged as long as the 74HC595 is powered on continuously.
  - When new data comes, the data in the storage register will be overwritten and updated.


Storage Register Clock
Shift Register Data: 11101110
0
1
1
1
0
1
1
1
Q0
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Shift Register Data: 11100000
0
0
0
0
0
1
1
1
Q0
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Storage Register

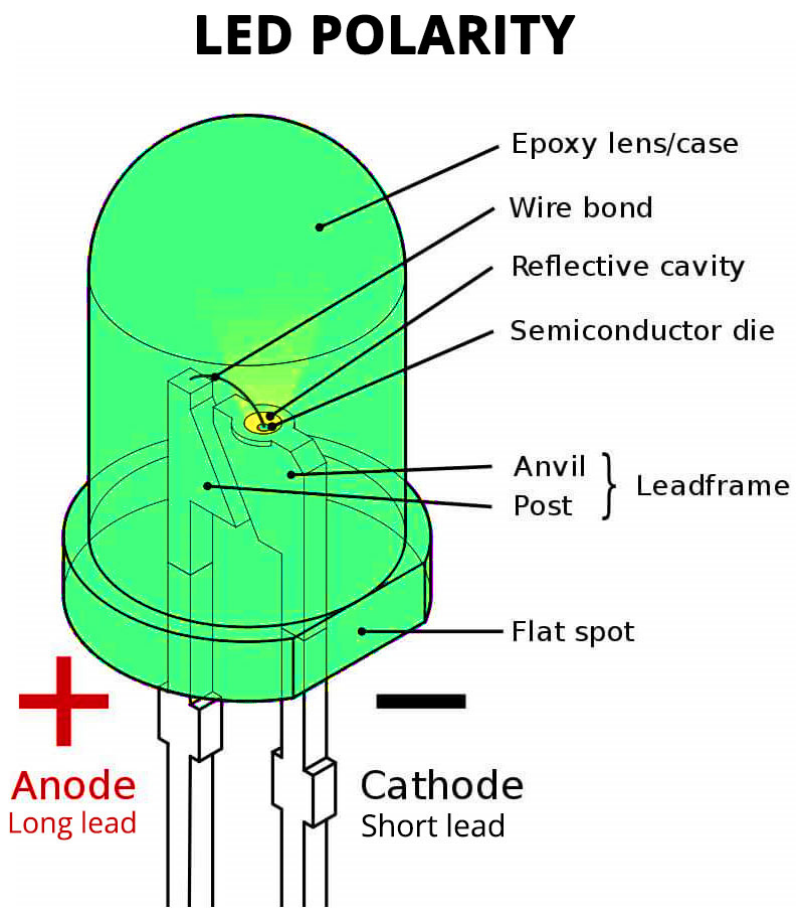
Display

CHAPTER

NINE

LED

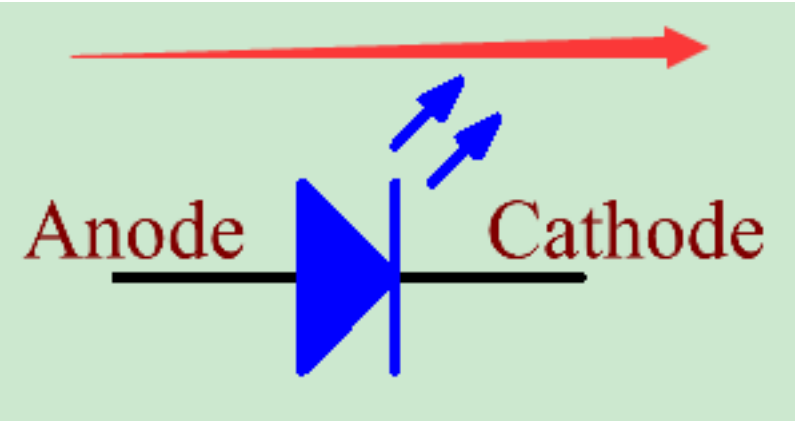
What's LED?



LEDs are very common electronic devices that can be used to decorate your room during the festival, and you can also use them as indicators for various things, such as whether the power to your home appliances is on or off. They come in dozens of different shapes and sizes, and the most common are LEDs with through hole LEDs, which generally have long leads and can be plugged into a breadboard.

The full name of LED is light-emitting diode, so it has the characteristics of a diode, where current flows in one direction, from the anode (positive) to the cathode (negative).

Here are the electrical symbols for LEDs.

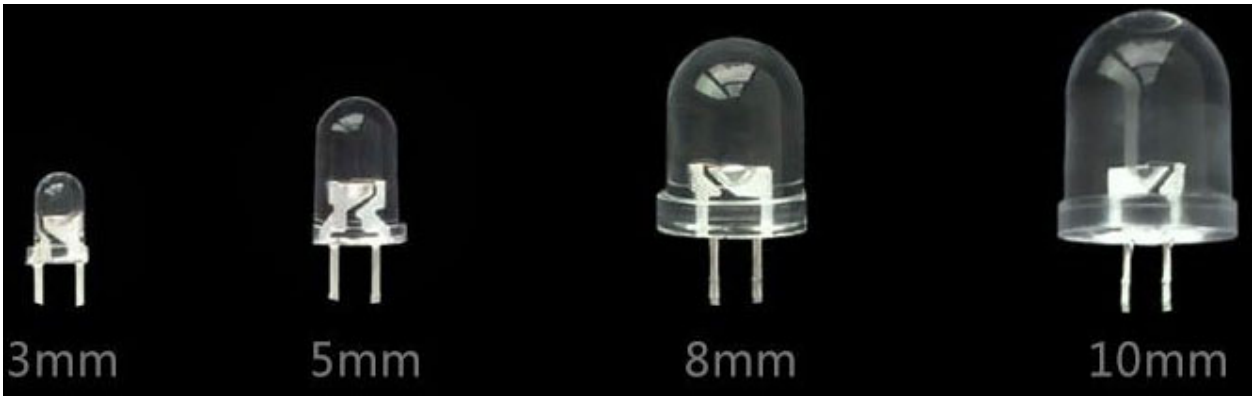


Various sizes and colors

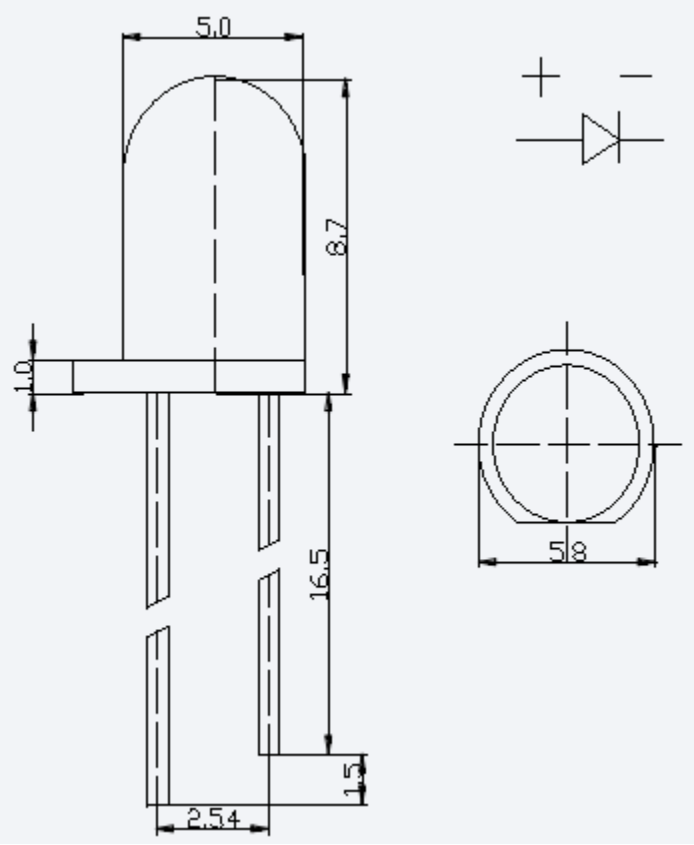
Red, yellow, blue, green, and white are the most common LED colors, and the light emitted is usually the same color as the appearance.

We rarely use LEDs that are transparent or matte in appearance, but the light emitted may be a color other than white.

LEDs come in four sizes: 3mm, 5mm, 8mm and 10mm, with 5mm being the most common size.



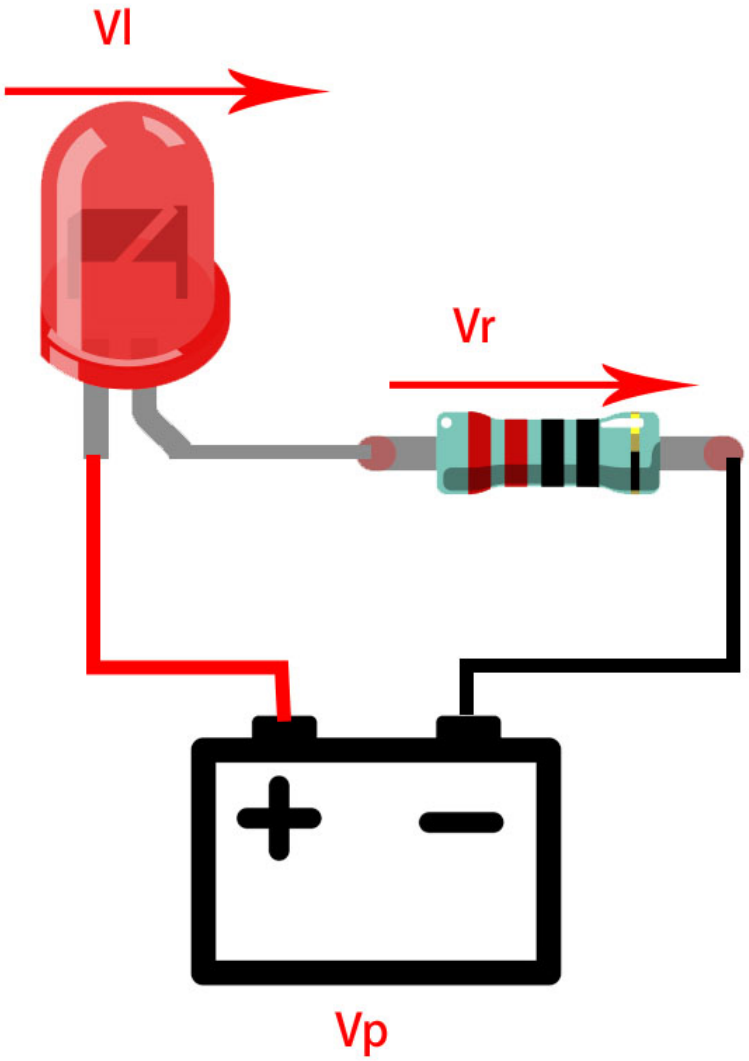
Below is the LED size of 5mm in mm.



Forward Voltage

The Forward Voltage is a very important parameter to know when using LEDs, as it determines how much power you use and how large the current limiting resistor should be.

The Forward Voltage is the voltage that the LED needs to use when it lights up. For most red, yellow, orange and light green LEDs, they generally use a voltage between 1.9V and 2.1V.



According to Ohm's law, the current through this circuit decreases as the resistance increases, which causes the LED to dim.

I = (Vp-Vl)/R

To get the LEDs to light up safely and with the right brightness, how much resistance should we use in the circuit?

For 99% of 5mm LEDs, the recommended current is 20mA, as you can see from the Conditions column of its data sheet.

Electrical / Optical Characteristics at TA=25°C

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Forward Voltage	VF	Lf=20mA	1.9		2.1	V
Reverd Current	IR	VR=5V			10	uA
Vtewing Angle	201/2	IF=20mA		20		deg
Lulninous Intensity	ϕv	IF=20mA	3000		4000	mcd
Chromaticity	Tc	IF=20mA	620		625	K
Chromaticity Coordinates	X.Y	IF=20mA	0. 29, 0. 29			

Now convert the above formula as shown below.

R = (Vp-Vl)/I

If `Vp` is 5V, `Vl` (Forward Voltage) is 2V, and `I` is 20mA, then `R` is 150.

So we can make the LED brighter by reducing the resistance of the resistor, but it is not recommended to go below 150 (this resistance may not be very accurate, because different suppliers provide LEDs have differences).

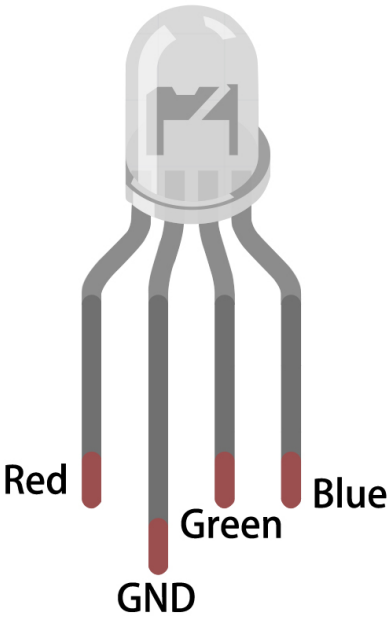
Below are the forward voltages and wavelengths of different color LEDs that you can use as reference.

LED Color	Forward Voltage	Wavelength
Red	1.8V ~ 2.1V	620 ~ 625
Yellow	1.9V ~ 2.2V	580 ~ 590
Green	1.9V ~ 2.2V	520 ~ 530
Blue	3.0V ~ 3.2V	460 ~ 465
White	3.0V ~ 3.2V	8000 ~ 9000

CHAPTER

TEN

RGB LED



RGB LEDs emit light in various colors. An RGB LED packages three LEDs of red, green, and blue into a transparent or semitransparent plastic shell. It can display various colors by changing the input voltage of the three pins and superimpose them, which, according to statistics, can create 16,777,216 different colors.

Features

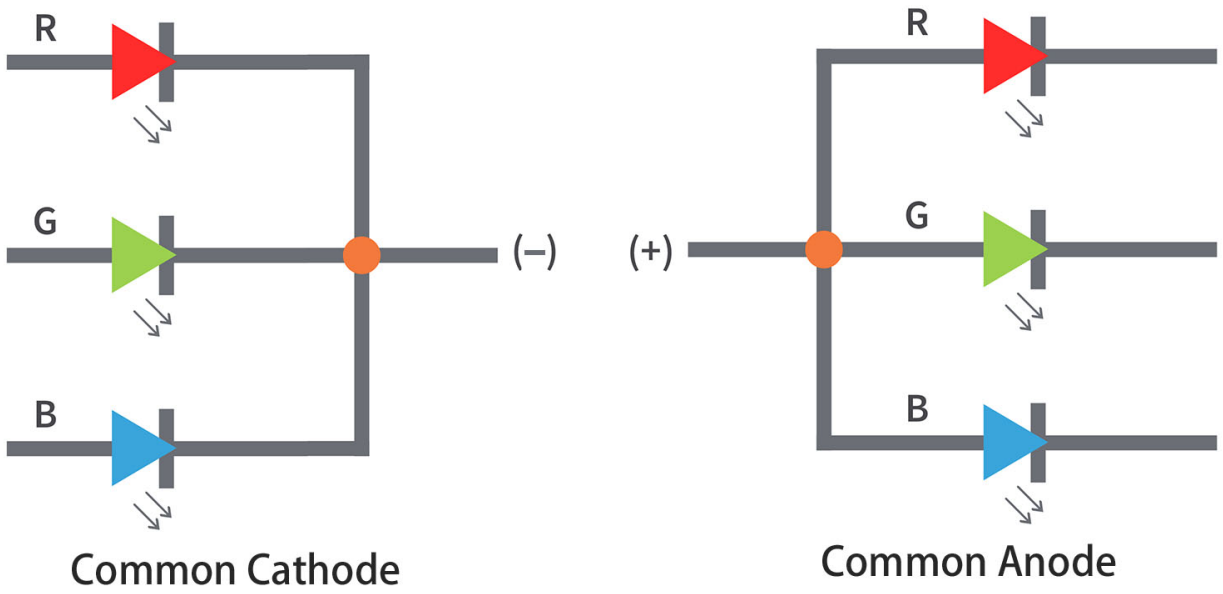
- Color: Tri-Color (Red/Green/Blue)
- Common Cathode
- 5mm Clear Round Lens
- Forward Voltage: Red: DC 2.0 - 2.2V; Blue&Green: DC 3.0 - 3.2V (IF=20mA)
- 0.06 Watts DIP RGB LED
- Luminance Brighter Up To +20%
- Viewing Angle: 30°

Common Anode and Common Cathode

RGB LEDs can be categorized into common anode and common cathode ones.

- In a common cathode RGB LED, all three LEDs share a negative connection (cathode).

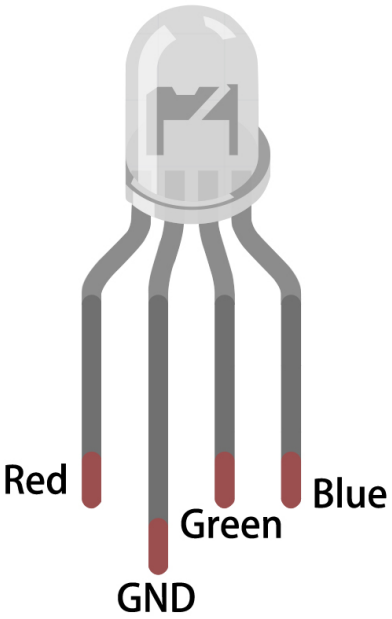
- In a common anode RGB LED, the three LEDs share a positive connection (anode).



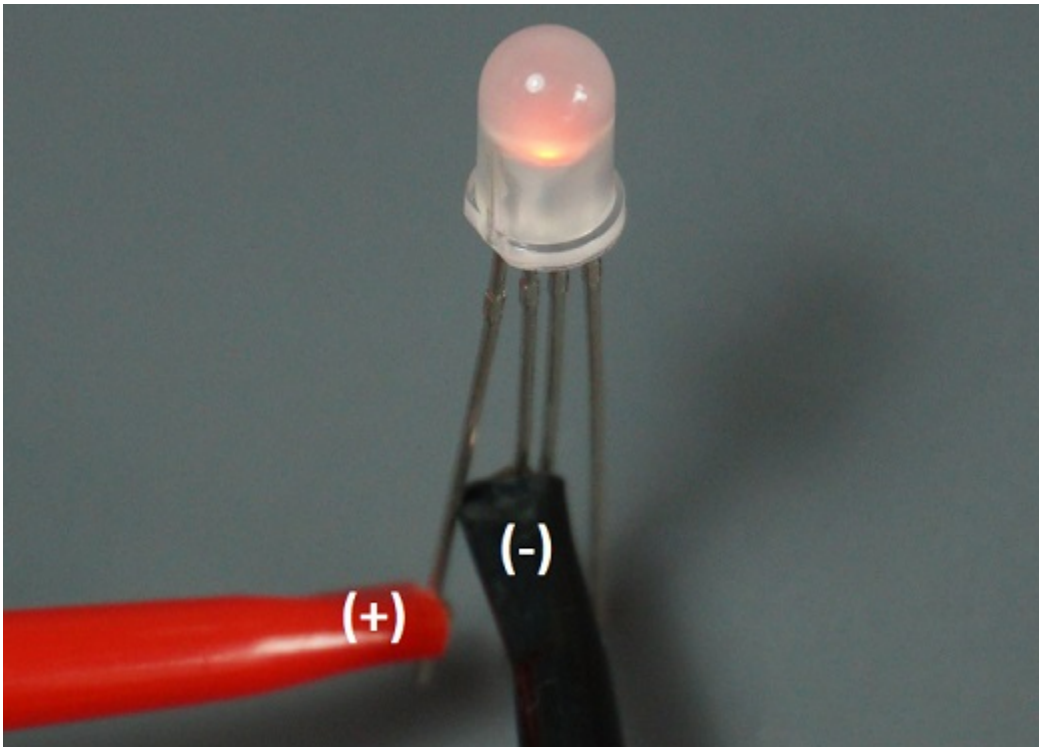
Note: We use the common cathode one.

RGB LED Pins

An RGB LED has 4 pins: the longest one is GND; the others are Red, Green and Blue. Place the RGB LEDs as shown, so that the longest lead is second from the left. Then the pin numbers of the RGB LEDs should be Red, GND, Green and Blue.



You can also use the multimeter to select Diode Test mode, and then connect as shown below to measure the color of each pin.

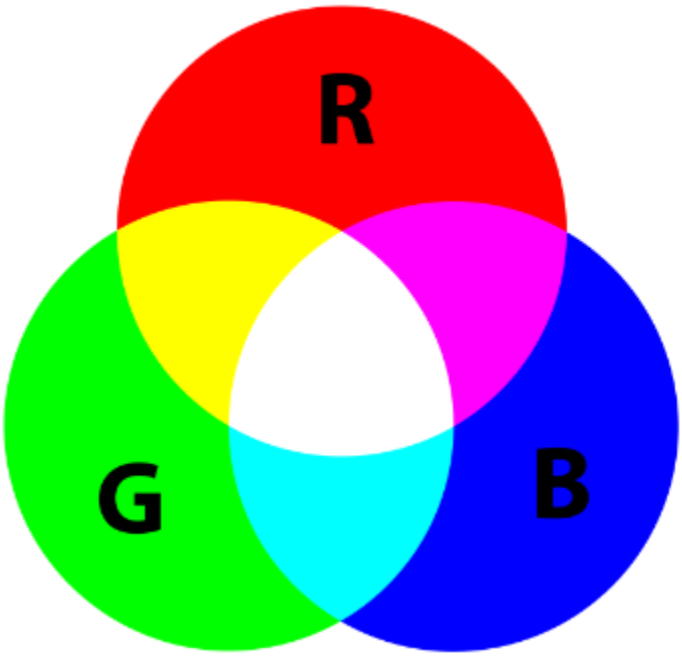


Mix colors

To generate additional colors, you can combine the three colors at different intensities. To adjust the intensity of each LED, you can use a PWM signal.

Because the LEDs are so close to each other, our eyes see the result of the color combination rather than the three colors individually.

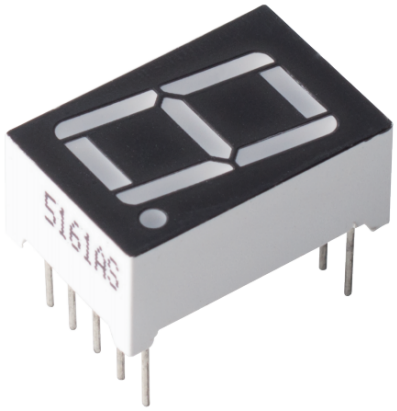
Check out the table below to see how the colors are combined. It will give you an idea of how the color mixing chart works and how different colors are produced.



CHAPTER

ELEVEN

7-SEGMENT DISPLAY



A 7-segment display is an 8-shaped component which packages 7 LEDs. Each LED is called a segment - when energized, one segment forms part of a numeral to be displayed.

- Each of the LEDs in the display is given a positional segment with one of its connection pins led out from the rectangular plastic package.
- These LED pins are labeled from “a” through to “g” representing each individual LED.
- The other LED pins are connected together forming a common pin.
- So by forward biasing the appropriate pins of the LED segments in a particular order, some segments will brighten and others stay dim, thus showing the corresponding character on the display.

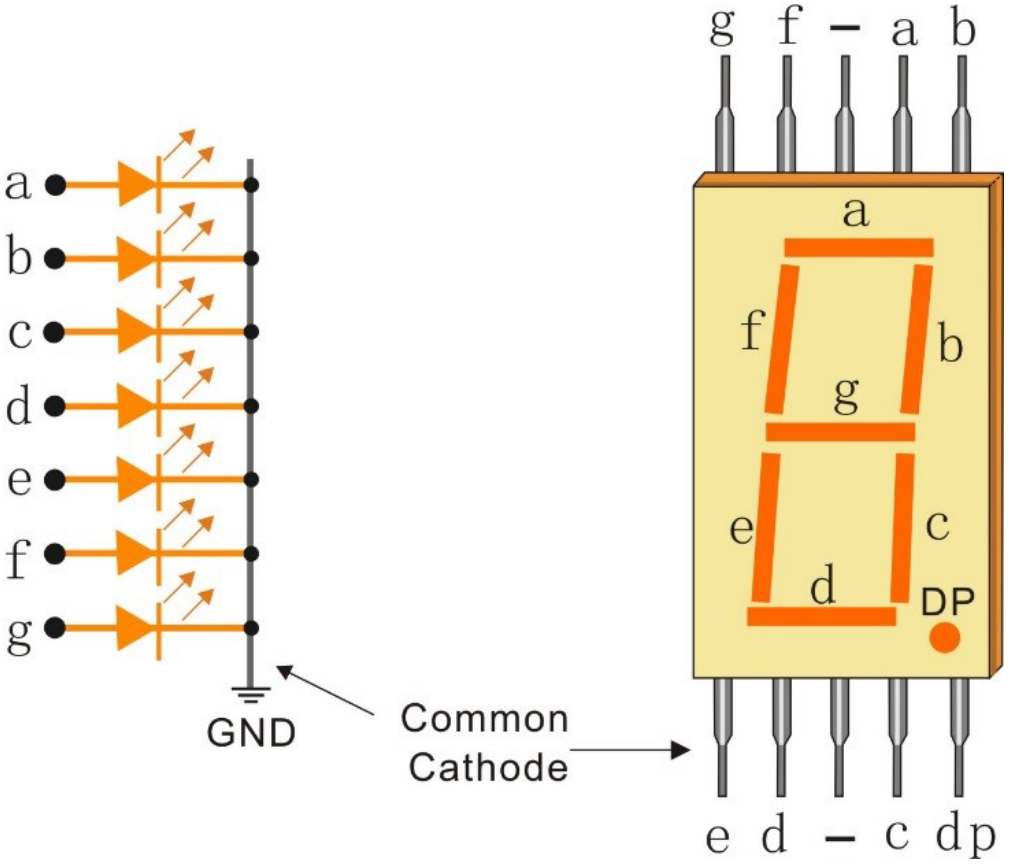
Features

- Size: 19 x 12.7 x 13.8mm(LxWxH, include the pin)
- Screen: 0.56”
- Color: red
- Common Cathode
- Forward Voltage: 1.8V
- 10 pins
- Pitch: standard 0.1” (2.54mm)

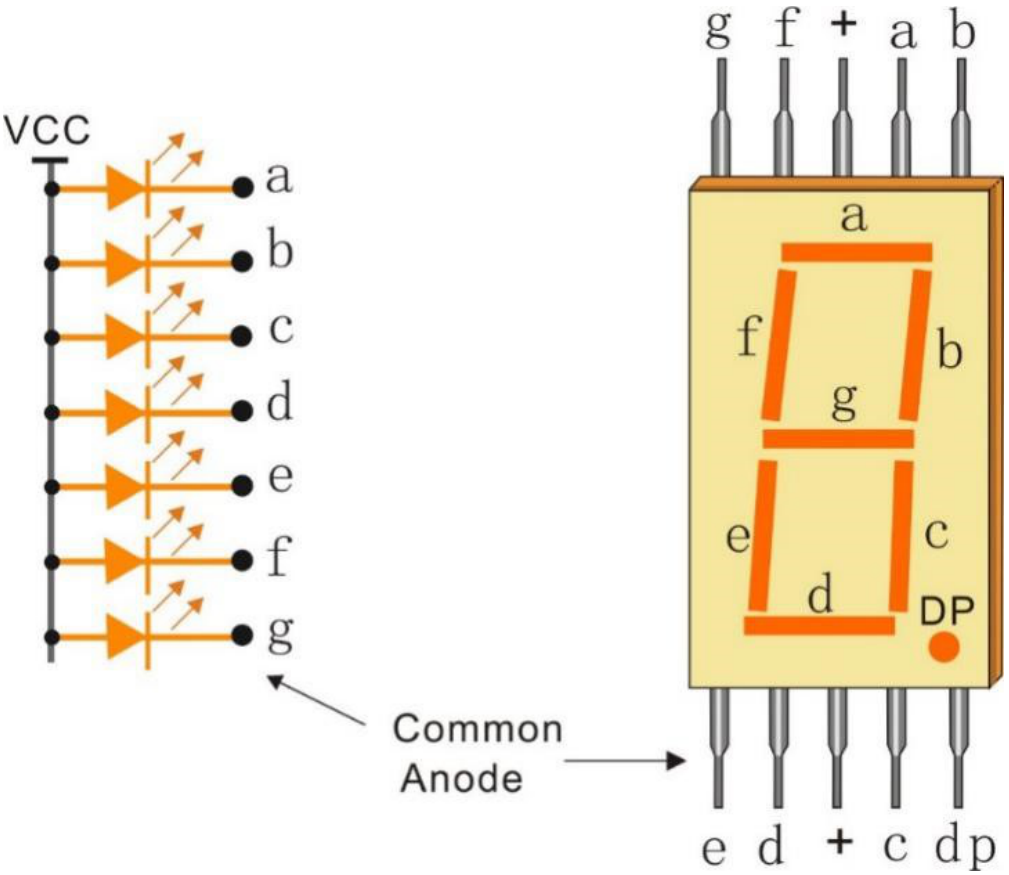
Common Cathode (CC) or Common Anode (CA)

There are two types of pin connection: Common Cathode (CC) and Common Anode (CA). As the name suggests, a CC display has all the cathodes of the 7 LEDs connected when a CA display has all the anodes of the 7 segments connected.

- Common Cathode 7-Segment Display

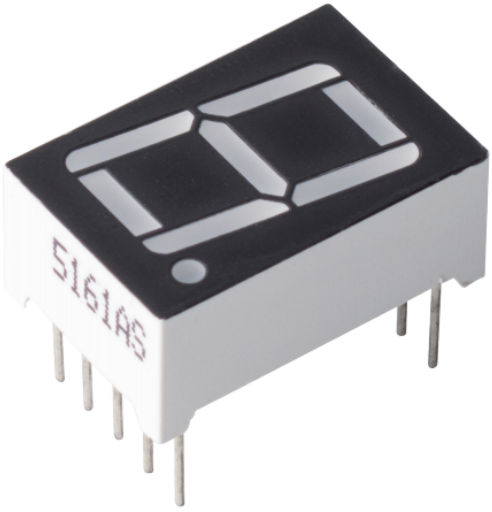


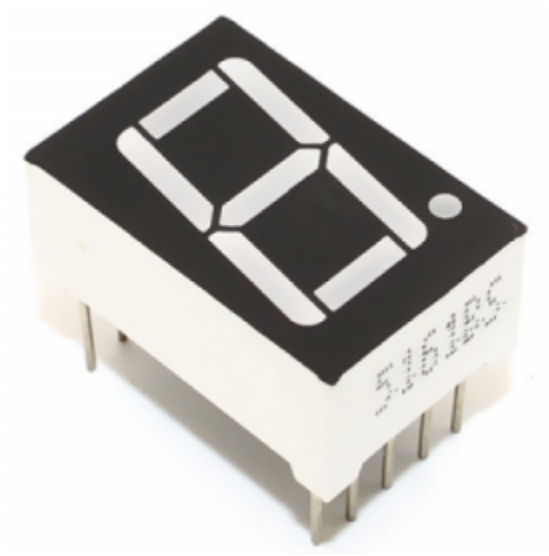
- Common Anode 7-Segment Display



How to Know CC or CA?

Usually there will be label on the side of the 7-segment display, xxxAx or xxxBx. Generally speaking xxxAx stands for common cathode and xxxBx stands for common anode.





You can also use a multimeter to check the 7-segment display if there is no label. Set the multimeter to diode test mode and connect the black lead to the middle pin of the 7-segment display, and the red lead to any other pin except the middle one. The 7-segment display is common cathode if a segment lights up.

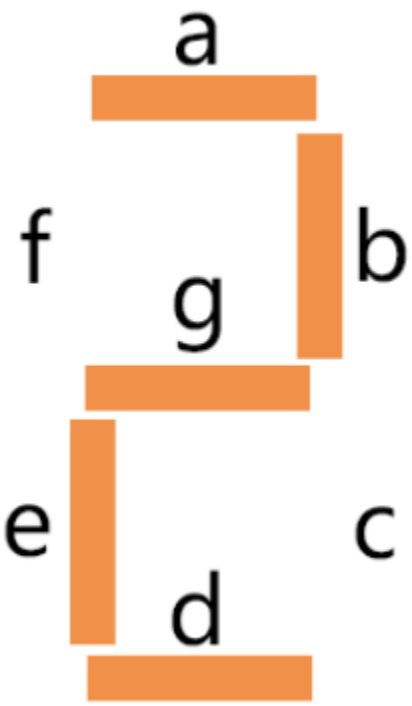
You swap the red and black meter heads if there is no segment lit. When a segment is lit, it indicates a common anode.

Display Codes

To help you get to know how 7-segment displays(Common Cathode) display Numbers, we have drawn the following table. Numbers are the number 0-F displayed on the 7-segment display; (DP) GFEDCBA refers to the corresponding LED set to 0 or 1.

Numbers	Common Cathode		Numbers	Common Cathode	
	(DP)GFEDCBA	Hex Code		(DP)GFEDCBA	Hex Code
0	00111111	0x3f	A	01110111	0x77
1	00000110	0x06	B	01111100	0x7c
2	01011011	0x5b	C	00111001	0x39
3	01001111	0x4f	D	01011110	0x5e
4	01100110	0x66	E	01111001	0x79
5	01101101	0x6d	F	01110001	0x71
6	01111101	0x7d			
7	00000111	0x07			
8	01111111	0x7f			
9	01101111	0x6f			

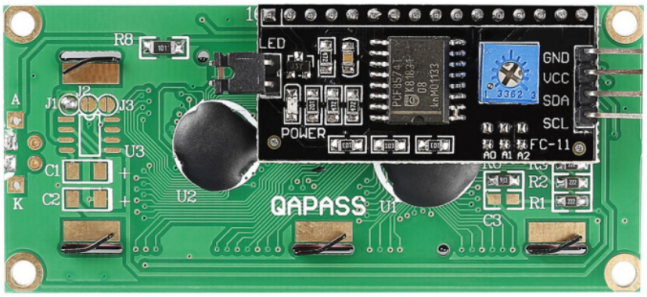
For example, 01011011 means that DP, F and C are set to 0, while others are set to 1. Therefore, the number 2 is displayed on the 7-segment display.


a
f
b
g
e
c
d

CHAPTER

TWELVE

I2C LCD1602



- **GND**: Ground
- **VCC**: Voltage supply, 5V.
- **SDA**: Serial data line.
- **SCL**: Serial clock line.

As we all know, though LCD and some other displays greatly enrich the man-machine interaction, they share a common weakness. When they are connected to a controller, multiple IOs will be occupied of the controller which has no so many outer ports. Also it restricts other functions of the controller.

Therefore, LCD1602 with an I2C module is developed to solve the problem. The I2C module has a built-in PCF8574 I2C chip that converts I2C serial data to parallel data for the LCD display.

- PCF8574 Datasheet

Features

- Display 2-lines x 16-characters
- ColorBlue Backlight, White characters
- Default Address: 0x27
- Working voltage: 5V
- Chip: PCF8574T
- Backlight on by default
- Contrast can be adjusted via potentiometer
- 4 Pins: GND, VCC, SDA and SCL

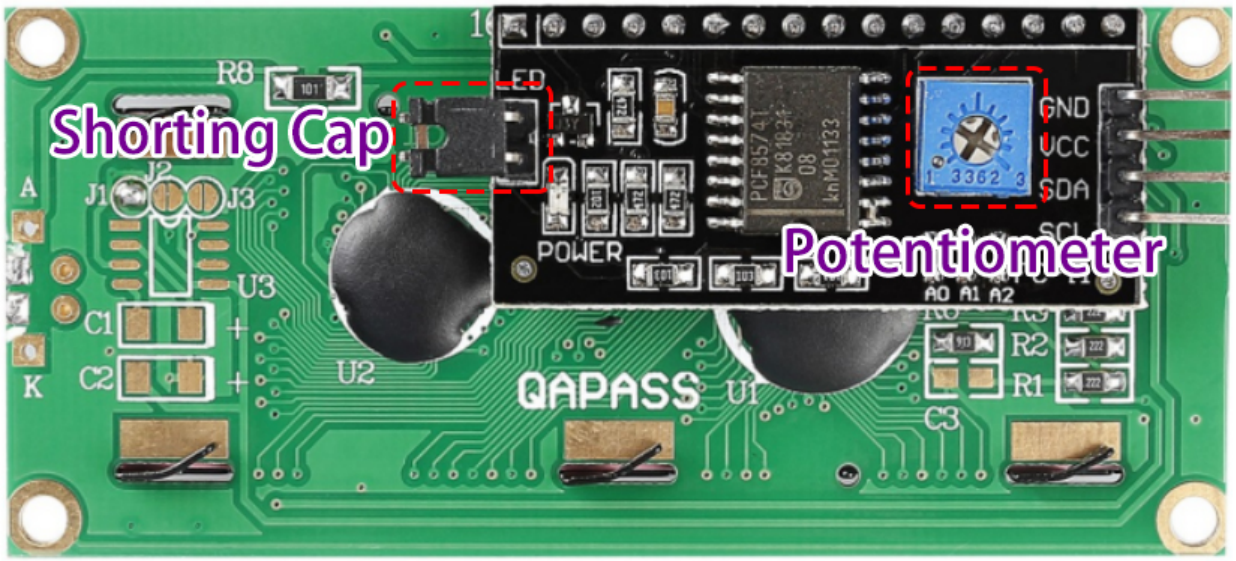
I2C Address

The default address is basically 0x27, in a few cases it may be 0x3F.

Taking the default address of 0x27 as an example, the device address can be modified by shorting the A0/A1/A2 pads; in the default state, A0/A1/A2 is 1, and if the pad is shorted, A0/A1/A2 is 0.

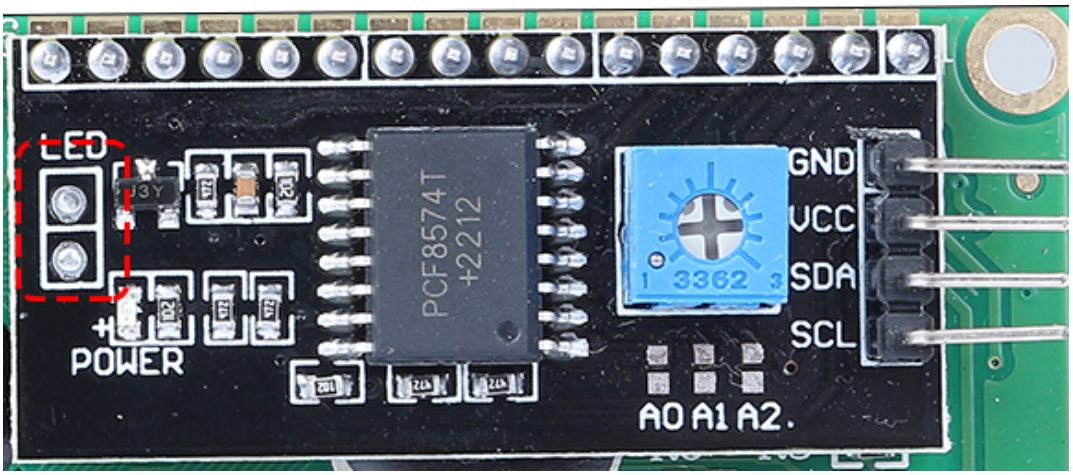
Backlight/Contrast

Backlight can be enabled by jumper cap, unplugg the jumper cap to disable the backlight. The blue potentiometer on the back is used to adjust the contrast (the ratio of brightness between the brightest white and the darkest black).



- **Potentiometer**: It is used to adjust the contrast (the clarity of the displayed text), which is increased in the clockwise direction and decreased in the counterclockwise direction.
- **Shorting Cap**: Backlight can be enabled by this capunplugg this cap to disable the backlight.

Note: Because of the different production batches, the backlight on some I2C LCD1602 is on by default, so there is no solder pin and no jumper cap required.



Sound

CHAPTER

THIRTEEN

BUZZER

A buzzer or beeper is an audio signaling device commonly used in computers, printers, copiers, alarms, electronic toys, automotive electronics, telephones, timers, and other electronics.

Features

- Oscillation Frequency: 2.3±0.3KHz
- Operating Voltage: 3 ~ 6VDC
- Rated Voltage: 5 VDC
- Current Consumption: MAX.25mA
- Sound Pressure Level: MIN. 85dB
- Tone Nature: Constant
- Operating Temperature: -20 ~ +45°C
- Storage Temperature: -25 ~ +60°C
- Dimension: 12.0 x H9.5mm
- Weight (MAX): 2.0 gram
- Housing Material: ABS(Black)

Active Buzzer or Passive Buzzer

Buzzers can be categorized as active and passive ones. Turn the buzzer so that its pins are facing up, and the buzzer with a green circuit board is a passive buzzer, while the one enclosed with a black tape is an active one.

The difference between an active buzzer and a passive buzzer:

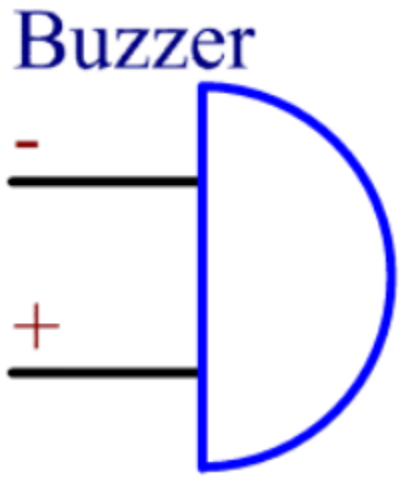
- An active buzzer has a built-in oscillating source, so it will make sounds when electrified.
- But a passive buzzer does not have such source, so it will not beep if DC signals are used; instead, you need to use square waves whose frequency is between 2K and 5K to drive it.
- The active buzzer is often more expensive than the passive one because of multiple built-in oscillating circuits.

How to Know Anode or Cathode?

With a + in the surface represents the anode and the other is the cathode.

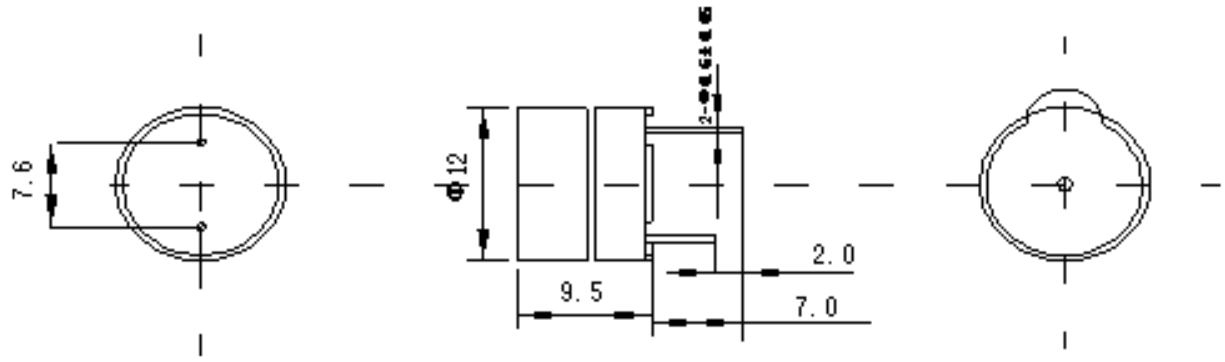
You can also check the pins of the buzzer, the longer one is the anode and the shorter one is the cathode. Please don't mix them up when connecting, otherwise the buzzer will not make sound.

Electrical Symbol

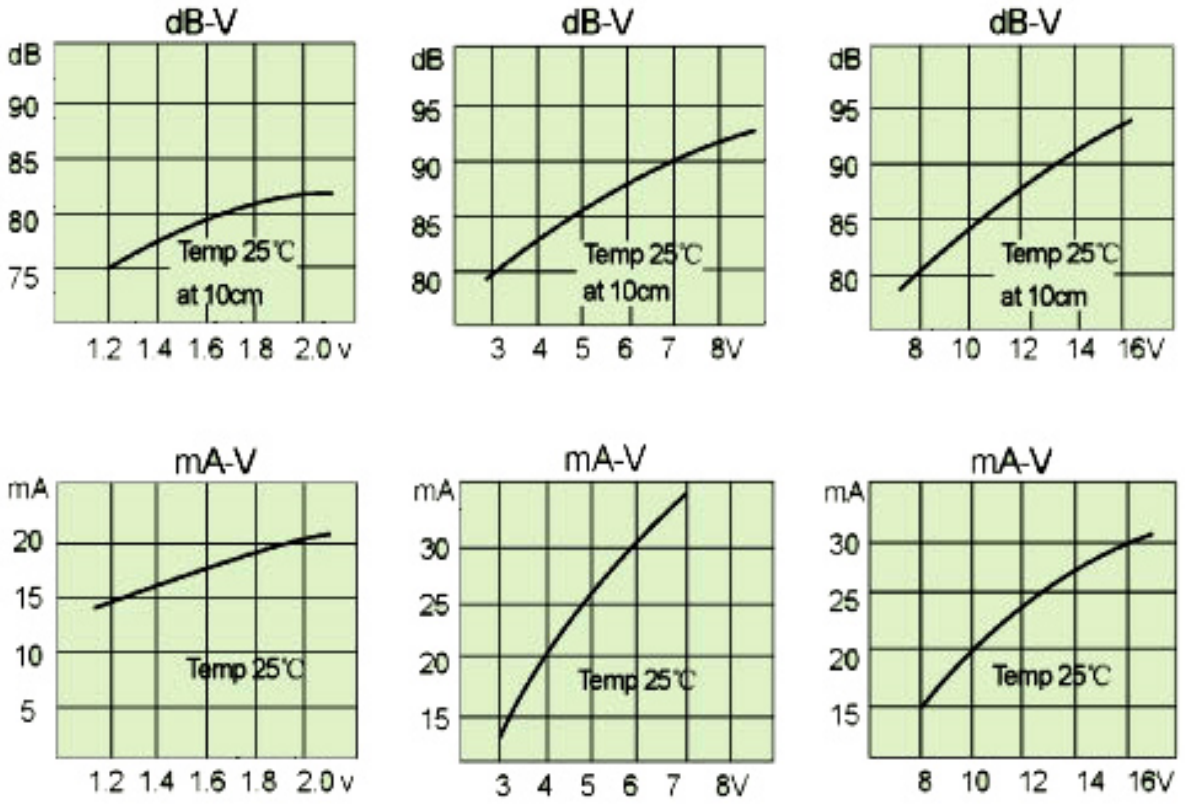


Demensions

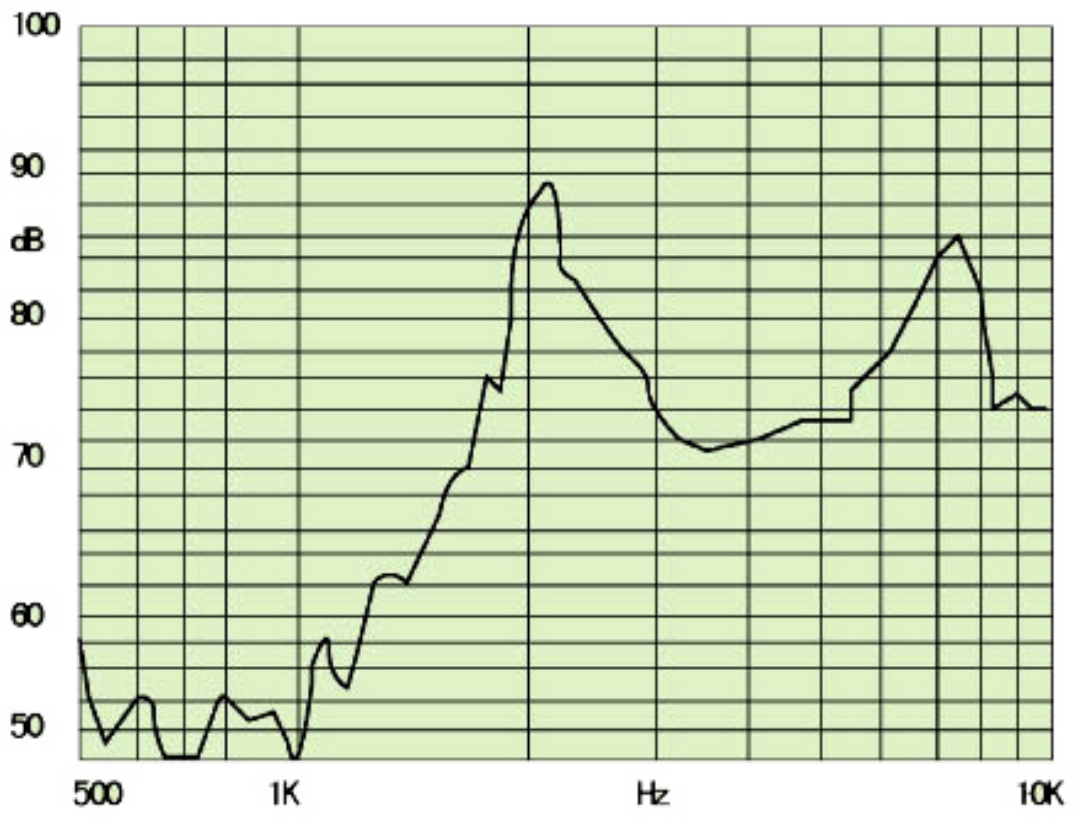
Unit: mm



Active Buzzer Frequency Response Curve



Passive Buzzer Frequency Response Curve

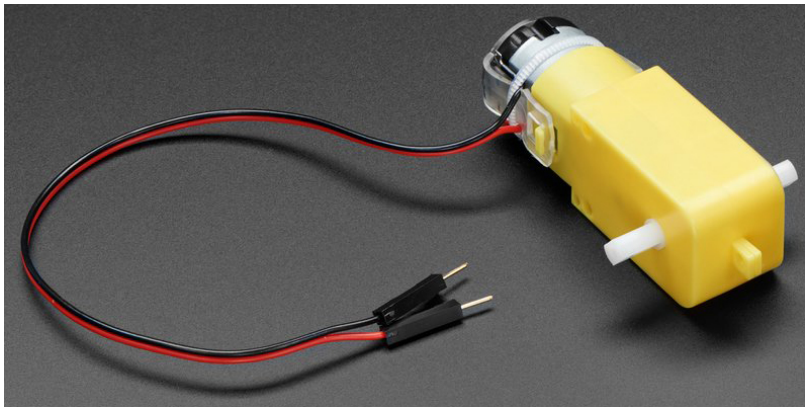


Driver

CHAPTER

FOURTEEN

TT MOTOR



This is a TT DC gearbox motor with a gear ratio of 1:48, it comes with 2 x 200mm wires with 0.1” male connectors that fit into a breadboard. Perfect for plugging into a breadboard or terminal block.

You can power these motors with 3 ~ 6VDC, but of course, they will go a little faster at higher voltages.

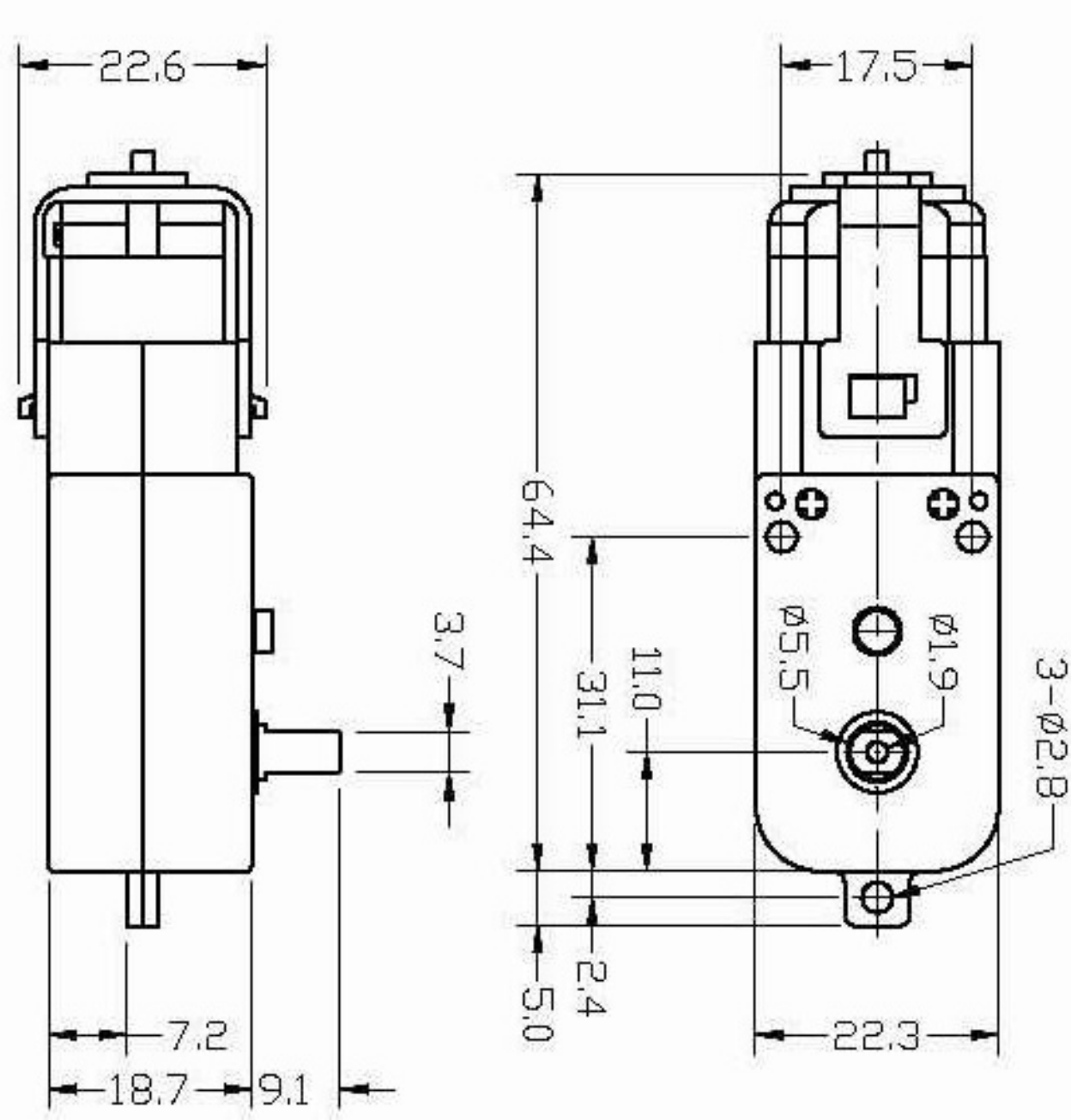
Note that these are very basic motors with no built-in encoder, speed control or position feedback. The voltage goes in and the spin comes out. There will be variation from motor to motor, so if you need precise motion, you’ll need a separate feedback system.

Features

- Rated Voltage: 3~6V
- Continuous No-Load Current: 150mA +/- 10%
- Min. Operating Speed (3V): 90+/- 10% RPM
- Min. Operating Speed (6V): 200+/- 10% RPM
- Stall Torque (3V): 0.4kg.cm
- Stall Torque (6V): 0.8kg.cm
- Gear Ratio: 1:48
- Body Dimensions: 70 x 22 x 18mm
- Wires Length: 200mm & 28 AWG
- Weight: 30.6g

Dimensional Drawing

Unit: mm


22.6
17.5
64.4
31.1
11.0
3.7
Ø5.5
Ø1.9
3-Ø2.8
2.4
5.0
7.2
18.7
9.1
22.3

CHAPTER

FIFTEEN

SERVO

What is a Servo

- Brown Line: GND
- Orange Line: Signal pin, connect to the PWM pin of main board.
- Red wire: VCC

The servo is a type of motor that can rotate very precisely. In most cases, servo motors feature a control circuit that provides feedback about the current position of the motor shaft, allowing the motor to rotate very precisely. If you want to rotate an object at some specific angle or distance, then you use a servo.

Features

- Name: SG90
- Size: 22.4 x 12.5 x 23.8mm
- Weight: 10g±5%
- Wire length: 25cm±1cm
- Working voltage: 4.8v-6v
- Blocking torque: 1.3kg.cm-1.6kg.cm
- No-load speed: 0.09sev/60°
- No-load current: 90mA
- Output shaft: 20T

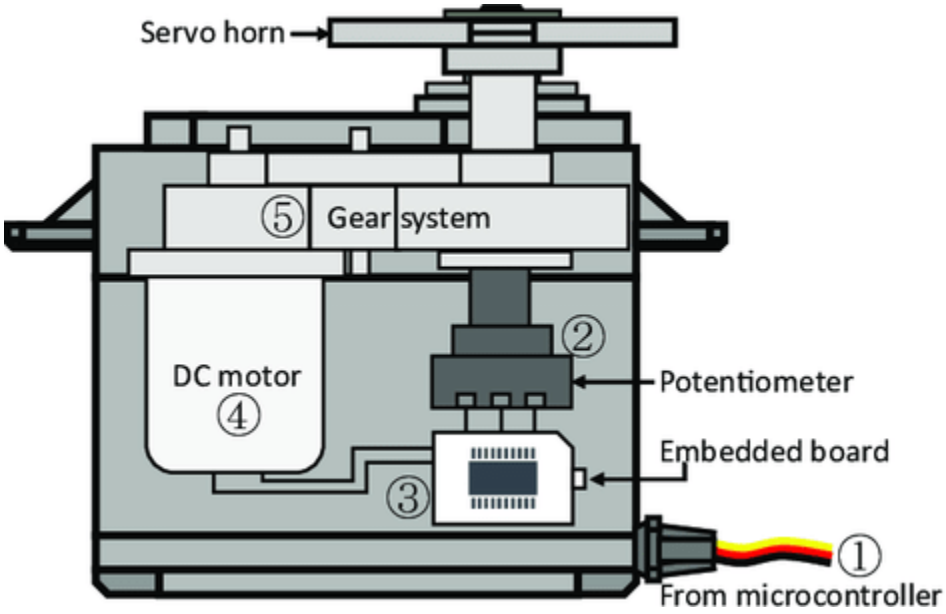
How it work?

A servo is generally composed of the following parts: case, shaft, gear system, potentiometer, DC motor, and embedded board.

It works like this:

- The microcontroller sends out PWM signals to the servo, and then the embedded board in the servo receives the signals through the signal pin and controls the motor inside to turn.
- As a result, the motor drives the gear system and then motivates the shaft after deceleration.

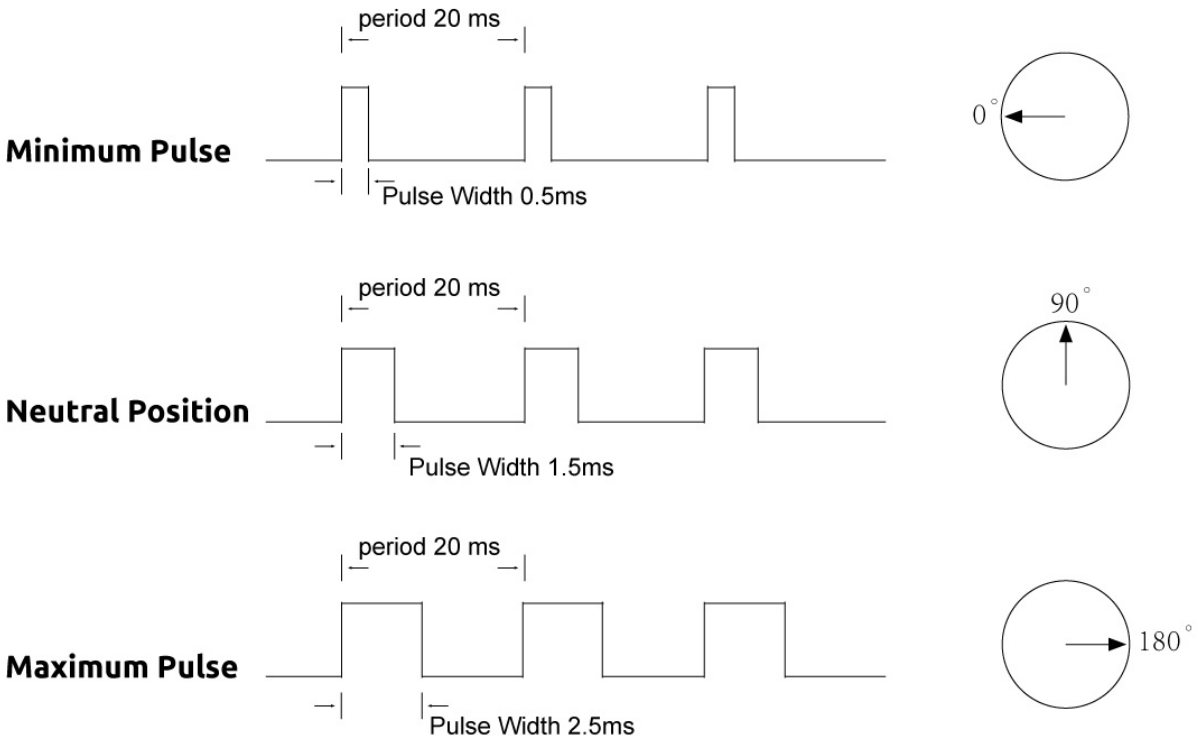
- The shaft and potentiometer of the servo are connected together.
- When the shaft rotates, it drives the potentiometer, so the potentiometer outputs a voltage signal to the embedded board.
- Then the board determines the direction and speed of rotation based on the current position, so it can stop exactly at the right position as defined and hold there.



Work Pulse

The angle is determined by the duration of a pulse that is applied to the control wire. This is called Pulse width Modulation.

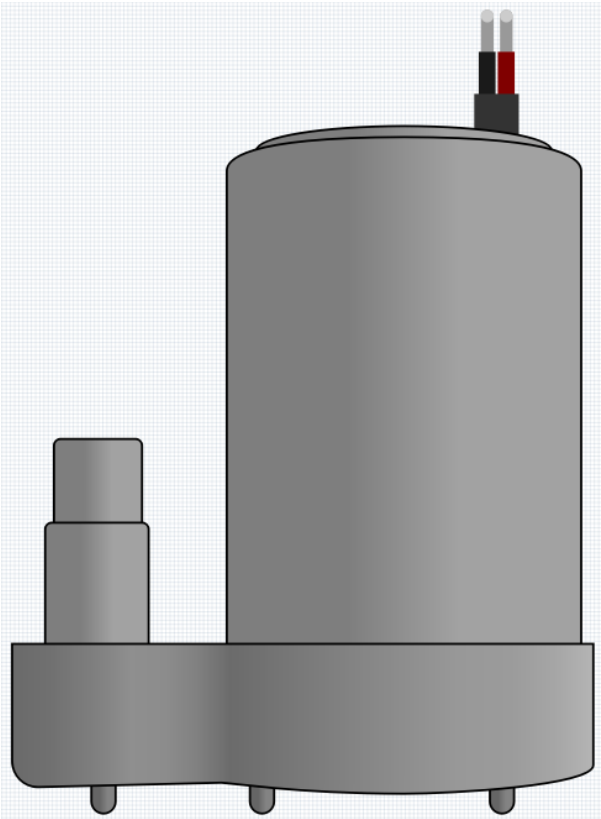
- The servo expects to see a pulse every 20 ms. The length of the pulse will determine how far the servo turns.
- For example, a 1.5ms pulse will make the servo turn to the 90 degree position (neutral position).
- When a pulse is sent to a servo that is less than 1.5 ms, the servo rotates to a position and holds its output shaft some number of degrees counterclockwise from the neutral point.
- When the pulse is wider than 1.5 ms the opposite occurs.
- The minimal width and the maximum width of pulse that will command the servo to turn to a valid position are functions of each servo.
- Generally the pulse will be about 0.5 ms ~ 2.5 ms wide.


period 20 ms
Minimum Pulse
Pulse Width 0.5ms
0°
period 20 ms
Neutral Position
Pulse Width 1.5ms
90°
period 20 ms
Maximum Pulse
Pulse Width 2.5ms
180°

CHAPTER

SIXTEEN

CENTRIFUGAL PUMP

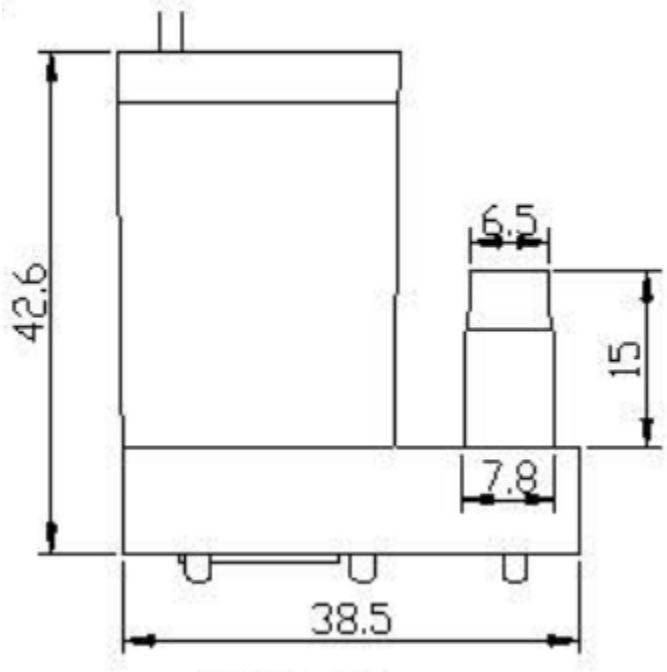


3V 3V 100mA

The centrifugal pump converts rotational kinetic energy into hydrodynamic energy to transport fluid. The rotation energy comes from the electric motor. The fluid enters the pump impeller along or near the rotating shaft, is accelerated by the impeller, flows radially outward into the diffuser or volute chamber, and then flows out from there.

Common uses of centrifugal pumps include water, sewage, agricultural, petroleum, and petrochemical pumping.

mm



Features

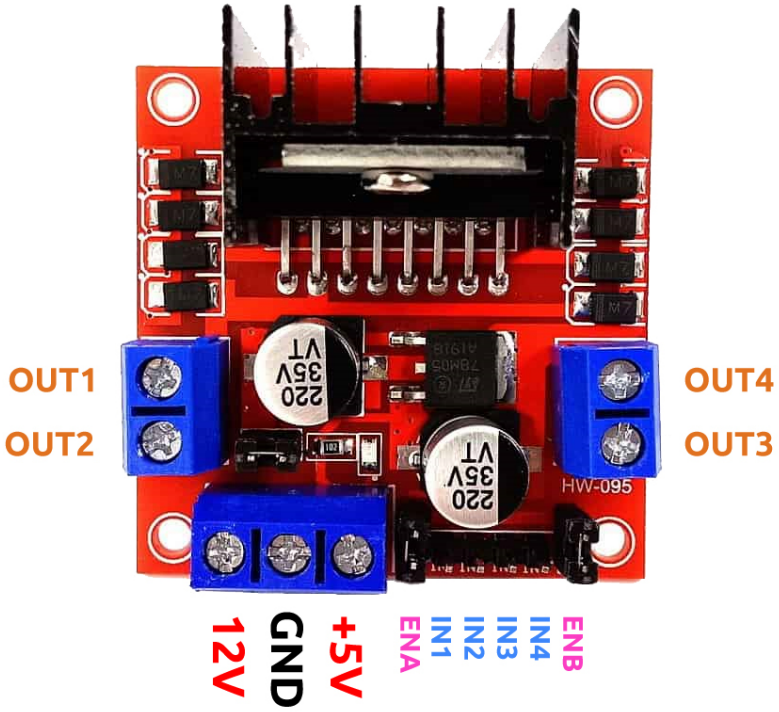
- **Voltage Scope**: DC 3 ~ 4.5V
- **Operating Current**: 120 ~ 180mA
- **Power**: 0.36 ~ 0.91W
- **Max Water Head**: 0.35 ~ 0.55M
- **Max Flow Rate**: 80 ~ 100 L/H
- **Continuous Working Life**: 100 hours
- **Water Fing Grade**: IP68
- **Driving Mode**: DC, Magnetic Driving
- **Material**: Engineering Plastic
- **Outlet Outside Diameter**: 7.8 mm
- **Outlet Inside Diameter**: 6.5 mm
- It is a submersible pump and should be used that way. It tends to heat too much that there's a risk of overheating if you turn it on unsubmerged.

CHAPTER

SEVENTEEN

L298N MODULE

This L298N Motor Driver Module is a high power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control.



- **IN1 & IN2**: Motor A input pins. Used to control the spinning direction of Motor A
- **IN3 & IN4**: Motor B input pins. Used to control the spinning direction of Motor B
- **ENA**: Enables PWM signal for Motor A. Here it has been connected to 5V with a jumper cap.
- **ENB**: Enables PWM signal for Motor B. Here it has been connected to 5V with a jumper cap.
- **OUT1 & OUT2**: Output pins of Motor A
- **OUT3 & OUT4**: Output pins of Motor B
- **12V**: 12V input from DC power Source
- **5V**: Supplies power for the switching logic circuitry inside L298N IC
- **GND**: Ground pin

Features

- Driver Model: L298N 2A
- Driver Chip: Double H Bridge L298N
- Motor Supply Voltage (Maximum): 46V
- Motor Supply Current (Maximum): 2A
- Logic Voltage: 5V
- Driver Voltage: 5-35V
- Driver Current:2A
- Logical Current:0-36mA
- Maximum Power (W): 25W
- Current Sense for each motor
- Heatsink for better performance
- Power-On LED indicator

Operating Principle

The driver module can drive two motors. The enabled terminals ENA and ENB are effective at high level.

The working relationship between ENA and IN1,IN2 is as follows

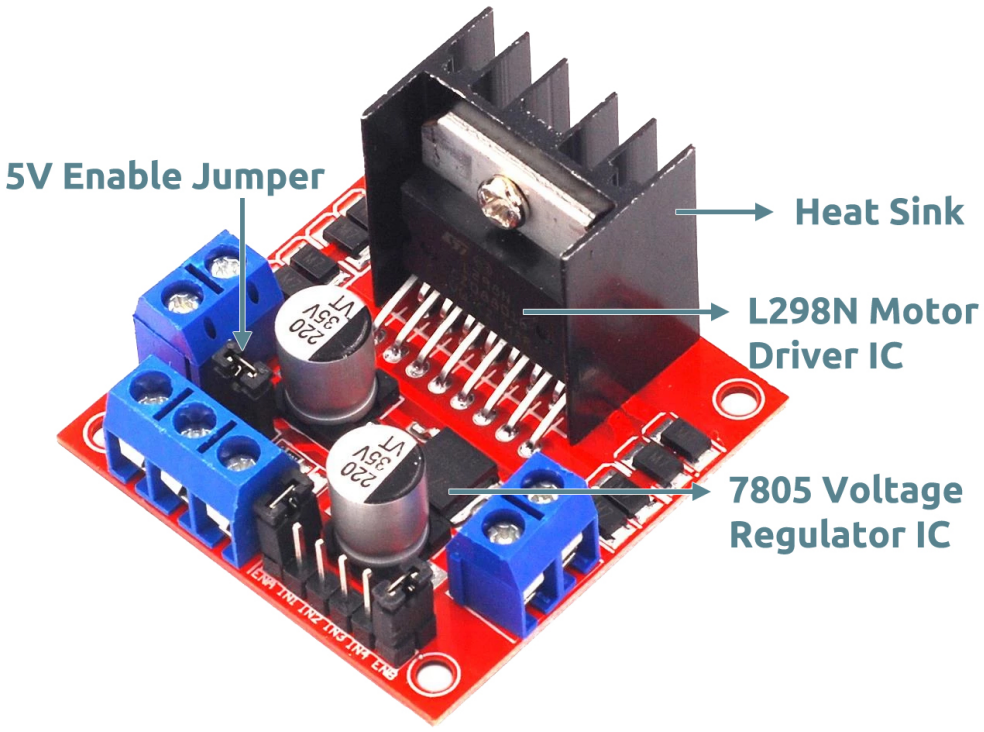
ENA	IN1	IN2	The state of Motor A
0	X	X	Stop
1	0	0	Brake
1	0	1	Rotate clockwise
1	1	0	Rotate counterclockwise
1	1	1	Brake

The working relationship between ENB and IN3,IN4 is as follows.

ENB	IN3	IN4	The state of Motor B
0	X	X	Stop
1	0	0	Brake
1	0	1	Rotate clockwise
1	1	0	Rotate counterclockwise
1	1	1	Brake

About 5V Enable Cap

The L298N Motor Driver module consists of an L298 Motor Driver IC, 78M05 Voltage Regulator, resistors, capacitor, Power LED, 5V jumper in an integrated circuit.



78M05 Voltage regulator will be enabled only when the jumper is placed. When the power supply is less than or equal to 12V, then the internal circuitry will be powered by the voltage regulator and the 5V pin can be used as an output pin to power the microcontroller.

The jumper should not be placed when the power supply is greater than 12V and separate 5V should be given through 5V terminal to power the internal circuitry.

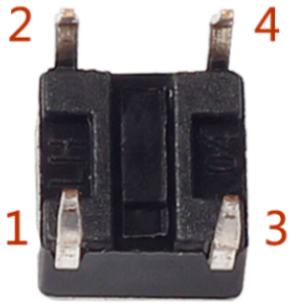
- L298N datasheet

Controller

CHAPTER

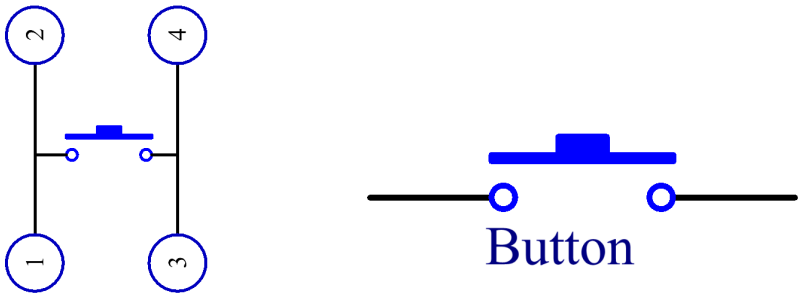
EIGHTEEN

BUTTON

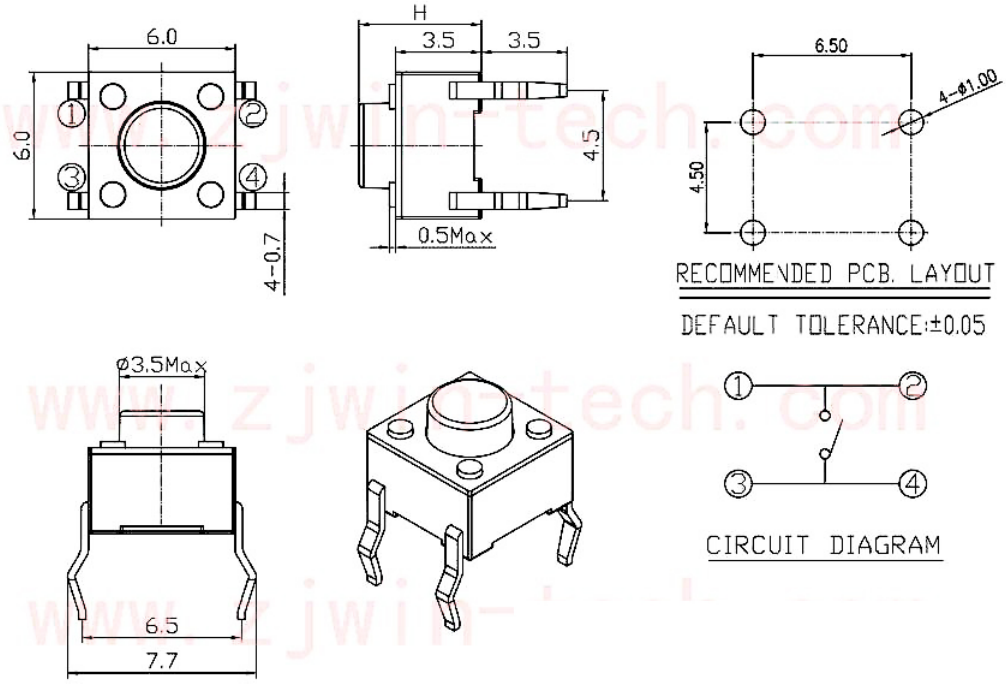


Buttons are a common component used to control electronic devices. They are usually used as switches to connect or break circuits. Although buttons come in a variety of sizes and shapes, the one used here is a 6mm mini-button as shown in the following pictures. Pin 1 is connected to pin 2 and pin 3 to pin 4. So you just need to connect either of pin 1 and pin 2 to pin 3 or pin 4.

The following is the internal structure of a button. The symbol on the right below is usually used to represent a button in circuits.



Since the pin 1 is connected to pin 2, and pin 3 to pin 4, when the button is pressed, the 4 pins are connected, thus closing the circuit.


6.0
6.0
4-0.7
H
3.5
3.5
4.5
0.5Max
6.50
4-ø1.00
4.50
RECOMMENDED PCB. LAYOUT
DEFAULT TOLERANCE:±0.05
ø3.5Max
6.5
7.7
CIRCUIT DIAGRAM

CHAPTER

NINETEEN

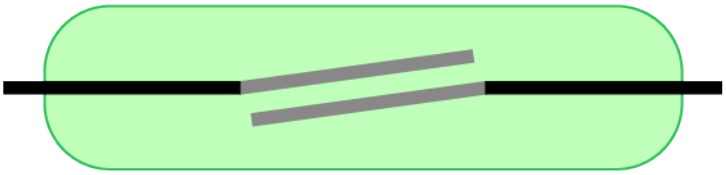
REED SWITCH

The Reed Switch is an electrical switch that operates by means of an applied magnetic field. It was invented by Walter B. Ellwood of Bell Telephone Laboratories in 1936 and patented in the United States on June 27, 1940, under patent number 2264746.

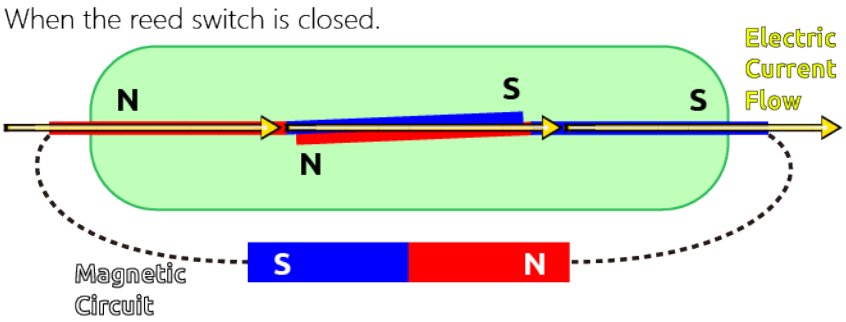
The principle of operation of a reed switch is very simple. Two reeds (usually made of iron and nickel, two metals) that overlap at the end points are sealed in a glass tube, with the two reeds overlapping and separated by a small gap (only about a few microns). The glass tube is filled with a high purity inert gas (such as nitrogen), and some reed switches are made to have a vacuum inside to enhance their high voltage performance.

The reed acts as a magnetic flux conductor. The two reeds are not in contact when not yet in operation; when passing through a magnetic field generated by a permanent magnet or electromagnetic coil, the applied magnetic field causes the two reeds to have different polarities near their endpoints, and when the magnetic force exceeds the spring force of the reeds themselves, the two reeds will be drawn together to conduct the circuit; when the magnetic field weakens or disappears, the reeds are released due to their own elasticity, and the contact surfaces will separate to open the circuit.

When the reed switch is open.



When the reed switch is closed.

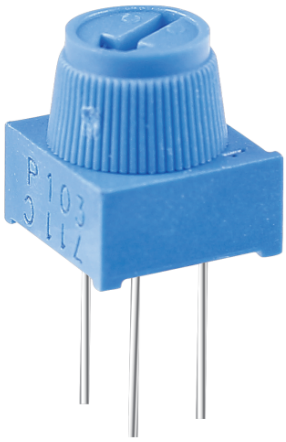


- Reed Switch - Wikipedia

CHAPTER

TWENTY

POTENTIOMETER

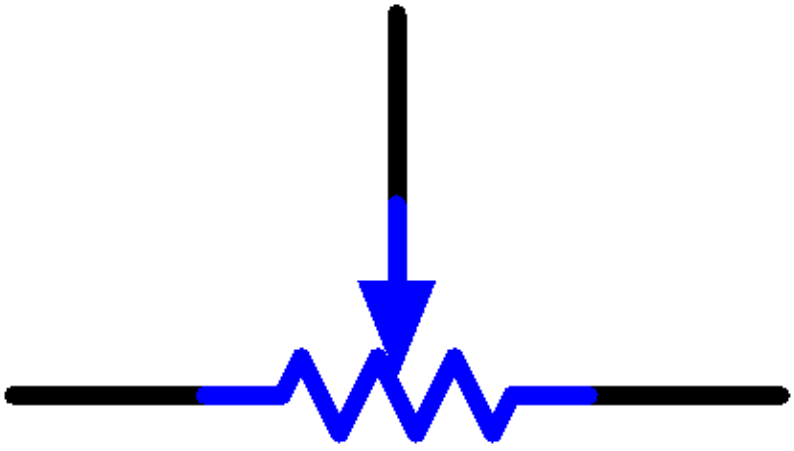


Potentiometer is also a resistance component with 3 terminals and its resistance value can be adjusted according to some regular variation.

Potentiometers come in various shapes, sizes, and values, but they all have the following things in common:

- They have three terminals (or connection points).
- They have a knob, screw, or slider that can be moved to vary the resistance between the middle terminal and either one of the outer terminals.
- The resistance between the middle terminal and either one of the outer terminals varies from 0 to the maximum resistance of the pot as the knob, screw, or slider is moved.

Here is the circuit symbol of potentiometer.



The functions of the potentiometer in the circuit are as follows:

1. Serving as a voltage divider

   Potentiometer is a continuously adjustable resistor. When you adjust the shaft or sliding handle of the potentiometer, the movable contact will slide on the resistor. At this point, a voltage can be output depending on the voltage applied onto the potentiometer and the angle the movable arm has rotated to or the travel it has made.

2. Serving as a rheostat

   When the potentiometer is used as a rheostat, connect the middle pin and one of the other 2 pins in the circuit. Thus you can get a smoothly and continuously changed resistance value within the travel of the moving contact.

3. Serving as a current controller

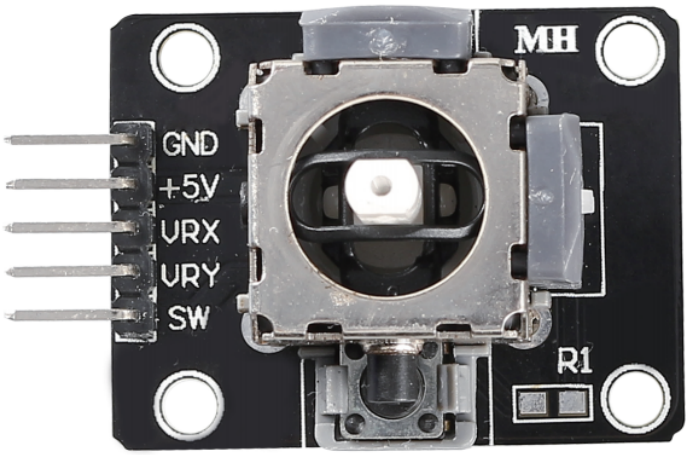
   When the potentiometer acts as a current controller, the sliding contact terminal must be connected as one of the output terminals.

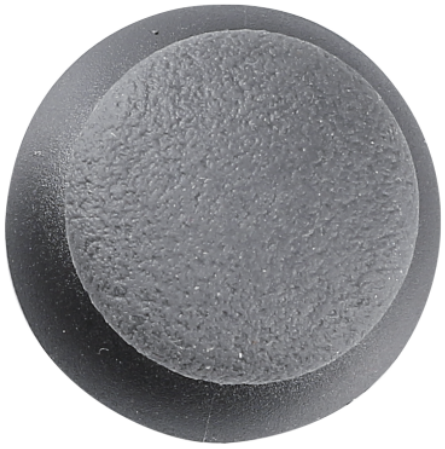
If you want to know more about potentiometer, refer to: Potentiometer - Wikipedia

CHAPTER

TWENTYONE

JOYSTICK MODULE



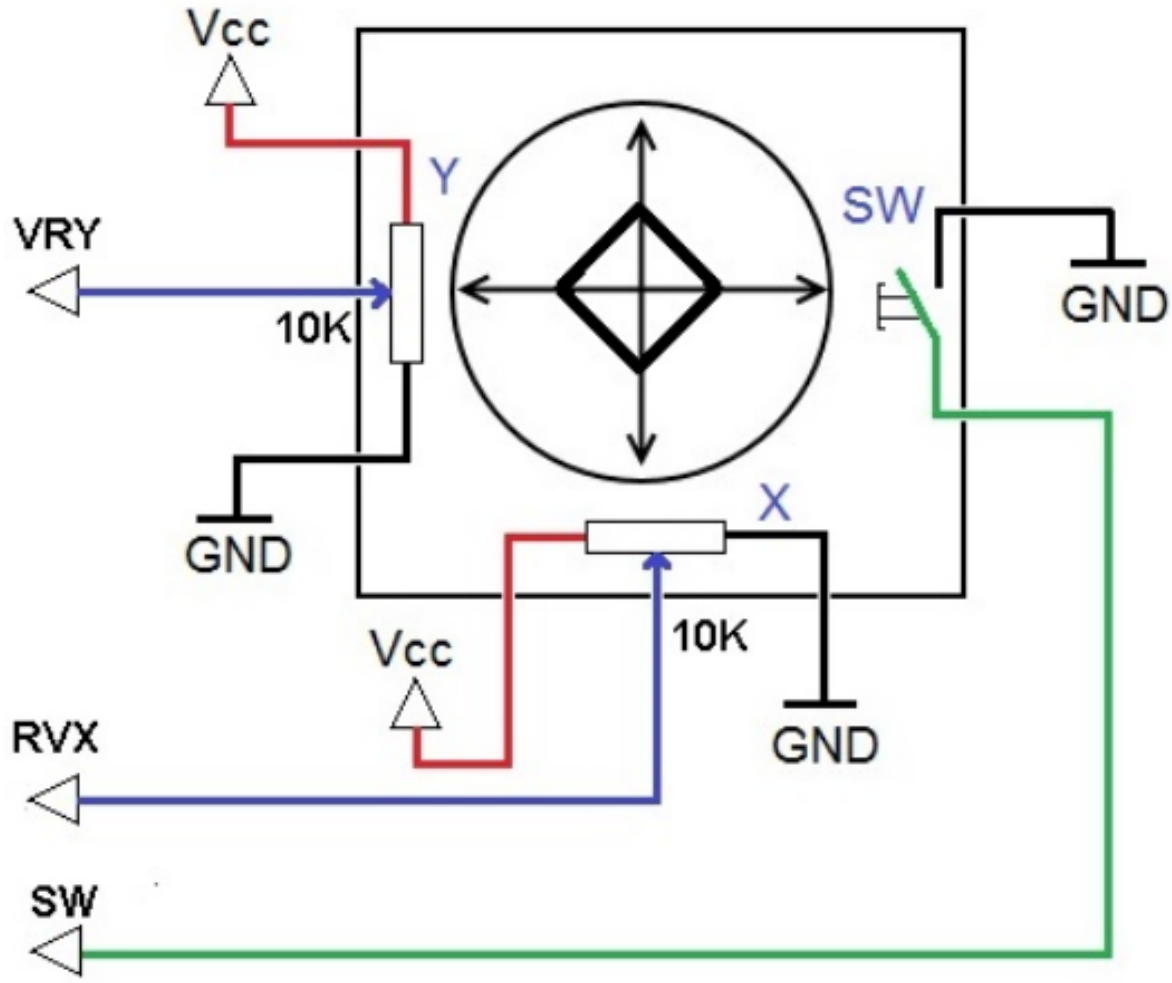


The basic idea of a joystick is to translate the movement of a stick into electronic information that a computer can process.

In order to communicate a full range of motion to the computer, a joystick needs to measure the stick's position on two axes – the X-axis (left to right) and the Y-axis (up and down). Just as in basic geometry, the X-Y coordinates pinpoint the stick's position exactly.

To determine the location of the stick, the joystick control system simply monitors the position of each shaft. The conventional analog joystick design does this with two potentiometers, or variable resistors.

The joystick also has a digital input that is actuated when the joystick is pressed down.

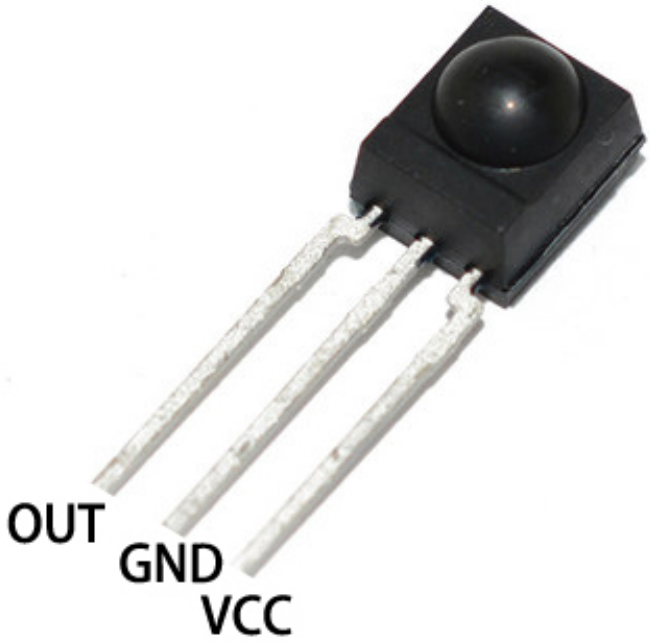

Vcc
Y
VRY
10K
GND
SW
GND
X
Vcc
10K
GND
RVX
SW

CHAPTER

TWENTYTWO

IR RECEIVER

IR Receiver



- OUT: Signal output
- GNDGND
- VCC: power supply, 3.3v~5V

An infrared-receiver is a component which receives infrared signals and can independently receive infrared rays and output signals compatible with TTL level. It is similar with a normal plastic-packaged transistor in size and is suitable for all kinds of infrared remote control and infrared transmission.

Infrared, or IR, communication is a popular, low-cost, easy-to-use wireless communication technology. Infrared light has a slightly longer wavelength than visible light, so it is imperceptible to the human eye - ideal for wireless communication. A common modulation scheme for infrared communication is 38KHz modulation.

- Adopted HS0038B IR Receiver Sensor, high sensitivity
- Can be used for remote control
- Power Supply: 5V
- Interface: Digital
- Modulate Frequency: 38Khz

- Pin Definitions: (1) Output (2) Vcc (3) GND
- Size: 23.5mm x 21.5mm

Remote Control

This is a Mini thin infrared wireless remote control with 21 function buttons and a transmitting distance of up to 8 meters, which is suitable for operating a wide range of devices in a kid's room.

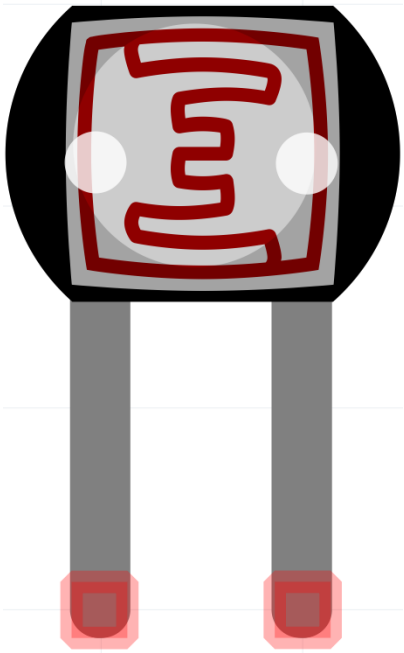
- Size: 85x39x6mm
- Remote control range: 8-10m
- Battery: 3V button type lithium manganese battery
- Infrared carrier frequency: 38KHz
- Surface paste material: 0.125mm PET
- Effective life: more than 20,000 times

Sensor

CHAPTER

TWENTYTHREE

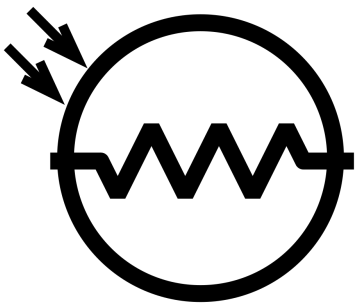
PHOTORESISTOR



A photoresistor or photocell is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity; in other words, it exhibits photo conductivity.

A photoresistor can be applied in light-sensitive detector circuits and light-activated and dark-activated switching circuits acting as a resistance semiconductor. In the dark, a photoresistor can have a resistance as high as several megaohms (M), while in the light, a photoresistor can have a resistance as low as a few hundred ohms.

Here is the electronic symbol of photoresistor.

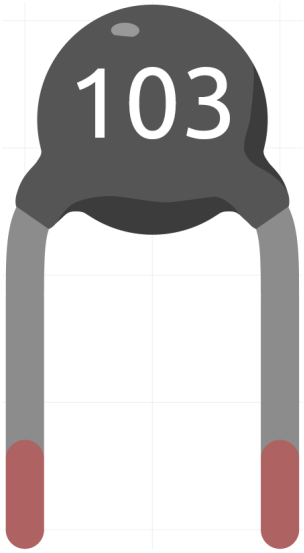


- Photoresistor - Wikipedia

CHAPTER

TWENTYFOUR

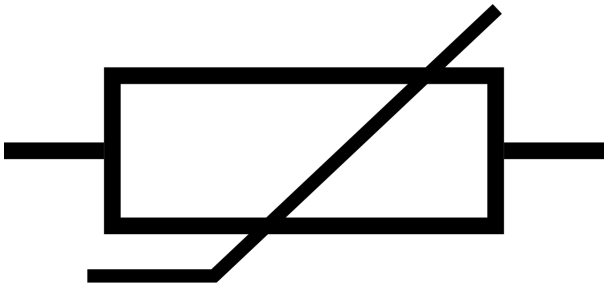
THERMISTOR



A thermistor is a type of resistor whose resistance is strongly dependent on temperature, more so than in standard resistors. The word is a combination of thermal and resistor. Thermistors are widely used as inrush current limiters, temperature sensors (negative temperature coefficient or NTC type typically), self-resetting overcurrent protectors, and self-regulating heating elements (positive temperature coefficient or PTC type typically).

- Thermistor - Wikipedia

Here is the electronic symbol of thermistor.



Thermistors are of two opposite fundamental types:

- With NTC thermistors, resistance decreases as temperature rises usually due to an increase in conduction electrons bumped up by thermal agitation from valency band. An NTC is commonly used as a temperature sensor, or in series with a circuit as an inrush current limiter.

- With PTC thermistors, resistance increases as temperature rises usually due to increased thermal lattice agitations particularly those of impurities and imperfections. PTC thermistors are commonly installed in series with a circuit, and used to protect against overcurrent conditions, as resettable fuses.

In this kit we use an NTC one. Each thermistor has a normal resistance. Here it is 10k ohm, which is measured under 25 degree Celsius.

Here is the relation between the resistance and temperature:

RT = RN * expB(1/TK – 1/TN)

- **RT** is the resistance of the NTC thermistor when the temperature is TK.
- **RN** is the resistance of the NTC thermistor under the rated temperature TN. Here, the numerical value of RN is 10k.
- **TK** is a Kelvin temperature and the unit is K. Here, the numerical value of TK is 273.15 + degree Celsius.
- **TN** is a rated Kelvin temperature; the unit is K too. Here, the numerical value of TN is 273.15+25.
- And **B(beta)**, the material constant of NTC thermistor, is also called heat sensitivity index with a numerical value 3950.
- **exp** is the abbreviation of exponential, and the base number e is a natural number and equals 2.7 approximately.

Convert this formula TK=1/(ln(RT/RN)/B+1/TN) to get Kelvin temperature that minus 273.15 equals degree Celsius.

This relation is an empirical formula. It is accurate only when the temperature and resistance are within the effective range.

CHAPTER

TWENTYFIVE

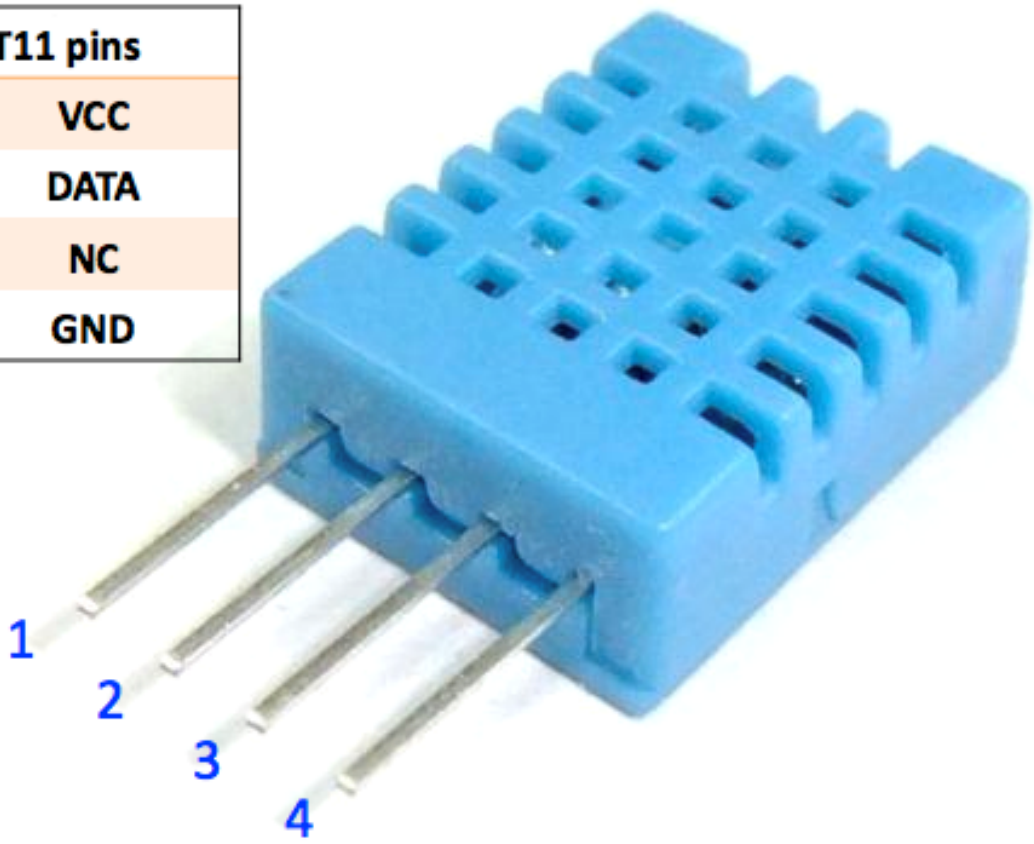
DHT11 HUMITURE SENSOR

The digital temperature and humidity sensor DHT11 is a composite sensor that contains a calibrated digital signal output of temperature and humidity. The technology of a dedicated digital modules collection and the temperature and humidity sensing technology are applied to ensure that the product has high reliability and excellent long-term stability.

The sensor includes a resistive sense of wet component and an NTC temperature measurement device, and is connected with a high-performance 8-bit microcontroller.

Only three pins are available for use: VCC, GND, and DATA. The communication process begins with the DATA line sending start signals to DHT11, and DHT11 receives the signals and returns an answer signal. Then the host receives the answer signal and begins to receive 40-bit humiture data (8-bit humidity integer + 8-bit humidity decimal + 8-bit temperature integer + 8-bit temperature decimal + 8-bit checksum).

DHT11 pins	
1	VCC
2	DATA
3	NC
4	GND



Features

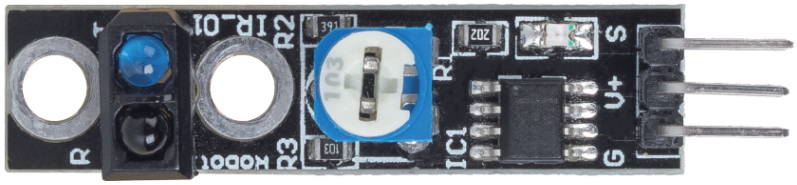
1. Humidity measurement range: 20 - 90%RH
2. Temperature measurement range: 0 - 60°C
3. Output digital signals indicating temperature and humidity
4. Working voltage:DC 5V; PCB size: 2.0 x 2.0 cm
5. Humidity measurement accuracy: ±5%RH
6. Temperature measurement accuracy: ±2°C

- DHT11 Datasheet

CHAPTER

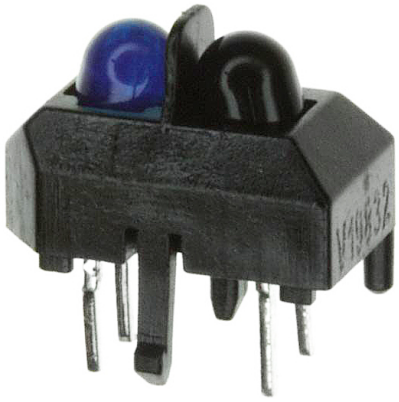
TWENTYSIX

LINE TRACKING MODULE



- S: Usually low level, high level when the black line is detected.
- V+Power supply, 3.3v~5V
- G: Ground

This is a 1-channel Line Tracking module which, as the name suggests, tracks black lines on a white background or white lines against a black background.



The module uses a TCRT500 infrared sensor, which consists of an infrared LED (blue) and a photosensitive triplet (black).

- The blue infrared LED, when powered on, emits infrared light that is invisible to the human eye.
- The black phototransistor, which is used to receive infrared light, has an internal resistor whose resistance varies with the infrared light received; the more infrared light received, the lower its resistance decreases and vice versa.

There is a LM393 comparator on the module, which is used to compare the voltage of the phototransistor with the set voltage (adjusted by potentiometer), if it is greater than the set voltage, the output is 1; otherwise the output is 0.

Therefore, when the infrared emitter tube shines on a black surface, because the black will absorb light, the photosensitive transistor receives less infrared light, its resistance will increase (voltage increase), after LM393 comparator, the output high level.

Similarly, when it shines on a white surface, the reflected light will become more and the resistance of the photosensitive transistor will decrease (voltage decreases); therefore, the comparator outputs a low level and the indicator LED lights up.

- TCRT5000

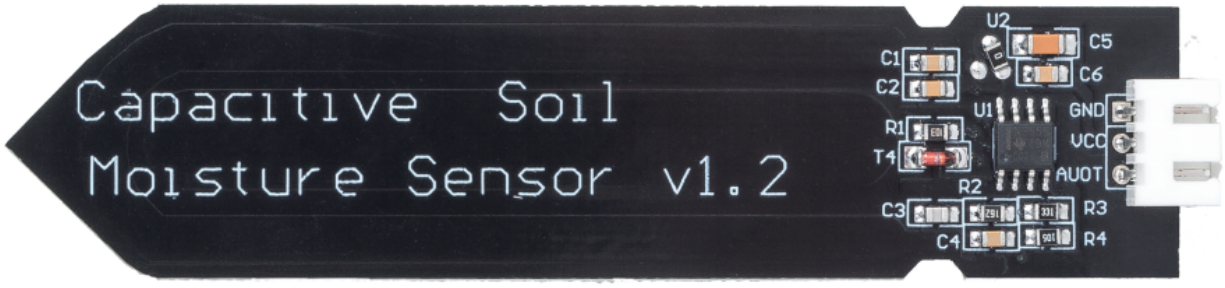
Features

- Using infrared emission sensor TCRT5000
- Detection distance: 1-8mm, focal length of 2.5mm
- Comparator output signal clean, good waveform, driving capacity greater than 15mA
- Using potentiometer for sensitivity adjustment
- Operating voltage: 3.3V-5V
- Digital output: 0 (white) and 1 (black)
- Uses wide voltage LM393 comparator.
- Size: 42mmx10mm

CHAPTER

TWENTYSEVEN

SOIL MOISTURE MODULE

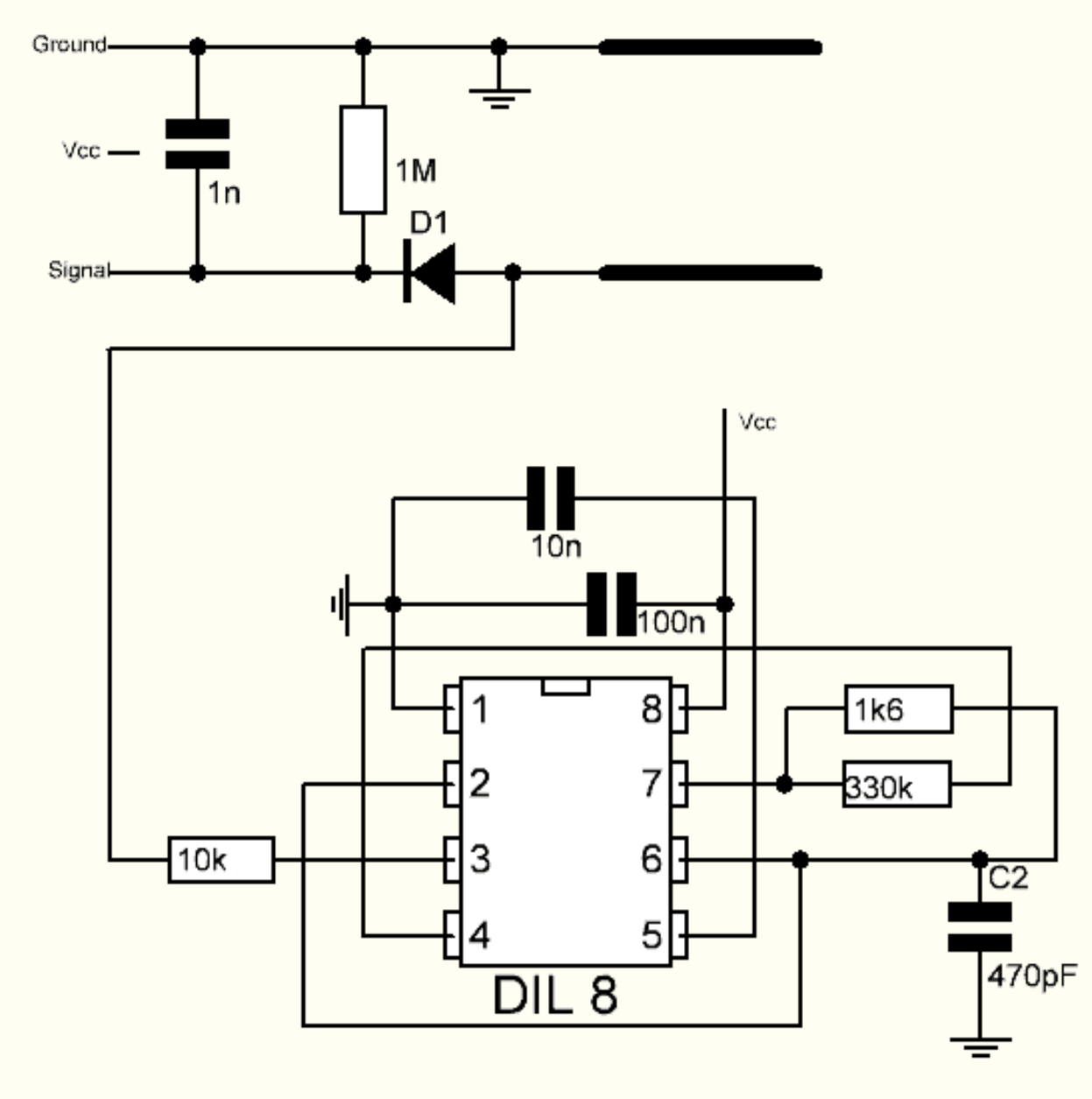


- GND: Ground
- VCCPower supply, 3.3v~5V
- AOUT: Outputs the soil moisture value, the wetter the soil, the smaller its value.

This capacitive soil moisture sensor is different from most of the resistive sensors on the market, using the principle of capacitive induction to detect soil moisture. It avoids the problem that resistive sensors are highly susceptible to corrosion and greatly extends its working life.

It is made of corrosion-resistant materials and has an excellent service life. Insert it into the soil around plants and monitor real-time soil moisture data. The module includes an on-board voltage regulator that allows it to operate over a voltage range of 3.3 ~ 5.5 V. It is ideal for low-voltage microcontrollers with 3.3 V and 5 V supplies.

The hardware schematic of the capacitive soil moisture sensor is shown below.



There is a fixed frequency oscillator, which is built with a 555 timer IC. The generated square wave is then fed to the sensor like a capacitor. However, for the square wave signal, the capacitor has a certain reactance or, for the sake of argument, a resistor with a pure ohmic resistor (10k resistor on pin 3) to form a voltage divider.

The higher the soil moisture, the higher the capacitance of the sensor. As a result, the square wave has less reactance, which reduces the voltage on the signal line, and the smaller the value of the analog input through the microcontroller.

Specification

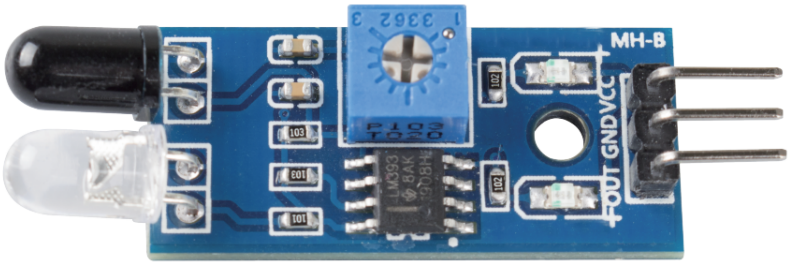
- Operating Voltage: 3.3 ~ 5.5 VDC
- Output Voltage: 0 ~ 3.0VDC
- Operating Current: 5mA
- Interface: PH2.0-3P

- Dimensions: 3.86 x 0.905 inches (L x W)
- Weight: 15g

CHAPTER

TWENTYEIGHT

OBSTACLE AVOIDANCE MODULE

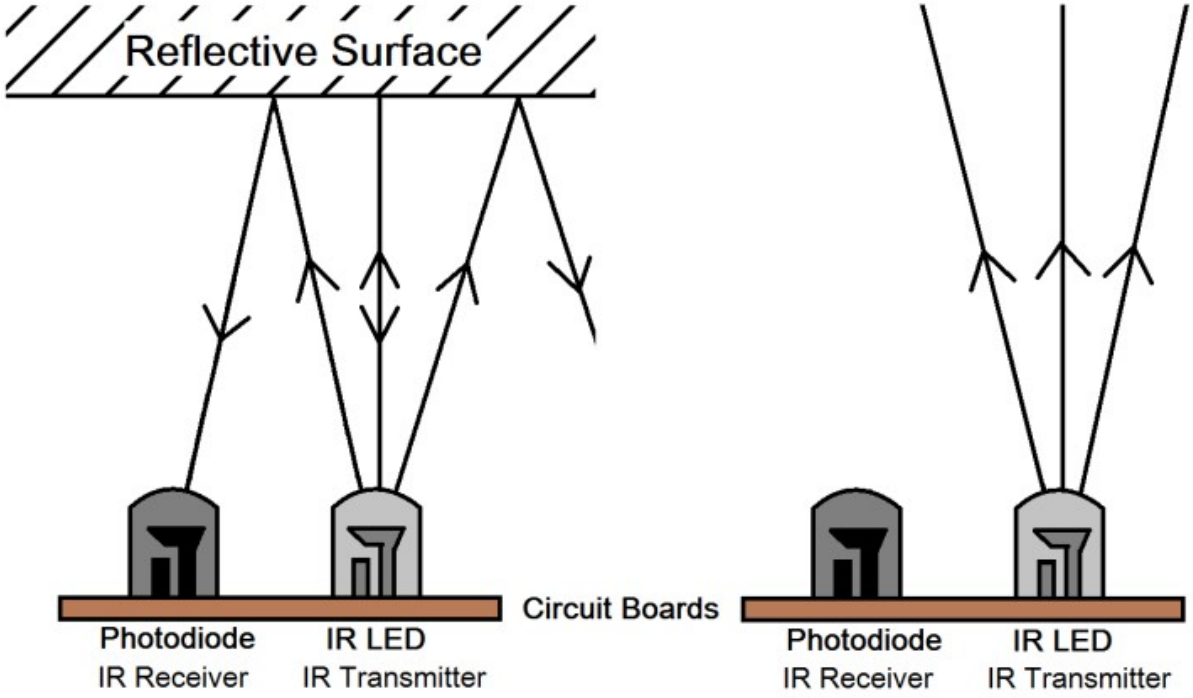


- **VCC**: Power supply, 3.3 ~ 5V DC.
- **GND**: Ground
- **OUT**: Signal pin, usually high level, and low level when an obstacle is detected.

The IR obstacle avoidance module has strong adaptability to environmental light, it has a pair of infrared transmitting and receiving tubes.

The transmitting tube emits infrared frequency, when the detection direction encounters an obstacle, the infrared radiation is received by the receiving tube, after the comparator circuit processing, the indicator will light up and output low level signal.

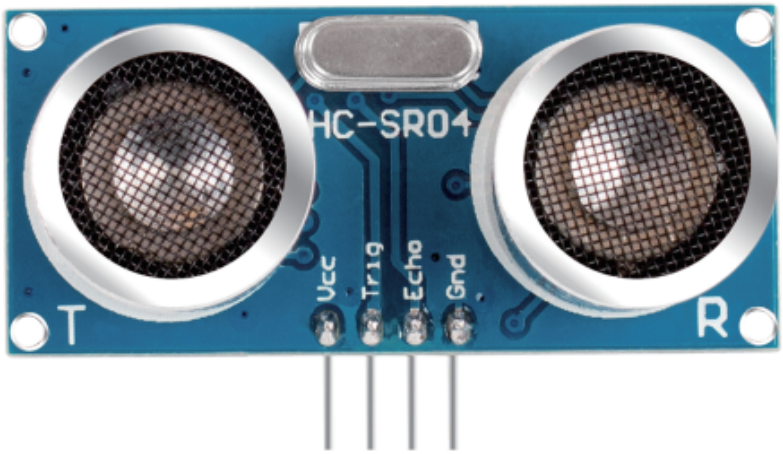
The detection distance can be adjusted by potentiometer, the effective distance range 2-30cm.


Reflective Surface
Photodiode
IR Receiver
IR LED
IR Transmitter
Circuit Boards
Photodiode
IR Receiver
IR LED
IR Transmitter

CHAPTER

TWENTYNINE

ULTRASONIC MODULE

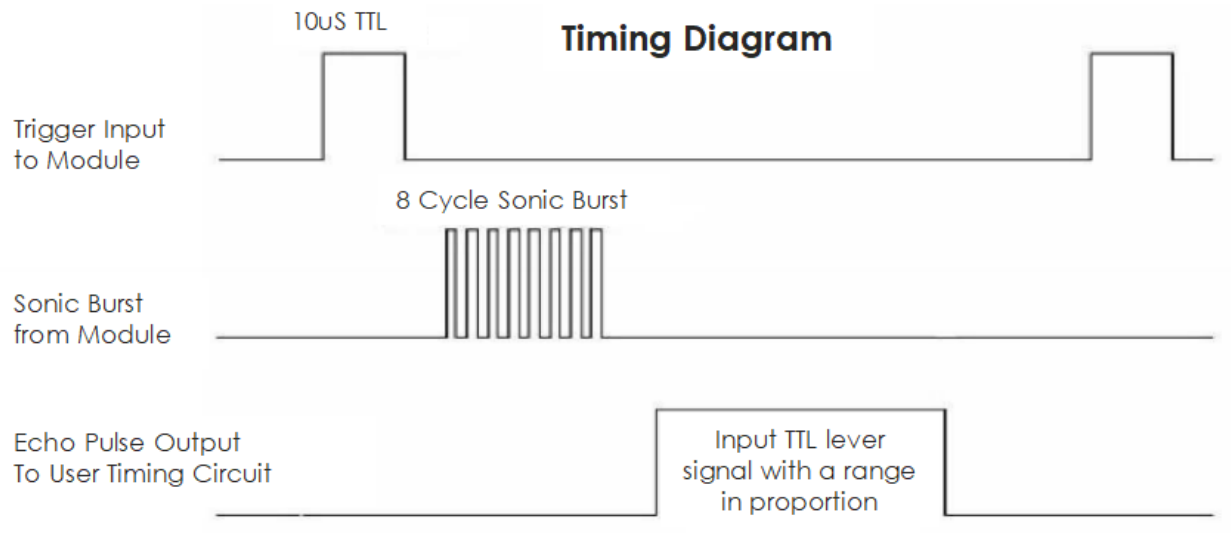


Ultrasonic ranging module provides 2cm - 400cm non-contact measurement function, and the ranging accuracy can reach to 3mm. It can ensure that the signal is stable within 5m, and the signal is gradually weakened after 5m, till the 7m position disappears.

The module includes ultrasonic transmitters, receiver and control circuit. The basic principles are as follows:

1. Use an IO flip-flop to process a high level signal of at least 10us.
2. The module automatically sends eight 40khz and detects if there is a pulse signal return.
3. If the signal returns, passing the high level, the high output IO duration is the time from the transmission of the ultrasonic wave to the return of it. Here, test distance = (high time x sound speed (340 m / s) / 2.

The timing diagram is shown below.



You only need to supply a short 10us pulse for the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. You can calculate the range through the time interval between sending trigger signal and receiving echo signal.

Formula: us / 58 = centimeters or us / 148 =inch; or: the range = high level time * velocity (340M/S) / 2; you are suggested to use measurement cycle over 60ms in order to prevent signal collisions of trigger signal and the echo signal.

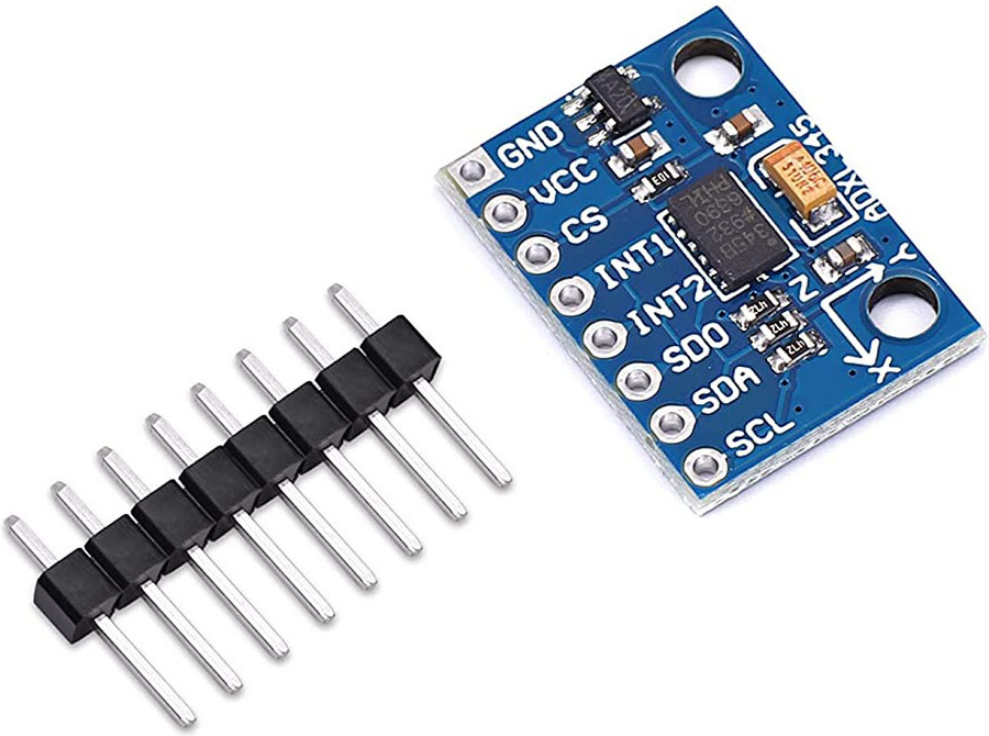
CHAPTER

THIRTY

ADXL345 MODULE

The purpose of this project is to introduce you to the ADXL345 module and show you how to use it with Arduino and Raspberry Pi.

30.1 About ADXL345 Module



- **GND**: Cathode of the power supply.
- **VCC**: The power supply is connected to 3-5V.
- **CS**: Chip select.
- **INT1**: Interrupt the output 1.
- **INT2**: Interrupt the output 2.
- **SD0**: Serial data output (SPI 4 wire), spare I2C address choose(I2C).
- **SDA**: Serial data (I2C), Serial data input (SPI line 4), Serial data input, output(SPI Line 3)

- **SCL**: Serial data (I2C), Serial data input (SPI line 4), Serial data input, output(SPI Line 3)

The ADXL345 is a small, thin, ultralow power, 3-axis accelerometer with high resolution (13-bit) measurement at up to ±16 g. Digital output data is formatted as 16-bit twos complement and is accessible through either a SPI (3- or 4-wire) or I2C digital interface.

The ADXL345 is well suited for mobile device applications. It measures the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion or shock. Its high resolution (3.9 mg/LSB) enables measurement of inclination changes less than 1.0°.

- ADXL345 - datasheet

Main Features

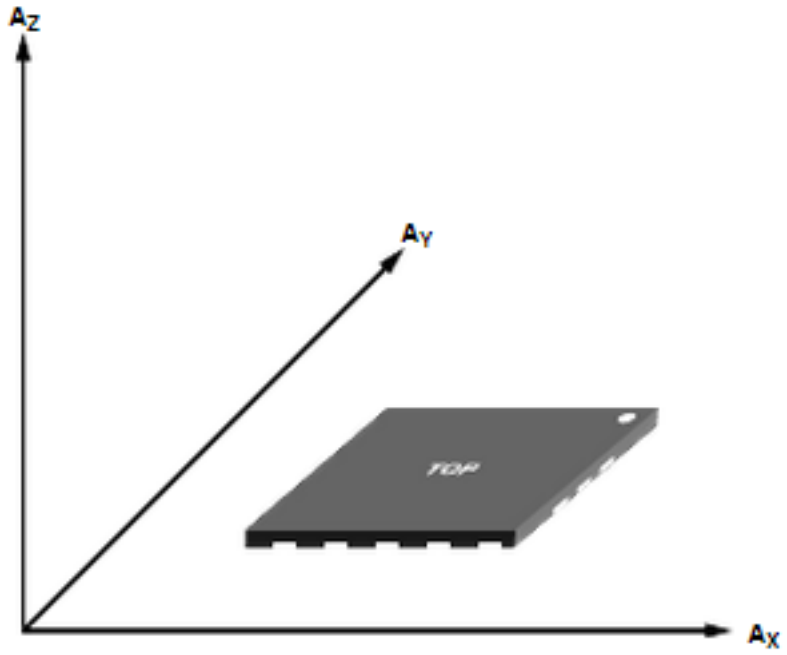
- Type: GY-291
- Chip: ADXL345
- Power Supply: 3~5V
- Communication Mode: Standard IIC/SPI communicating protocol
- Measuring Range: ±2g±16g
- 3 axis, ± 2g/ ± 4g/ ± 8g/ ± 16g

Application

- Mobile Phone
- Medical instrument
- Game and pointing device
- Industrial instrument
- Personal navigation device
- HDD Protection from falling
- Screen flip on tablet computer

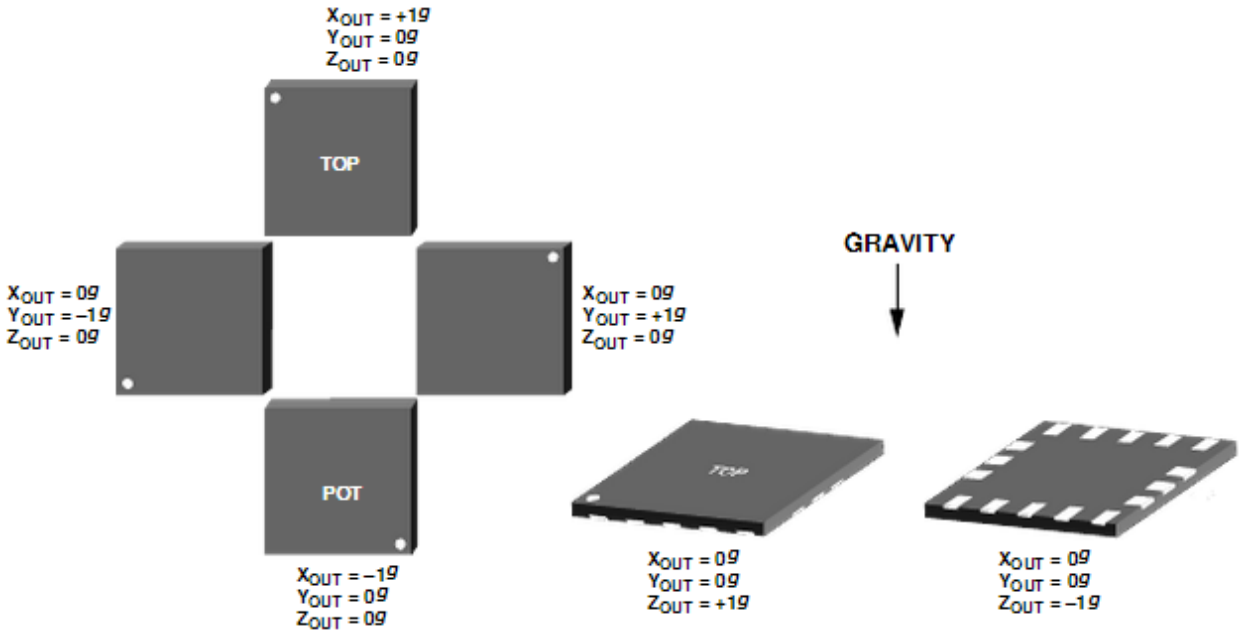
Principle

ADXL345 works like this:



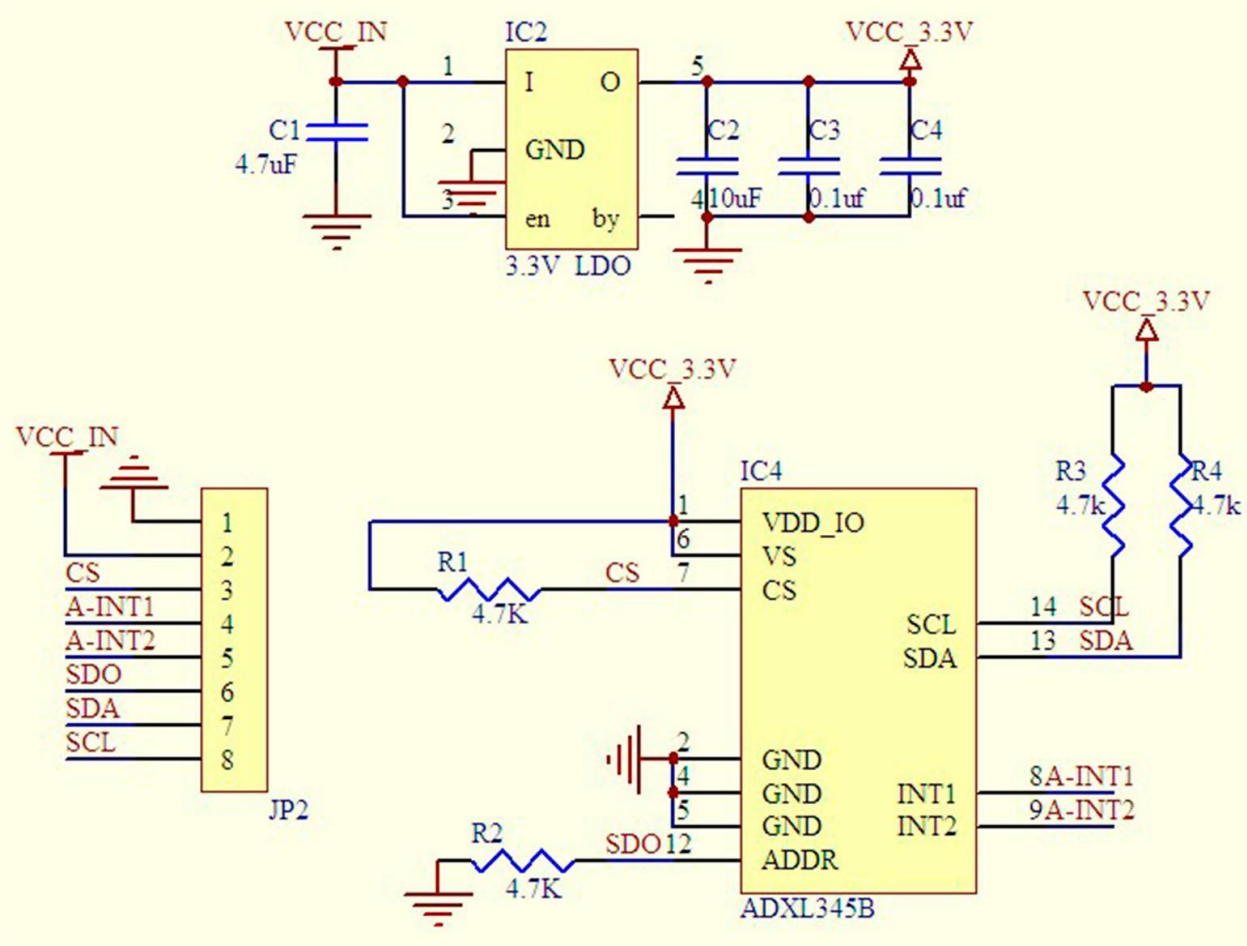
Axes of detection by ADXL345

When you place the module face up, Z_OUT is at the maximum which is +1g; face down, Z_OUT is at the minimum. No matter of face, as long as it's placed on a level surface, X_OUT increases along the Ax axis direction, so does Y_OUT along the Ay axis. See the picture below. Thus, when you rotate the module, you can see the changes of X_OUT, Y_OUT, and Z_OUT.



Relationship between output and gravity direction

Schematic

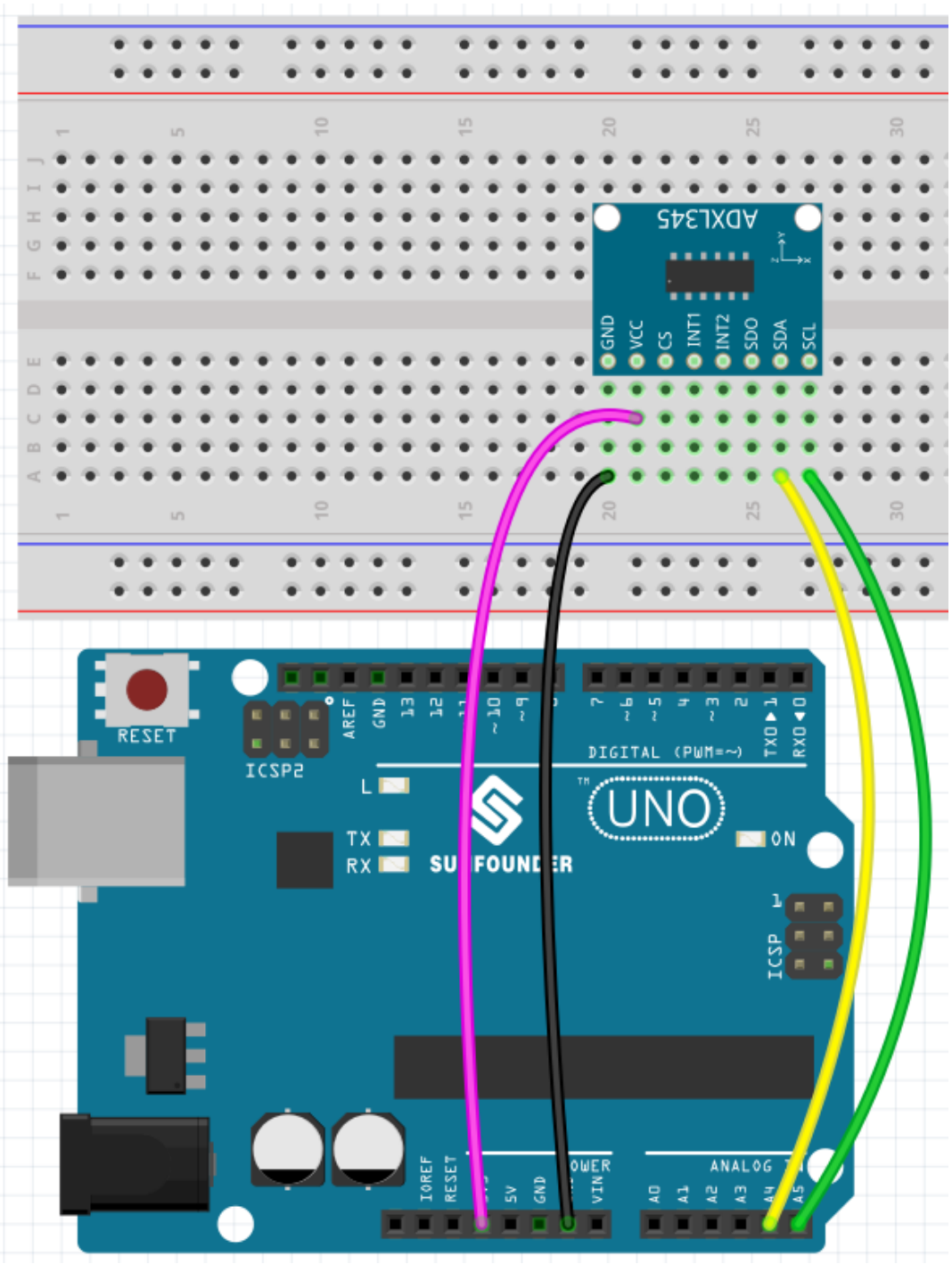


30.2 How to use?

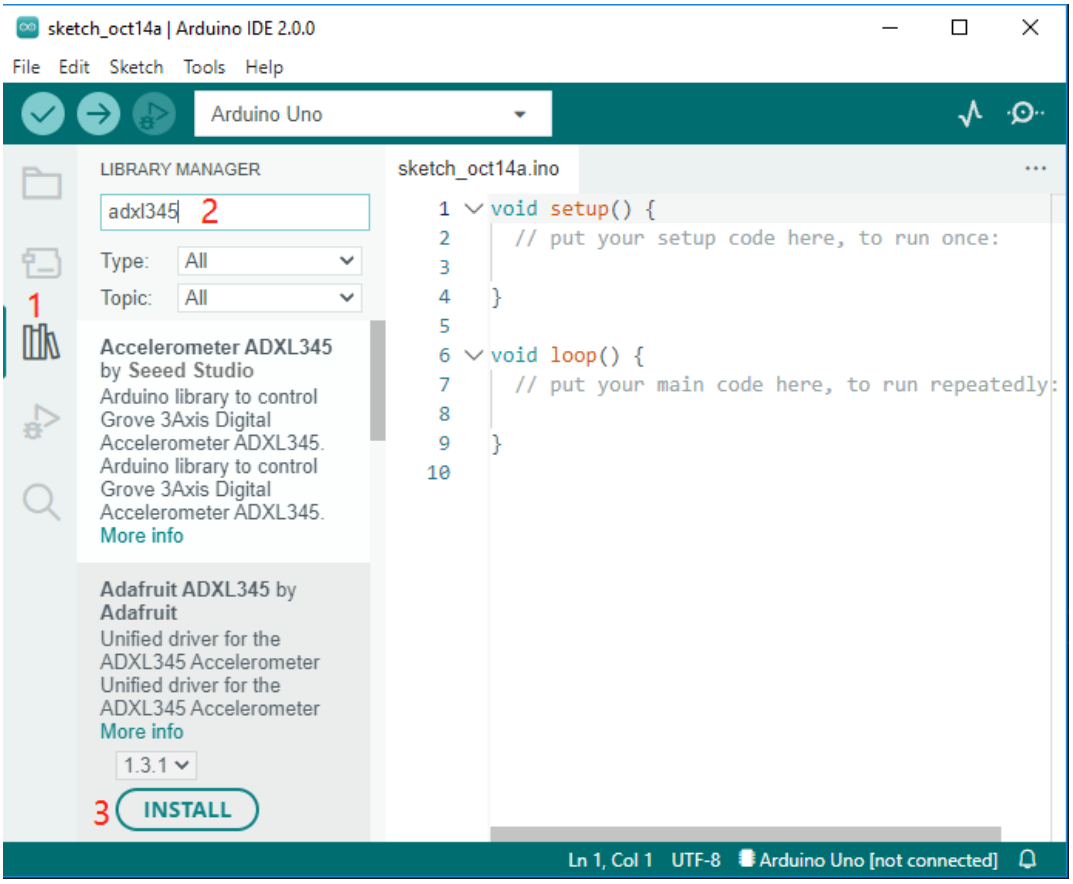
30.2.1 Use with Arduino

If you are Arduino user, you can follow the steps to use the module.

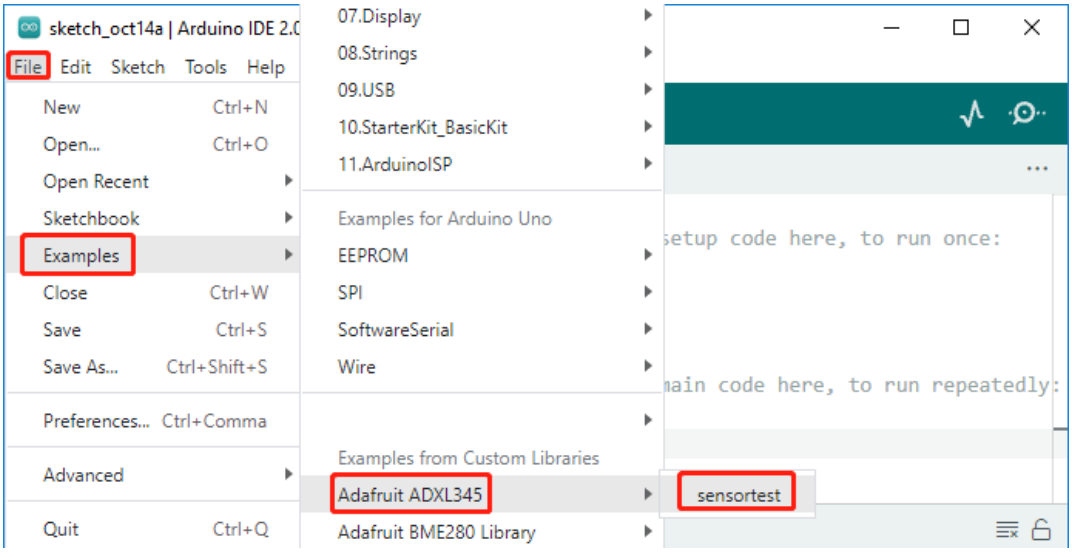
1. Build the circuit.



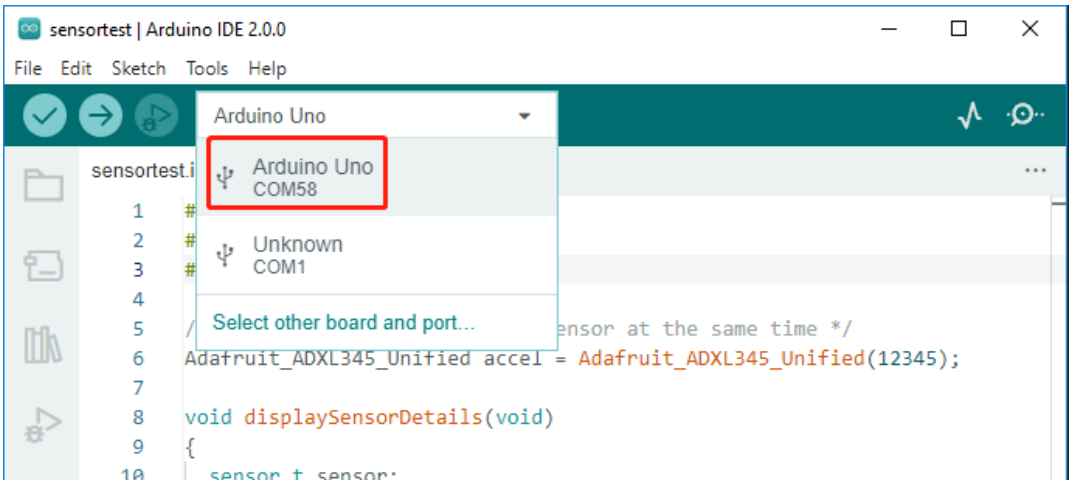
2. In the **Library Manager**, type `adxl345` and choose a library to install. **Adafruit ADXL345** is installed here, and choosing **INSTALL ALL** in the pop-up window is recommended.



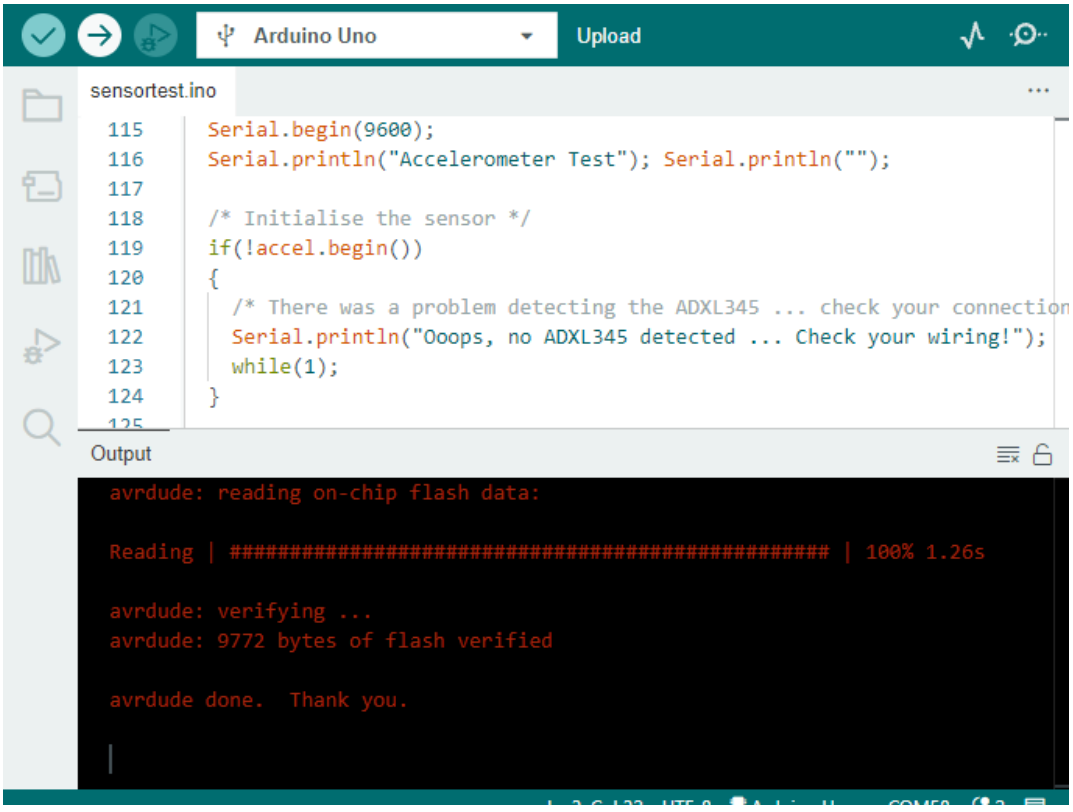
3. Open the sample code.



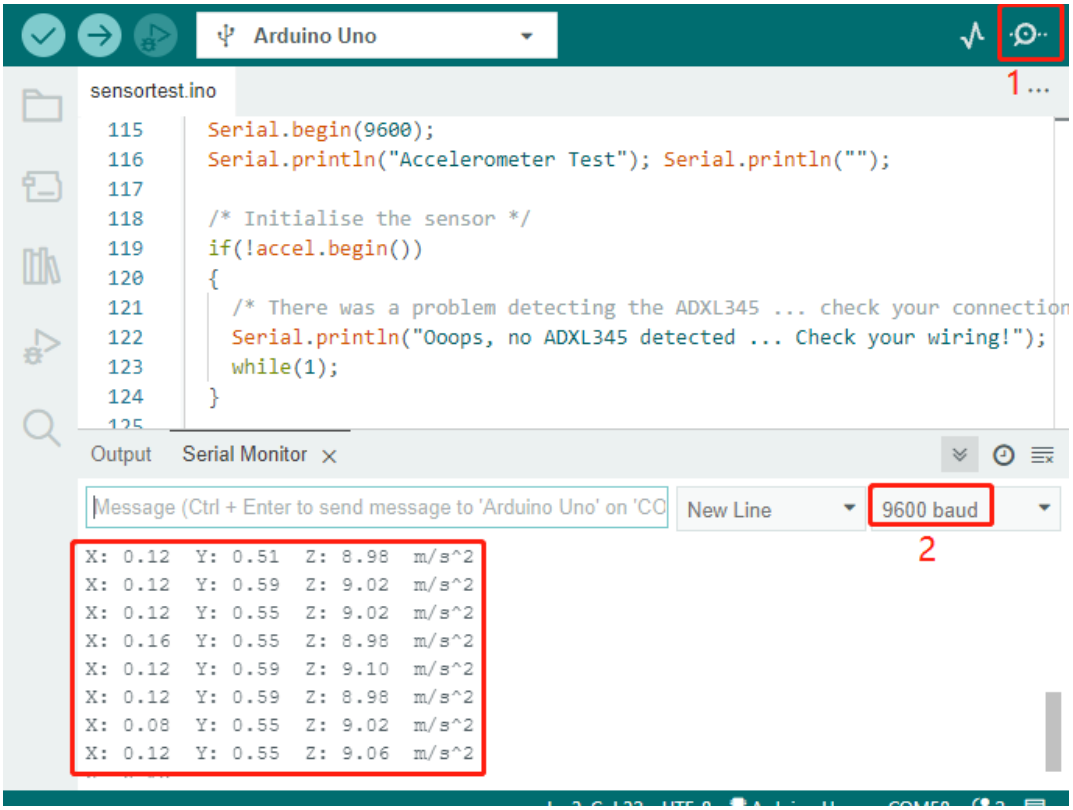
4. Select the board and port, here it is Arduino Uno, you can select other boards if you are using other boards.



5. Upload the code to your Arduino board.



6. Set the baud rate to 9600 in the serial monitor to see acceleration on the X, Y, and Z axes. You can turn the module in all directions and see how the values printed change.



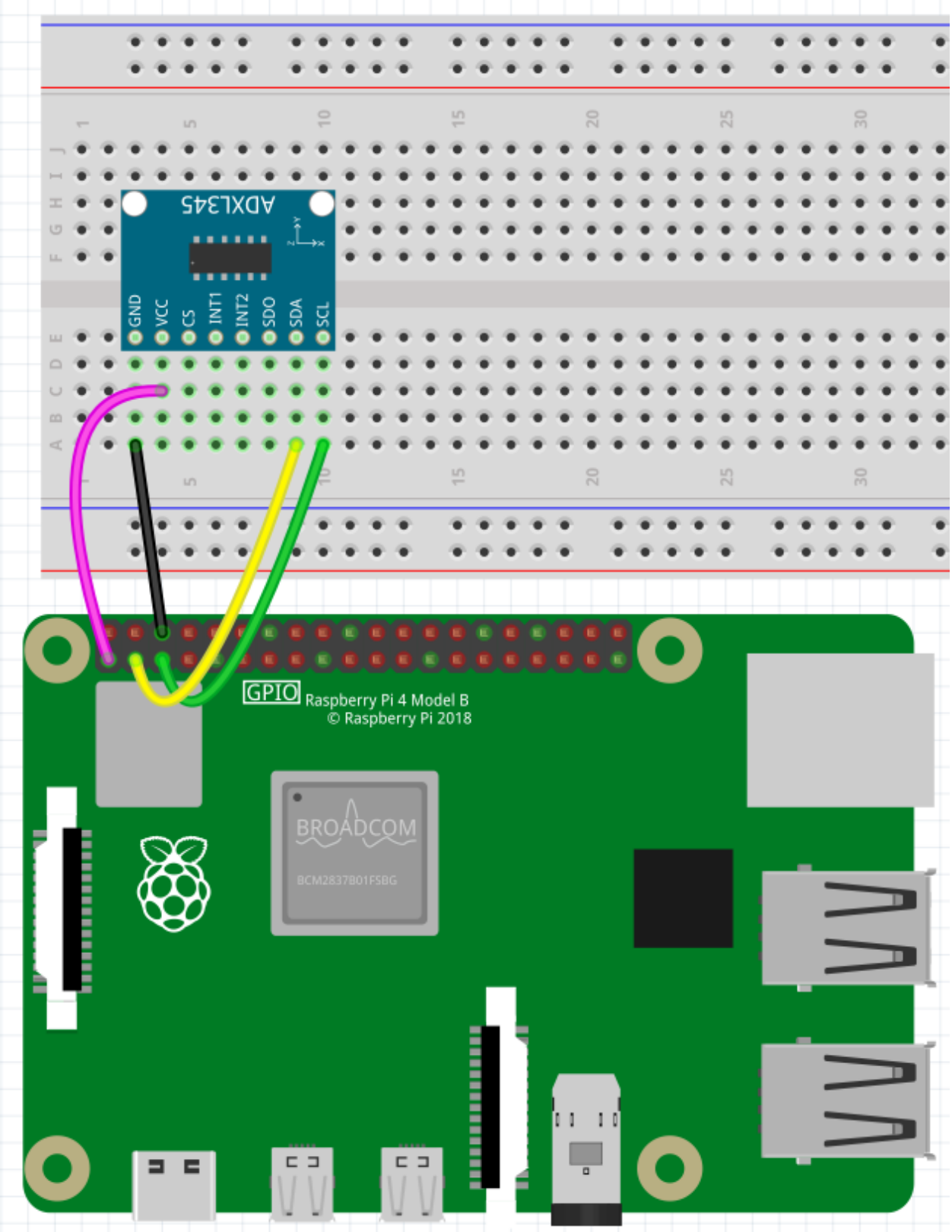
30.2.2 Use with Raspberry Pi

Refer to the following tutorial if you intend to use the ADXL345 module on Raspberry Pi.

1. Connecting Raspberry Pi and ADXL345 module

Follow the diagram below to plug the ADXL345 module into the breadboard first, then go to connect the Raspberry Pi. With the male - female cable, you can also connect this module directly to the Raspberry Pi if you don't have a breadboard.

Wire the **GND** pin of the module to Physical **Pin 6 (GND)** on the Raspberry Pi. Wire the **VCC** pin of the module to Physical **Pin 1 (3v3)** on the Raspberry Pi. Wire the **SDA** pin of the module to Physical **Pin 3 (SDA)** on the Raspberry Pi. Wire the **SCL** pin of the module to Physical **Pin 5 (SCL)** on the Raspberry Pi.



2. Configuring the Raspberry Pi

The Raspberry Pi's configuration must be altered before it can retrieve data from the ADXL345 module.

1. Let's first make sure everything is up to date by running the following two commands.

```
sudo apt-get update
sudo apt-get upgrade
```

2. In order to enable I2C on the Raspberry Pi, we will need to launch the Raspberry configuration tool once the Raspberry Pi has been updated.

```
sudo raspi-config
```

   - On this screen, you need to go to the **3 Interface Options** menu.
   - The ARROW keys can be used to navigate through the raspi-config tools menu. Select an option by pressing ENTER.
   - Now in the interface options menu, go ahead and select **I5 I2C**.
   - When asked if you would like to enable the ARM I2C interface, select **<YES>**.

3. I2C is now enabled, so we can go ahead and install the packages we will use to talk to the ADXL345 module. In the latest Raspberry Pi OS(Bullseye), these tools are already installed by default, you can skip this step.

```
sudo apt-get install python3-dev python3-pip python3-smbus i2c-tools -y
```

4. Now let's check if the Raspberry Pi can see the ADXL345 module.

```
sudo i2cdetect -y 1
```

   From this command, you should see quite a bit displayed on the command line. In this result, you should see at least one number, for example **53**.

```
pi@raspberrypi:~ $ sudo i2cdetect -y 1
    0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:                         -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50: -- -- -- 53 -- -- -- -- -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- --
```

   If nothing appears, make sure the ADXL345 accelerometer is properly connected to the Raspberry Pi and that all solder joints on the sensor pins are clean. If you see errors, try re-enabling I2C again.

3. Writing code

To talk to ADXL345, we will use , but you need to check your Python version first, because this library does not support Python 2.x.

1. Type `python`, the current version of Python will appear and you can use `exit()` to exit.

```
pi@raspberrypi:~ $ python
Python 3.9.2 (default, Feb 28 2021, 17:03:44)
[GCC 10.2.1 20210110] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> exit()
```

2. If you have Python 2.x, use the following command to install Python 3.

```
sudo apt-get install python3
```

3. Now you can use the following command to install .

```
sudo pip3 install adafruit-circuitpython-adxl34x
```

4. Now that all the packages we need are installed on the Raspberry Pi, we can start writing Python script to read information from the accelerometer. Use the following command to create a new blank script.

```
nano adxl345.py
```

5. Copy the following sample code into it.

```
import time
import board
import adafruit_adxl34x

i2c = board.I2C()  # uses board.SCL and board.SDA

# For ADXL345
accelerometer = adafruit_adxl34x.ADXL345(i2c)

while True:
    print("%f %f %f" % accelerometer.acceleration)
    time.sleep(0.2)
```

When you are sure that all the code is correct, you can press `CTRL+X` then `Y` and then `ENTER` to save it.

6. With the code now done, let's go ahead and run the script.

```
python3 ./adxl345.py
```

By running this code, you should see the values being read in from the accelerometer.

```
pi@raspberrypi:~/Documents $ python3 ./adxl345.py
0.000000 0.000000 0.000000
0.000000 -0.196133 9.218251
0.000000 -0.156906 9.061345
0.000000 -0.196133 9.022118
0.000000 -0.156906 9.022118
0.000000 -0.117680 9.022118
0.000000 -0.156906 9.061345
0.000000 -0.117680 9.061345
0.000000 -0.117680 9.061345
0.000000 -0.156906 9.061345
0.000000 -0.117680 9.022118
0.000000 -0.156906 9.061345
0.000000 -0.156906 9.061345
-0.039227 -0.156906 8.982891
```

Press `Ctrl+C` to stop running the script.

4. More about ADXL345 Accelerometer Library

In addition to reading the acceleration(`accelerometer.acceleration`), this library can also perform the following detections.

- `acceleration` - The acceleration values on the x, y and z axes

- `enable_motion_detection` - Enables motion detection. Allows for setting threshold. Threshold defaults to 18.
- `enable_tap_detection` - Enables tap detection. Allows for single or double-tap detection.
- `enable_freefall_detection` - Enables freefall detection. Allows for setting threshold and time. Threshold defaults to 10, time defaults to 25.
- `events` - Used to read the events when motion detection, tap detection and freefall detection are enables. Requires specifying which event you are trying to read.

For specific usage examples, please refer to: https://github.com/adafruit/Adafruit_CircuitPython_ADXL34x/tree/main/examples.