# IR BASED HOME AUTOMATION

## A Project-I

***Report Submitted in Partial fulfillment of the requirements for the degree of Bachelor of Engineering in Electrical & Electronics Engineering***

Submitted to

**Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal (M.P.)**


Submitted By:

| | |
|---|---|
| Abhishek Bhargava | 0126EX161002 |
| Chitransh Deshmukh | 0126EX161013 |
| Sumit Ankar | 0126EX161050 |

Under the Guidance of

**Prof. Kaushal Sen**

**Asst. Prof.**

**Department of Electrical & Electronics Engineering**

**ORIENTAL COLLEGE OF TECHNOLOGY, BHOPAL**

**Approved by AICTE New Delhi & Govt. of M.P.**

**Affiliated to Rajiv Gandhi Proudyogiki Vishwavidhyalaya, Bhopal (M.P.)**


**Session: July-Dec, 2019**

# ORIENTAL COLLEGE OF TECHNOLOGY, BHOPAL

**Approved by AICTE New Delhi & Govt. of M.P. & Affiliated to Rajiv Gandhi Proudyogiki Vishwavidyalaya Bhopal (M.P.)**

## Department of Electrical & Electronics Engineering

# CERTIFICATE

This is to certify that the work embodied in this Project-I entitled as **"IR BASED HOME AUTOMATION"** has been satisfactorily completed by **Abhishek Bhargava, Chitransh Deshmukh, Sumit Ankar** students of B.E-VIII Semester.

It is a bonafide piece of work, carried out under my guidance for the partial fulfillment of the **Bachelor of Engineering in Electrical & Electronics Engg.** degree during the academic session Jan-June, 2020.

**Prof. Kaushal Sen**
Supervisor
EX, OCT

**Mrs. Urmila S. Soni**
Head of Department
EX, OCT

**Dr. Netra Pal Singh**
Director, OCT

# CANDIDATE DECLARATION

I hereby declare that the Project-I report entitled as **"IR BASED HOME AUTOMATION"** submitted in the partial fulfillment of the requirements for the award of the degree of Bachelor of Engineering in Electrical & Electronics Engineering of Oriental College of Technology is an authentic record of my own work carried out at Oriental College of Technology, Bhopal.

I have not submitted the part and partial of this report for the award of any other degree or diploma.

| | |
|---|---|
| Abhishek Bhargava | 0126EX161002 |
| Chitransh Deshmukh | 0126EX161013 |
| Sumit Ankar | 0126EX161050 |

Date:

This is to certify that the above statement made by the candidates is correct to the best of my knowledge.

**Prof. Kaushal Sen**
Supervisor
EX, OCT

# ACKNOWLEDGMENT

We are heartily thankful to the **Management of Oriental College of Technology** for providing me all the facilities and infrastructure to take my work to the final stage.

We are thankful to **Dr. Netra Pal Singh**, Director, Oriental College of Technology, Bhopal, for providing us moral support for successfully completion of major project report.

We are also very thankful to **Dr. N.P. Singh**, Assistant Director, Oriental College of Technology, Bhopal, for his constant support & motivation.

We express deep sense of gratitude and respect to my learned guide **Prof. Kaushal Sen**, Assistant Professor in the Department of Electrical & Electronics Engineering. During all phases of my work without him enthusiasm and encouragement this dissertation would not have been completed. His valuable knowledge and innovative ideas helped me to take the work to the final stage. He has timely suggested actions and procedures to follow for which I am really grateful and thankful to him.

We also express gratefulness to **Prof. Urmila S. Soni**, Head Electrical & Electronics Engineering Department for providing all the facilities available in the department for her continuous support, advice, and encouragement during this work and also help to extend my knowledge and proper guidelines.

We are thankful to all the faculty members and other non teaching staff of Electrical & Electronics Engineering Department for their cooperation.

Constant help, moral and financial support of my loving parents motivated me to complete the work. I express my heartily thanks to my all family members for their co-operation.

We really admire the fond support of my class-mates for their co-operation and constant help. It gives immense pleasure to acknowledge the encouragement and support extended by them. Last but not the least we are extremely thankful to all who have directly or indirectly helped me for the completion of my work

| | |
|---|---|
| Abhishek Bhargava | 0126EX161002 |
| Chitransh Deshmukh | 0126EX161013 |
| Sumit Ankar | 0126EX161050 |

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# ABSTRACT

IR based wireless communication is used for controlling home appliances Arduino is used for controlling whole the process. We send some commands to the controlling system by using IR TV/DVD/MP3 remote for controlling AC home appliances. After receiving signal from IR remote, Arduino sends related signal to relays which are responsible for switching ON or OFF of the home appliances through a relay driver. we have used 7, 8 and 9 number button of IR remote, for controlling Fan, Light and TV respectively and ON/OFF button (Power button) is used for turning ON and OFF all the appliances simultaneously. **Toggle method** is nothing but to get that whether the button is pressed even no of times or the odd no of times. This is found by getting the reminder after dividing it by 2 (i%2), if there is some reminder then device will be turned ON and if reminder is 0 then it will be turned OFF. Suppose Key 7 is pressed on the remote then remote sends a signal to Arduino through TSOP IR Receiver. Then Arduino decode it and store the with the predefined hex value of key 7.

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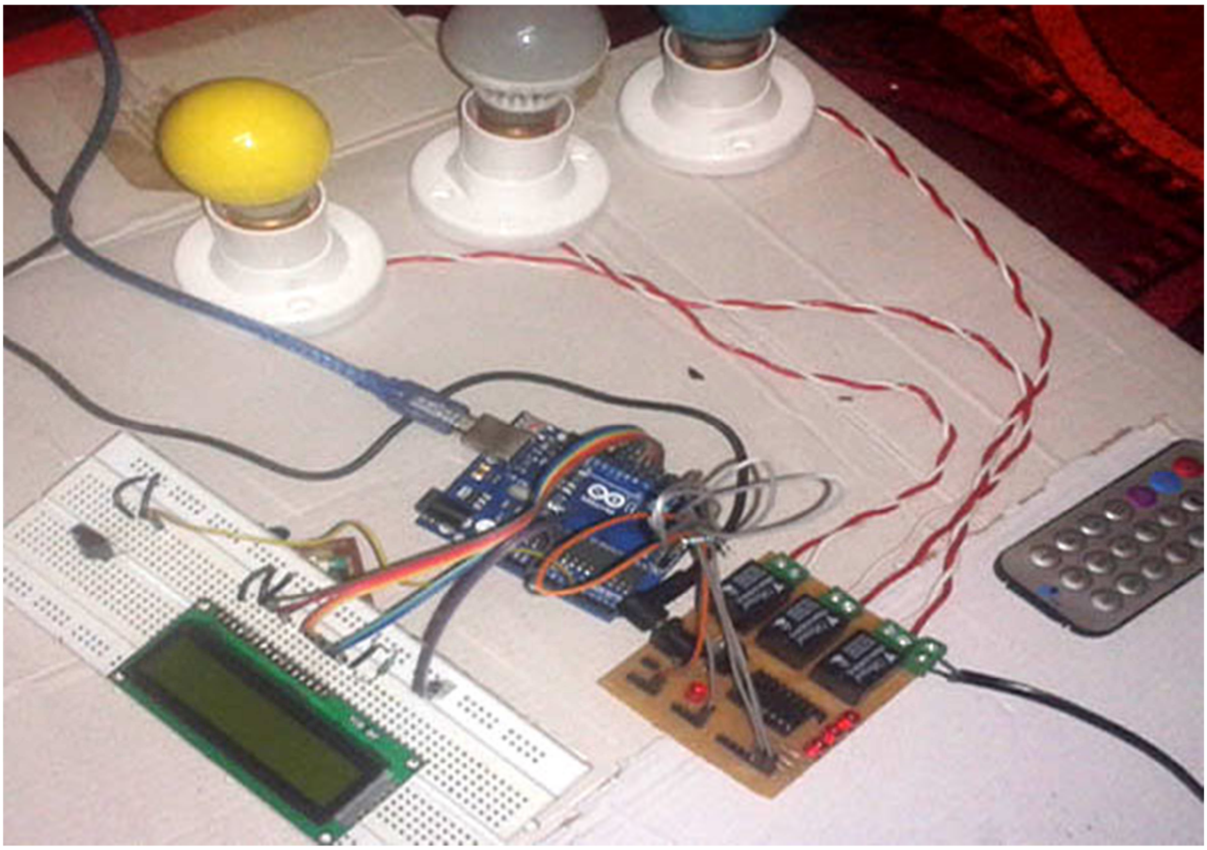
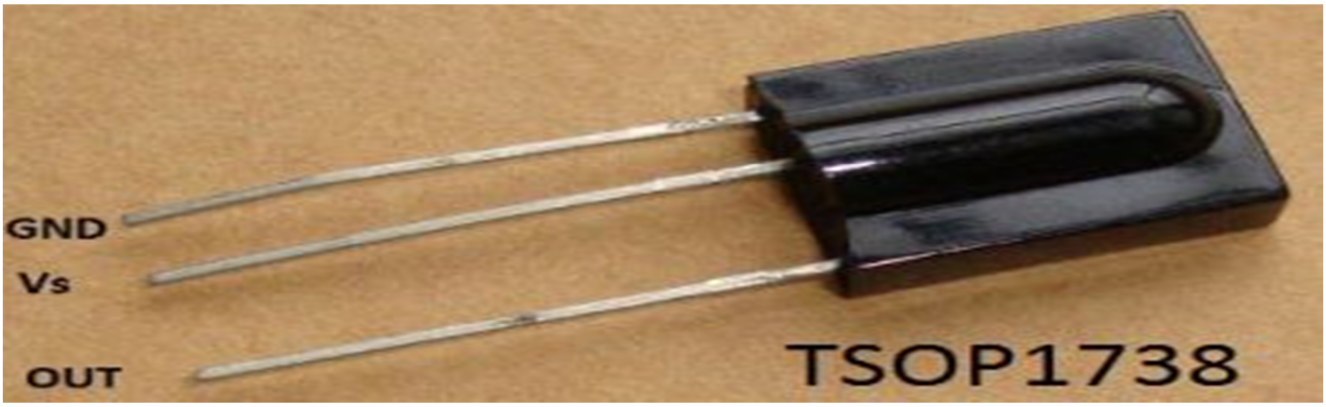
## IR REMOTE CONTROLLED HOME AUTOMATION



In this project, we are using IR based wireless communication for controlling home appliances. In this project, Arduino is used for controlling whole the process. We send some commands to the controlling system by using IR TV/DVD/MP3 remote for controlling AC home appliances. After receiving signal from IR remote, Arduino sends related signal to relays which are responsible for switching ON or OFF of the home appliances through a relay driver.



## COMPONENTS:

- Arduino UNO
- TSOP1738
- IR TV/DVD Remote
- ULN2003
- Relays 5 volt
- Bulb with holder
- Connecting wires
- Bread board
- 16x2 LCD
- Power supply
- PVT
- IC 7805

Here in this project we have used 7, 8 and 9 number button of IR remote, for controlling Fan, Light and TV respectively and ON/OFF button (Power button) is used for turning ON and OFF all the appliances simultaneously.

Here we have used toggle [EVEN ODD] method for ON and OFF the single home appliance.  decoded value into the results variable. Now results variable has a hex value 0x1FE00FF, after matching it Toggle method is nothing but to get that whether the button is pressed even no of times or the odd no of times. This is found by getting the reminder after dividing it by 2 (i%2), if there is some reminder then device will be turned ON and if reminder is 0 then it will be turned OFF. Suppose Key 7 is pressed on the remote then remote sends a signal to Arduino through TSOP IR Receiver. Then Arduino decode it and store the with the predefined hex value of key 7 (see above image), Arduino turns ON the Fan. Now when we press the same key (key 7) again then IR sends the same code. Arduino gets same code and matched with same code like before but this time Fan turned OFF because of toggling the bit [EVEN ODD] (i%2).

## DECODING IR REMOTE CONTROL SIGNALS USING ARDUINO:

Here is a list of a DVD NEC type Remote decoded output codes:

| Decimal | Hex | key |
|---|---|---|
| 33441975 | 1FE48B7 | OFF |
| 33446055 | 1FE58A7 | mode |
| 33454215 | 1FE7887 | mute |
| 33456255 | 1FE807F | resume |
| 33439935 | 1FE40BF | previous |
| 33472575 | 1FEC03F | next |
| 33431775 | 1FE20DF | EQ |
| 33464415 | 1FEA05F | volume – |
| 33448095 | 1FE609F | volume + |
| 33480735 | 1FEE01F | 0 |
| 33427695 | 1FE10EF | RPT |
| 33460335 | 1FE906F | U/SD |
| 33444015 | 1FE50AF | 1 |
| 33478695 | 1FED827 | 2 |
| 33486855 | 1FEF807 | 3 |
| 33435855 | 1FE30CF | 4 |
| 33468495 | 1FEB04F | 5 |
| 33423615 | 1FE708F | 6 |
| 33452175 | 1FE00FF | 7 |
| 33484815 | 1FEF00F | 8 |
| 33462375 | 1FE9867 | 9 |

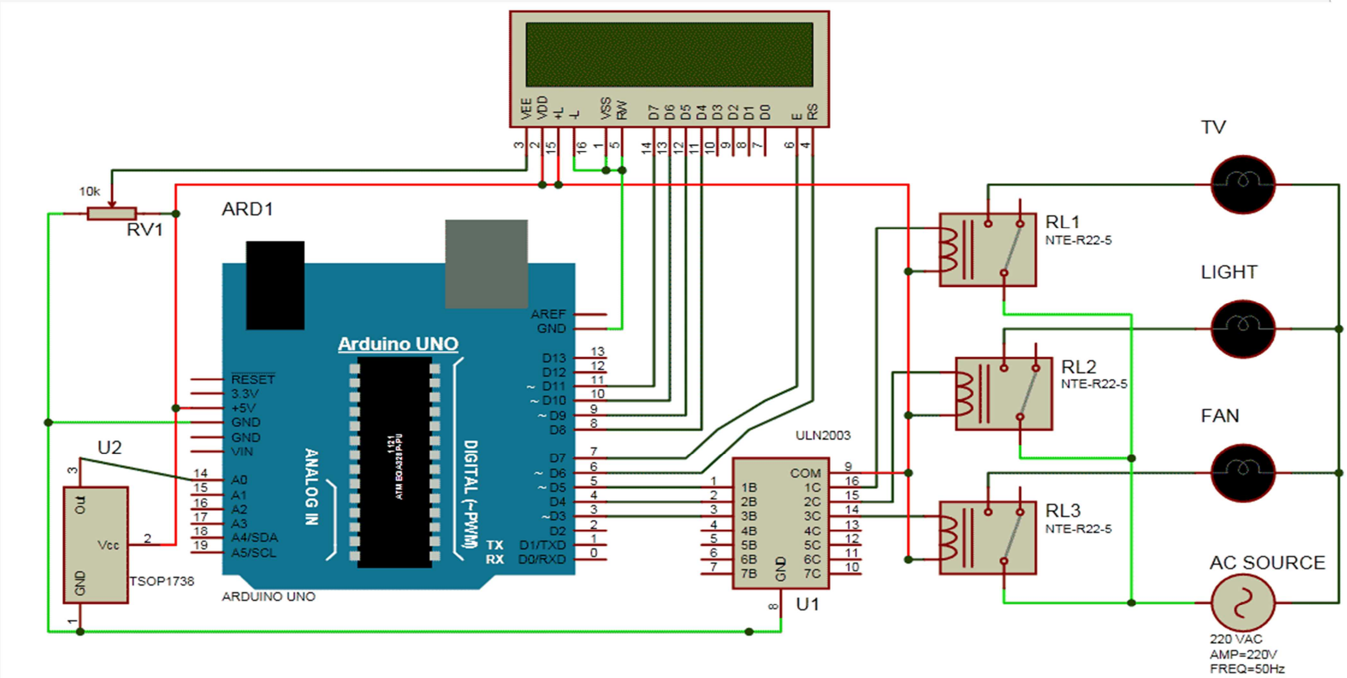

If you don’t know the Decoded output for your IR remote, it can be easily found, just follow these steps:

1. Download the IR remote library from here https://github.com/z3t0/Arduino-IRremote.
2. Unzip it, and place it in your Arduino ‘Libraries’ folder. Then rename the extracted folder to IRremote.
3. Run the below program from your Arduino and open the Serial Monitor window in Arduino IDE. Now press any IR Remote button and see the corresponding decoded hex output in Serial Monitor window.

```
* IRremote: IRrecvDemo - demonstrates receiving IR codes with IRrecv
 * An IR detector/demodulator must be connected to the input RECV_PIN.
 * Version 0.1 July, 2009
 * Copyright 2009 Ken Shirriff
 * http://arcfn.com
 */

#include <IRremote.h>
int RECV_PIN = 11;
```

```
IRrecv irrecv(RECV_PIN);
decode_results results;
void setup()
{
  Serial.begin(9600);
  irrecv.enableIRIn(); // Start the receiver
}
void loop() {
  if (irrecv.decode(&results)) {
    Serial.println(results.value, HEX);
    irrecv.resume(); // Receive the next value
  }
  delay(100);
}
```

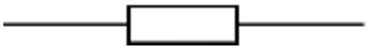



## Circuit description:

Connections of this circuit is very simple here a liquid crystal display is used for displaying status of home appliances which is directly connected to arduino in 4-bit mode. Data pins of LCD namely RS, EN, D4, D5, D6, D7 are connected to arduino digital pin number 6, 7, 8, 9, 10, 11. And output pin of TSOP1738 is directly connected at digital pin number 14 (A) of Arduino. And Vcc pin is connected a +5 volt and GND pin connected at Ground terminal of circuit. A relay driver namely ULN2003 is also used for driving relays. 5 volt SPDT 3 relays are used for controlling LIGHT, FAN and TV. And relays are connected to arduino pin number 3, 4 and 5 through relay driver ULN2003 for controlling LIGHT, FAN and TV respectively.

## RESISTORS

Example: 

Circuit symbol: 

**Function**

Resistors restrict the flow of electric current, for example a resistor is placed in series with a light-emitting diode (LED) to limit the current passing through the LED.

**The Resistor Colour Code**

| Colour | Number |
|---|---|
| | 0 |
| Brown | 1 |
| Red | 2 |
| Orange | 3 |
| Yellow | 4 |
| Green | 5 |
| Blue | 6 |

| | |
|---|---|
| Violet | 7 |
| Grey | 8 |
| White | 9 |

**Connecting and soldering**

Resistors may be connected either way round. They are not damaged by heat when soldering.

**Resistor values - the resistor colour code**

Resistance is measured in ohms; the symbol for ohm is an omega $\Omega$. 1 $\Omega$ is quite small so resistor values are often given in k$\Omega$ and M$\Omega$. 1 k$\Omega$ = 1000 $\Omega$ 1 M$\Omega$ = 1000000$\Omega$.

Resistor values are normally shown using coloured bands**.**

Each colour represents a number as shown in the table.

Most resistors have 4 bands:

- The first band gives the first digit.
- The second band gives the second digit.
- The third band indicates the number of zeros.
- *The fourth band is used to shows the tolerance (precision) of the resistor, this may be ignored for almost all circuits but further details are given below.*

This resistor has red (2), violet (7), yellow (4 zeros) and gold bands.

So its value is 270000$\Omega$=270k$\Omega$. On circuit diagrams the $\Omega$ is usually omitted and the value is written 270K.

***Small value resistors (less than 10 ohm)***

The standard colour code cannot show values of less than 10Ω. To show these small values two special colours are used for the third band: gold which means × 0.1 and silver which means × 0.01. The first and second bands represent the digits as normal.

For example:

Red, violet, gold bands represent $27 \times 0.1 = 2.7\,\Omega$
green, blue, silver bands represent $56 \times 0.01 = 0.56\,\Omega$

**Tolerance of resistors (fourth band of colour code)**

The tolerance of a resistor is shown by the fourth band of the colour code. Tolerance is the precision of the resistor and it is given as a percentage. For example a 390Ω resistor with a tolerance of ±10% will have a value within 10% of 390Ω, between 390 - 39 = 351Ω and 390 + 39 = 429Ω (39 is 10% of 390).

A special colour code is used for the fourth band tolerance:
silver ±10%, gold ±5%, red ±2%, brown ±1%.

If no fourth band is shown the tolerance is ±20%.

Tolerance may be ignored for almost all circuits because precise resistor values are rarely required**.**

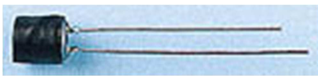
**Buzzer and Bleeper**

These devices are output transducers converting electrical energy to sound. They contain an internal oscillator to produce the sound which is set at about 400Hz for buzzers and about 3 kHz for bleeper's.

Buzzers have a voltage rating but it is only approximate, for example 6V and 12V buzzers can be used with a 9V supply. Their typical current is about 25mA.

Bleepers have wide voltage ranges, such as 3-30V, and they pass a low current of about 10mA**.**

Buzzers and beepers must be connected the right way round, their red lead is positive (+).



## INDUCTOR (COIL)

Inductor (miniature)

An inductor is a coil of wire which may have a core of air, iron or ferrite (a brittle material made from iron). Its electrical property is called inductance and the unit for this is the henry, symbol H. 1H is very large so mH and µH are used, 1000µH = 1mH and 1000mH = 1H. Iron and ferrite cores increase the inductance. Inductors are mainly used in tuned circuits and to block high frequency AC signals (they are sometimes called chokes). They pass DC easily, but block AC signals; this is the opposite of capacitors.

circuit symbol

Inductors are rarely found in simple projects, but one exception is the tuning coil of a radio receiver. This is an inductor which you may have to make yourself by neatly winding enameled copper wire around a ferrite rod. Enameled copper wire has very thin insulation, allowing the turns of the coil to be close together, but this makes it impossible to strip in the usual way - the best method is to gently pull the ends of the wire through folded emery paper.

**Warning:** a ferrite rod is brittle so treat it like glass, not iron!

An inductor may be connected either way round and no special precautions are required when soldering.

## LOUDSPEAKER

Loudspeakers are **output transducers** which convert an electrical signal to sound. Usually they are called 'speakers'. They require a driver circuit, such as a 555 astable or an audio amplifier, to provide a signal. There is a wide range available, but for many electronics projects a 300mW miniature loudspeaker is ideal. This type is about 70mm diameter and it is usually available with resistances of 8Ω and 64Ω. If a project specifies a 64Ω speaker you must use this higher resistance to prevent damage to the driving circuit.

Most circuits used to drive loudspeakers produce an audio (AC) signal which is combined with a constant DC signal. The DC will make a large current flow through the speaker due to its low resistance, possibly damaging both the speaker and the driving circuit. To prevent this happening a large value electrolytic capacitor is connected in series with the speaker, this blocks DC but passes audio (AC) signals.

Loudspeakers may be connected either way round except in stereo circuits when the + and - markings on their terminals must be observed to ensure the two speakers are in phase.

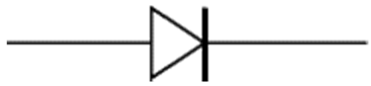
Correct polarity must always be observed for large speakers in cabinets because the cabinet may contain a small circuit (a 'crossover network') which diverts the high frequency signals to a small speaker (a 'tweeter') because the large main speaker is poor at reproducing them.

Miniature loudspeakers can also be used as a microphone and they work surprisingly well, certainly good enough for speech in an intercom system for example.

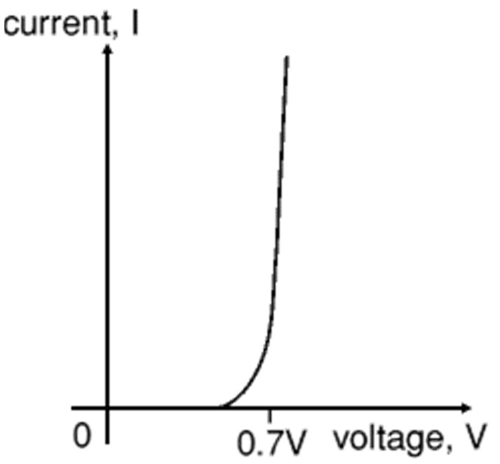
## DIODES

Example:

Circuit symbol:



**Function**




Characteristic of a Silicon Diode

Diodes allow electricity to flow in only one direction. The arrow of the circuit symbol shows the direction in which the current can flow. Diodes are the electrical version of a valve and early diodes were actually called valves.

***Forward voltage drop***

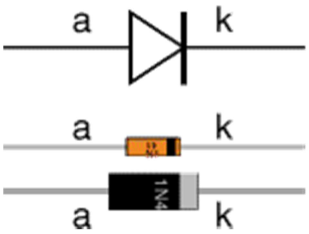
Electricity uses up a little energy pushing its way through the diode, rather like a person pushing through a door with a spring. This means that there is a small voltage across a conducting diode, it is called the forward voltage drop and is about 0.7V for all normal diodes which are made from silicon. The forward voltage drop of a diode is almost constant whatever the current passing through the diode so they have a very steep characteristic (current-voltage graph).

***Reverse voltage***

When a reverse voltage is applied a perfect diode does not conduct, but all real diodes leak a very tiny current of a few µA or less. This can be ignored in most circuits because it will be very much smaller than the current flowing in the forward direction. However, all diodes have a maximum reverse voltage (usually 50V or more) and if this is exceeded the diode will fail and pass a large current in the reverse direction, this is called breakdown.

Ordinary diodes can be split into two types: Signal diodes which pass small currents of 100mA or less and Rectifier diodes which can pass large currents.

**Connecting and soldering**




Diodes must be connected the correct way round, the diagram may be labelled **a** or **+** for anode and **k** or **-** for cathode (yes, it really is k, not c, for cathode!). The cathode is marked by a line painted on the body. Diodes are labelled with their code in small print; you may need a magnifying glass to read this on small signal diodes!

Small signal diodes can be damaged by heat when soldering, but the risk is small unless you are using a germanium diode (codes beginning OA...) in which case you should use a heat sink clipped to the lead between the joint and the diode body. A standard crocodile clip can be used as a heat sink.

**Rectifier diodes** are quite robust and no special precautions are needed for soldering them.

**Testing diodes**

You can use a multimeter or a simple tester (battery, resistor and LED) to check that a diode conducts in one direction but not the other. A lamp may be used to test a rectifier diode, but do NOT use a lamp to test a signal diode because the large current passed by the lamp will destroy the diode!

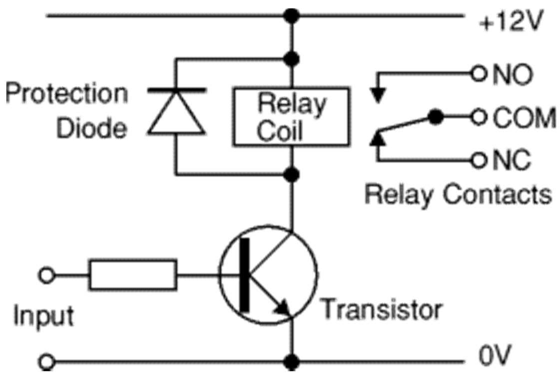
**Signal diodes (small current)**

Signal diodes are used to process information (electrical signals) in circuits, so they are only required to pass small currents of up to 100mA.

General purpose signal diodes such as the 1N4148 are made from silicon and have a forward voltage drop of 0.7V.

**Germanium diodes** such as the OA90 have a lower forward voltage drop of 0.2V and this makes them suitable to use in radio circuits as detectors which extract the audio signal from the weak radio signal.

For general use, where the size of the forward voltage drop is less important, silicon diodes are better because they are less easily damaged by heat when soldering, they have a lower resistance when conducting, and they have very low leakage currents when a reverse voltage is applied.




***Protection diodes for relays***

Signal diodes are also used with relays to protect transistors and integrated circuits from the brief high voltage produced when the relay coil is switched off. The diagram shows how a protection diode is connected across the relay coil, note that the diode is connected 'backwards' so that it will normally NOT conduct. Conduction only occurs when the relay coil is switched off, at this moment current tries to continue flowing through the coil and it is harmlessly diverted through the diode. Without the diode no current could flow and the coil would produce a damaging high voltage 'spike' in its attempt to keep the current flowing.

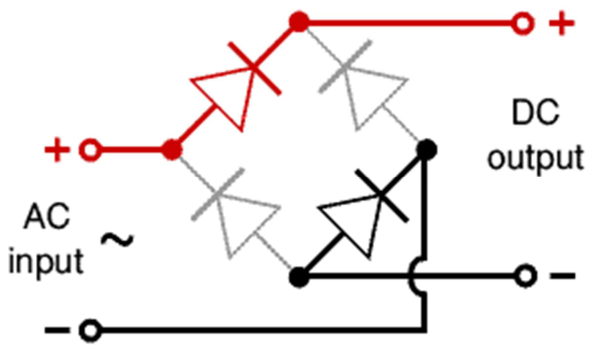
**Rectifier diodes (large current)**

| Diode | Maximum Current | Maximum Reverse Voltage |
|---|---|---|
| 1N4001 | 1A | 50V |
| 1N4002 | 1A | 100V |
| 1N4007 | 1A | 1000V |

Rectifier diodes are used in power supplies to convert alternating current (AC) to direct current (DC), a process called rectification. They are also used elsewhere in circuits where a large current must pass through the diode.

| | | |
|---|---|---|
| 1N5401 | 3A | 100V |
| 1N5408 | 3A | 1000V |

All rectifier diodes are made from silicon and therefore have a forward voltage drop of 0.7V. The table shows maximum current and maximum reverse voltage for some popular rectifier diodes. The 1N4001 is suitable for most low voltage circuits with a current of less than 1A.



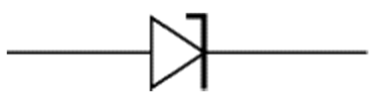

## BRIDGE RECTIFIERS

There are several ways of connecting diodes to make a rectifier to convert AC to DC. The bridge rectifier is one of them and it is available in special packages containing the four diodes required. Bridge rectifiers are rated by their maximum current and maximum reverse voltage. They have four leads or terminals: the two DC outputs are labelled + and -, the two AC inputs are labelled ~.

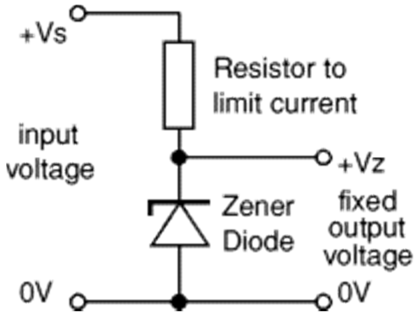
**Zener diodes**

Example:


Circuit symbol:



a = anode, k = cathode



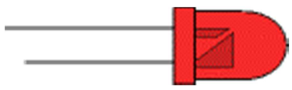

Zener diodes are used to maintain a fixed voltage. They are designed to 'breakdown' in a reliable and non-destructive way so that they can be used **in reverse** to maintain a fixed voltage across their terminals. The diagram shows how they are connected, with a resistor in series to limit the current.

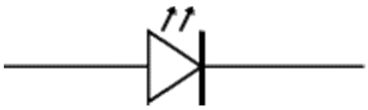
Zener diodes can be distinguished from ordinary diodes by their code and breakdown voltage which are printed on them. Zener diode codes begin BZX... or BZY... Their breakdown voltage is printed with V in place of a decimal point, so 4V7 means 4.7V for example.

Zener diodes are rated by their breakdown voltage and maximum power:

- The minimum voltage available is 2.7V.
- Power ratings of 400mW and 1.3W are common.

## LIGHT EMITTING DIODES (LEDS)

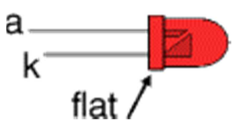
Example: 

Circuit symbol: 

**Function**

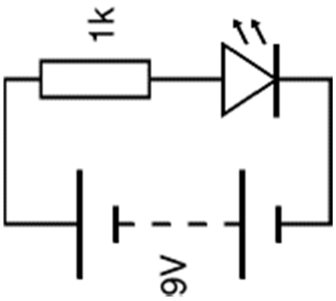
LEDs emit light when an electric current passes through them.

**Connecting and soldering**



LEDs must be connected the correct way round, the diagram may be labelled **a** or **+** for anode and **k** or **-** for cathode (yes, it really is k, not c, for cathode!). The cathode is the short lead and there may be a slight flat on the body of round LEDs. If you can see inside the LED the cathode is the larger electrode (but this is not an official identification method).

LEDs can be damaged by heat when soldering, but the risk is small unless you are very slow. No special precautions are needed for soldering most LEDs.

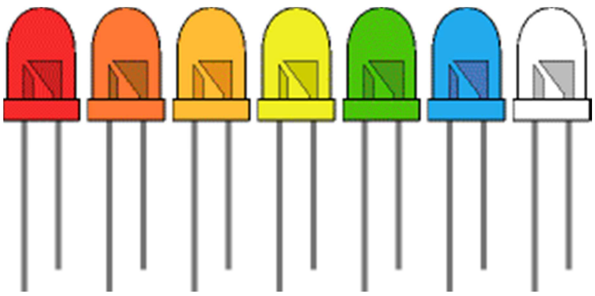



**Testing an LED**

Never connect an LED directly to a battery or power supply!
It will be destroyed almost instantly because too much current will pass through and burn it out.

LEDs must have a resistor in series to limit the current to a safe value, for quick testing purposes a 1kΩ resistor is suitable for most LEDs if your supply voltage is 12V or less. Remember to connect the LED the correct way round!

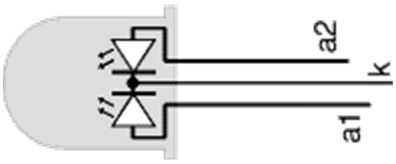
**Colours of LEDs**



LEDs are available in red, orange, amber, yellow, green, and blue and white. Blue and white LEDs are much more expensive than the other colours.

The colour of an LED is determined by the semiconductor material, not by the colouring of the 'package' (the plastic body). LEDs of all colours are available in uncolored packages which may be diffused (milky) or clear (often described as 'water clear'). The coloured packages are also available as diffused (the standard type) or transparent.

**Tri-colour LEDs**




The most popular type of tri-colour LED has a red and a green LED combined in one package with three leads. They are called tri-colour because mixed red and green light appears to be yellow and this is produced when both the red and green LEDs are on.

The diagram shows the construction of a tri-colour LED. Note the different lengths of the three leads. The centre lead (k) is the common cathode for both LEDs; the outer leads (a1 and a2) are the anodes to the LEDs allowing each one to be lit separately, or both together to give the third colour.

**Bi-colour LEDs**

A bi-colour LED has two LEDs wired in 'inverse parallel' (one forwards, one backwards) combined in one package with two leads. Only one of the LEDs can be lit at one time and they are less useful than the tri-colour LEDs described above.

**Sizes, Shapes and Viewing angles of LEDs**

LED Clip

LEDs are available in a wide variety of sizes and shapes. The 'standard' LED has a round cross-section of 5mm diameter and this is probably the best type for general use, but 3mm round LEDs are also popular.

Round cross-section LEDs are frequently used and they are very easy to install on boxes by drilling a hole of the LED diameter, adding a spot of glue will help to hold the LED if necessary. LED clips are also available to secure LEDs in holes. Other cross-section shapes include square, rectangular and triangular.

# CAPACITORS

**Function**

Capacitors store electric charge. They are used with resistors in timing circuits because it takes time for a capacitor to fill with charge. They are used to smooth varying DC supplies by acting as a reservoir of charge. They are also used in filter circuits because capacitors easily pass AC (changing) signals but they block DC (constant) signals.

**Capacitance**

This is a measure of a capacitor's ability to store charge. A large capacitance means that more charge can be stored. Capacitance is measured in farads, symbol F. However 1F is very large, so prefixes are used to show the smaller values.

Three prefixes (multipliers) are used, µ (micro), n (nano) and p (pico):

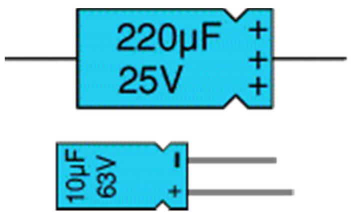
- µ means $10^{-6}$ (millionth), so 1000000µF = 1F
- n means $10^{-9}$ (thousand-millionth), so 1000nF = 1µF
- p means $10^{-12}$ (million-millionth), so 1000pF = 1nF

Capacitor values can be very difficult to find because there are many types of capacitor with different labelling systems!

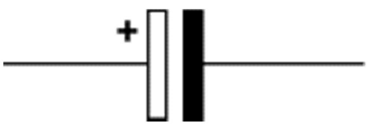
There are many types of capacitor but they can be split into two groups, polarised and Unpolarised. Each group has its own circuit symbol.

**Polarised capacitors (large values, 1µF +)**

Examples:




Circuit symbol:



***Electrolytic Capacitors***

Electrolytic capacitors are polarized and they must be connected the correct way round, at least one of their leads will be marked + or -. They are not damaged by heat when soldering.

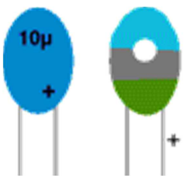
There are two designs of electrolytic capacitors; axial where the leads are attached to each end (220µF in picture) and radial where both leads are at the same end (10µF in picture). Radial capacitors tend to be a little smaller and they stand upright on the circuit board.

It is easy to find the value of electrolytic capacitors because they are clearly printed with their capacitance and voltage rating. The voltage rating can be quite low (6V for example) and it should always be checked when selecting an electrolytic capacitor. It the project parts list does not specify a voltage; choose a capacitor with a rating which is greater than the project's power supply voltage. 25V is a sensible minimum for most battery circuits.

***Tantalum Bead Capacitors***

Tantalum bead capacitors are polarised and have low voltage ratings like electrolytic capacitors. They are expensive but very small, so they are used where a large capacitance is needed in a small size.

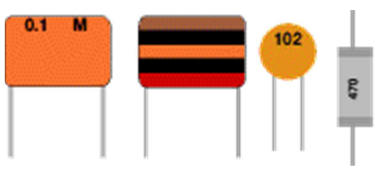
Modern tantalum bead capacitors are printed with their capacitance, voltage and polarity in full. However older ones use a colour-code system which has two stripes (for the two digits) and a spot of colour for the number of zeros to give the value in µF. The standard colour code is used, but for the spot, **grey** is used to mean × 0.01 and **white** means × 0.1 so that values of less than 10µF can be shown. A third colour stripe near the leads shows the voltage (yellow 6.3V, black 10V, green 16V, blue 20V, grey 25V, white 30V, pink 35V). The positive (+) lead is to the right when the spot is facing you: 'when the spot is in sight, the positive is to the right'.



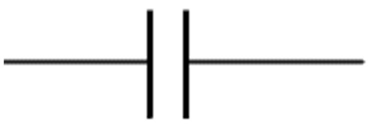

For example: blue, grey, black spot means 68µF
For example: blue**,** grey, white spot means 6.8µF
For example: blue, grey, grey spot means 0.68µF

**Unpolarised capacitors (small values, up to 1µF)**

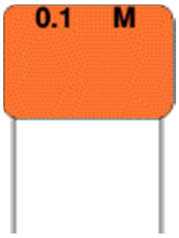
Examples:




Circuit symbol:



Small value capacitors are Unpolarised and may be connected either way round. They are not damaged by heat when soldering, except for one unusual type (polystyrene). They have high voltage ratings of at least 50V, usually 250V or so. It can be difficult to find the values of these small capacitors because there are many types of them and several different labelling systems!

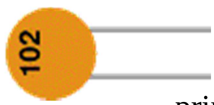



Many small value capacitors have their value printed but without a multiplier, so you need to use experience to work out what the multiplier should be!

For example 0.1 means 0.1µF = 100nF.

Sometimes the multiplier is used in place of the decimal point:
For example: 4n7 means 4.7nF.

***Capacitor Number Code***

A number code is often used on small capacitors where  printing is difficult:


- the 1st number is the 1st digit,
- the 2nd number is the 2nd digit,
- the 3rd number is the number of zeros to give the capacitance in pF.
- Ignore any letters - they just indicate tolerance and voltage rating.

For example: 102 means 1000pF = 1nF *(not 102pF!)*

For example: 472J means 4700pF = 4.7nF (J means 5% tolerance).

| **Colour Code** | |
|---|---|
| Colour | Number |
| | 0 |
| Brown | 1 |

*Capacitor Colour Code*

| | |
|---|---|
| Red | 2 |
| Orange | 3 |
| Yellow | 4 |
| Green | 5 |
| Blue | 6 |
| Violet | 7 |
| Grey | 8 |
| White | 9 |

A colour code was used on polyester capacitors for many years. It is now obsolete, but of course there are many still around. The colours should be read like the resistor code, the top three colour bands giving the value in pF. Ignore the 4th band (tolerance) and 5th band (voltage rating).

For example:

brown, black, orange means 10000pF = 10nF = 0.01µF.

Note that there are no gaps between the colour bands, so 2 identical bands actually appear as a wide band.

For example:

wide red, yellow means 220nF = 0.22µF.

*Polystyrene Capacitors*


This type is rarely used now. Their value (in pF) is normally printed without units. Polystyrene capacitors can be damaged by heat when soldering (it melts the polystyrene!) so you should use a heat sink (such as a crocodile clip). Clip the heat sink to the lead between the capacitor and the joint.

**Real capacitor values (the E3 and E6 series)**

You may have noticed that capacitors are not available with every possible value, for example 22µF and 47µF are readily available, but 25µF and 50µF are not!

Why is this? Imagine that you decided to make capacitors every 10µF giving 10, 20, 30, 40, 50 and so on. That seems fine, but what happens when you reach 1000? It would be pointless to make 1000, 1010, 1020, 1030 and so on because for these values 10 is a very small difference, too small to be noticeable in most circuits and capacitors cannot be made with that accuracy.

To produce a sensible range of capacitor values you need to increase the size of the 'step' as the value increases. The standard capacitor values are based on this idea and they form a series which follows the same pattern for every multiple of ten.

The E3 series (3values for each multiple often ) 10, 22, 47, then it continues 100, 220, 470, 1000, 2200, 4700, 10000 etc. Notice how the step size increases as the value increases (values roughly double each time).

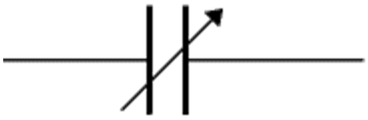
Th E6 series (6 values for each multiple often ) 10, 15, 22, 33, 47, 68**,** then it continues 100, 150, 220, 330, 470, 680, 1000 etc.

Notice how this is the E3 series with an extra value in the gaps.

The E3 series is the one most frequently used for capacitors because many types cannot be made with very accurate values.

**Variable capacitors**

Variable capacitors are mostly used in radio tuning circuits and they are sometimes called 'tuning capacitors'. They have very small capacitance values, typically between 100pF and 500pF (100pF = 0.0001µF). The type illustrated usually has trimmers built in (for making small adjustments - see below) as well as the main variable capacitor.



Variable Capacitor Symbol

Variable Capacitor

Many variable capacitors have very short spindles which are not suitable for the standard knobs used for variable resistors and rotary switches. It would be wise to check that a suitable knob is available before ordering a variable capacitor.

Variable capacitors are not normally used in timing circuits because their capacitance is too small to be practical and the range of values available is very limited. Instead timing circuits use a fixed capacitor and a variable resistor if it is necessary to vary the time period.

***Trimmer capacitors***

Trimmer Capacitor Symbol

Trimmer capacitors (trimmers) are miniature variable capacitors. They are designed to be mounted directly onto the circuit board and adjusted only when the circuit is built.

Trimmer Capacitor

A small screwdriver or similar tool is required to adjust trimmers. The process of adjusting them requires patience because the presence of your hand and the tool will slightly change the capacitance of the circuit in the region of the trimmer!

Trimmer capacitors are only available with very small capacitances, normally less than 100pF. It is impossible to reduce their capacitance to zero, so they are usually specified by their minimum and maximum values, for example 2-10pF.

## MULTIMETERS

Multimeters are very useful test instruments. By operating a multi-position switch on the meter they can be quickly and easily set to be a voltmeter, an ammeter or an ohmmeter. They have several settings (called 'ranges') for each type of meter and the choice of AC or DC. Some multimeters have additional features such as transistor testing and ranges for measuring capacitance and frequency.


Liquid-Crystal Display (LCD)

### Choosing a multimeter

The photographs below show modestly priced multimeters which are suitable for general electronics use, you should be able to buy meters like these for less than £15. A digital multimeter is the best choice for your first multimeter; even the cheapest will be suitable for testing simple projects.

If you are buying an analogue multimeter make sure it has a high sensitivity of 20k$\Omega$ /V or greater on DC voltage ranges, anything less is not suitable for electronics. The sensitivity is normally marked in a corner of the scale, ignore the lower AC value (sensitivity on AC ranges is less important), the higher DC value is the critical one. Beware of cheap analogue multimeters sold for electrical work on cars because their sensitivity is likely to be too low.

**Digital multimeters**

Digital Multimeter

All digital meters contain a battery to power the display so they use virtually no power from the circuit under test. This means that on their DC voltage ranges they have a very high resistance (usually called input impedance) of 1MΩ or more, usually 10MΩ, and they are very unlikely to affect the circuit under test.

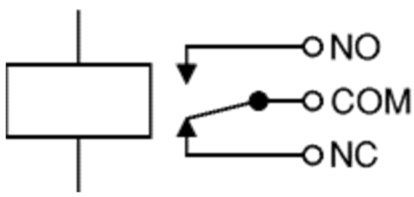
Typical ranges for digital multimeters like the one illustrated: (the values given are the maximum reading on each range)

- DC Voltage: 200mV, 2000mV, 20V, 200V, 600V.
- AC Voltage: 200V, 600V.
- DC Current: 200µA, 2000µA, 20mA, 200mA, 10A*.
- *The 10A range is usually unused and connected via a special socket.
- AC Current: None. (You are unlikely to need to measure this).
- Resistance: 200Ω, 2000Ω, 20kΩ, 200kΩ, 2000kΩ, Diode Test.

Digital meters have a special diode test setting because their resistance ranges cannot be used to test diodes and other semiconductors.

Multimeters are easily damaged by careless use so please take these precautions:

- Always disconnect the multimeter before adjusting the range switch.
- Always check the setting of the range switch before you connect to a circuit.
- Never leave a multimeter set to a current range (except when actually taking a reading). The greatest risk of damage is on the current ranges because the meter has a low resistance.




Circuit symbol for a relay

# RELAYS


Relays

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches.

Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits, the link is magnetic and mechanical.

The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. The maximum output current for the popular 555 timer IC is 200mA so these devices can supply relay coils directly without amplification.

Relays are usually SPDT or DPDT but they can have many more sets of switch contacts, for example relays with 4 sets of changeover contacts are readily available.

Most relays are designed for PCB mounting but you can solder wires directly to the pins providing you take care to avoid melting the plastic case of the relay.

The supplier's catalogue should show you the relay's connections. The coil will be obvious and it may be connected either way round. Relay coils produce brief high voltage 'spikes' when they are switched off and this can destroy transistors and ICs in the circuit. To prevent damage you must connect a protection diode across the relay coil.

The animated picture shows a working relay with its coil and switch contacts. You can see a lever on the left being attracted by magnetism when the coil is switched on. This lever moves the switch contacts. There is one set of contacts (SPDT) in the foreground and another behind them, making the relay DPDT.

The relay's switch connections are usually labelled COM, NC and NO:

- COM = Common, always connect to this; it is the moving part of the switch.

- NC = Normally Closed, COM is connected to this when the relay coil is off**.**
- NO = Normally Open, COM is connected to this when the relay coil is on.
- Connect to COM and NO if you want the switched circuit to be on when the relay coil is on.
- Connect to COM and NC if you want the switched circuit to be on when the relay coil is off.

## STEP TAKEN WHILE PREPARING CIRCUIT

The main purpose of printed circuit is in the routing of electric currents and signals through thin copper layer that is bounded firmly to and insulating base material some times called the substrata. This base is manufactured with an integral bounded layer of thin copper foil which has to be partly etched or other wise removed to arrive at a pre-designed pattern to suite the circuit connections.

From the constructors point of view the main attraction of using PCB is its role as the mechanical support for small components. There is less need for complicated and time consuming metal work or chassis construction except perhaps in providing the [mal enclosure. Most straight forward circuit designs can be easily converted into printed wiring layout the thorough required to carry out the conversion can often highlights any possible error that would otherwise be missed in convention point to point wiring. The finished project is usually neater and truly a work of art.

Through proper design of PCB can get noise immunity. The fabrication process of the printed circuit board will determine to a large extent the price and reliability of the equipment. A common target aimed at is the fabrication of small series of highly reliable professional quality pcbs with low investment cost.

**There are two types of PCB:-**

1. **Single sided board**
2. **Double sided board**

**Single sided board**

The single sided pcbs are mostly used in endearment electronics where manufacturing costs have to be kept at a minimum however in industrial electronics. Also cast factors cannot be neglected and single sided boards should be used whenever a particular circuit can be accommodated on such boards.

**Double sided boards**

Double sided pcbs can be made with or without plated through holes. The production of boards with plated-through holes is fairly expensive. Therefore, plated through hole boards are only chosen where the circuit complexity and density dose not leave any other choice.

**LAYOUT DESIGN**

The layout of a PCB has to incorporate all the information on the board before one can go on to the artwork preparation. This means that a concept, which clearly defines all the details of the circuit, is a prerequisite before the actual layout can start. The detailed circuit diagram is varying important for the layout designer but the must also be familiar with the design concept and with the philosophy behind the equipment. When designing the layout one should observe the minimum size (component body length and weight). Before starting to design the layout have all the required components to hand so that an accurate assessment of space can be made care must be taken so as to allow for adequate air flow after the components have been mounted.

It might be necessary to turn some components round to a different angular position so that terminals are closer to the connections of other components. The scale can be checked by positioning the components on the squad paper. If any connection crosses, then one can reroute to avoid such condition. All common or earth lines should ideally be connected to a common line routed around the perimeter of the layout this will act as the ground plane. If possibly try to route the outer supply line ground plane. If possibly try to route the other supply lines around the apposite edge of the layout or through the center. The first step is to rearrange the circuit to eliminate the crossover without altering the circuit detail in any way.

Plan the layout as if looking at the top side of the board first this should be translated in reverse later for the etching pattern. Larger areas are recommended to maintain good copper adhesive. It is important to bear in mind always that copper track width must be at least to the recommended minimum dimensions and allowance must be made for increased width where termination holes are needed from this aspect it can become little tricky to negotiate the route for connections to small transistors. One can effect the copper interconnection pattern in the under side of the board in a way described below Make the interconnections pattern looking like conventional point to point writing by routing uniform width of copper from component to component

**ETCHING PROCESS**

Etching process requires the use of chemicals, acid resistant dishes and a running water supply. Ferric chloride is the maximum used solution, but other enchants such as ammonium sulphate can be used.

Nitric acid can also be used but in general it is not used due to the poisonous fumes. The pattern prepared is glued to the copper surface of the board using a latex type of adhesive that can be cubed after use. The pattern is laid firmly on the copper, use vary sharp knife to cut round the pattern carefully and remove the paper corresponding to the required copper pattern areas. Then apply the resist solution clean outlines as for as possible. While the board is drying to test all components. Before going to the next stage, check the whole pattern and cross check against the circuit diagram check for any foreign matter on the copper. The etching bath should be in a glass or enamel disk. If using crystal of ferric chloride these should be thoroughly dissolved in water to the proportion suggested. There should be 0.5 Lt. Of water for 125 gm of crystal. The board is then immersed in fecl3 solution for 12 hours, in this process only the non hidden copper portion is etched out by the solution.

**2fecl3 + 2H2O + 3Cu 0 3cucl2 + 2Fe (OH) 2**

Waste liquid should be thoroughly diluted and buried in water land never pour down the drain. To prevent particles of copper hindering further etching, agitate the solutions carefully by gently twisting or rocking the tray. The board should not be left in the bath a moment longer than is needed to remove just the right amount of cooper. In spite of there being a resist coating, there is no protection against etching away through exposed copper edges; this leads to over etching. Have running water ready so that the etched board can be removed properly and rinsed; this will halt etching immediate.

Now the paint is washed out by the petrol. Now the copper layout on PCB is rubbed with a smooth sand paper slowly and lightly such that only the oxide layers over the Cu is removed. Now the holes are drilled at the respective places, according to component layout as shown in figure. Drilling is one of those operation that calls for great care, because most of the holes will be made and vary small drill. For most purpose a no. 60 drill all holes with this size first those that need to be larger can be easily drilled again with the appropriate large size.

**COMPONENT ASSEMBLY**

There should be no damage, such as hair line crack in the copper on PCB that could have a serious effect on the operational ability of the completed assembly holes.

If there are, than they can and should be repaired first, by soldering a short link of bare copper wire over the affected part. The most popular method of holding all the items is to bend the wires further apart after they have been inserted in the appropriate holes. This will hold the component in position ready for soldering.

Some component will be considerably larger than others, occupying and possibly partly obscuring component. Because of this, it is best to start by mounting the smallest first and progressing through to the largest, before starting, makes certain that no further drilling is likely to be necessary, because access may be impossible later. When filling each group of components, mark off each one on the components list as it is fitted and, if we have to leave the job, we will know where to recommence.

Although transistors and integrated circuits are small items, there are good reasons for leaving the soldering of these until the last step. The main point is that these components are varying sensitive to heat and if subjected to prolonged application of the soldering iron, they could be internally damaged. All the components before mounting are rubbed with sand paper so that oxide layer is removed iron their tips. Now they are mounted according to the components layout.

**Soldering Guide**

**How to Solder**

**First a few safety precautions:**

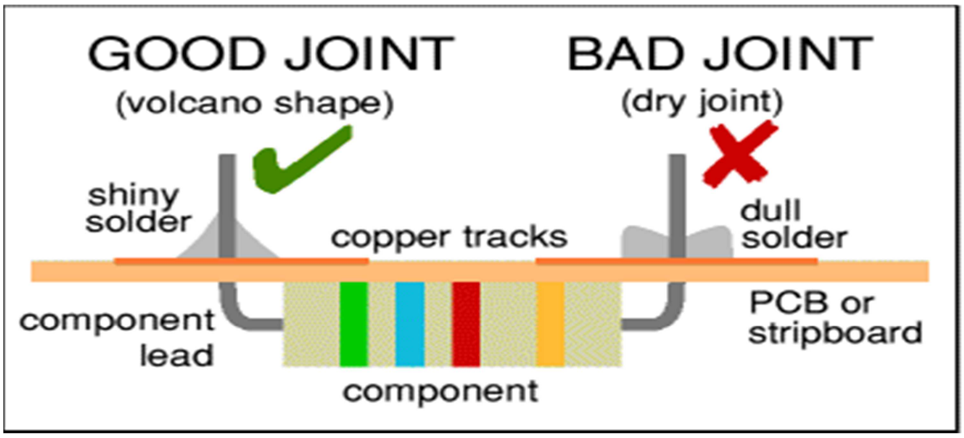
- Never touch the element or tip of the soldering iron. They are very hot (about 400°C) and will give you a nasty burn.
- Take great care to avoid touching the mains flex with the tip of the iron.
- The iron should have a heatproof flex for extra protection. An ordinary plastic flex will melt immediately if touched by a hot iron and there is a serious risk of burns and electric shock.
- Always return the soldering iron to its stand when not in use.
- Never put it down on your workbench, even for a moment!
- Work in a well-ventilated area.
- The smoke formed as you melt solder is mostly from the flux and quite irritating. Avoid breathing it by keeping you head to the side of, not above, your work.
- Wash your hands after using solder.
- Solder contains lead which is a poisonous metal.

**Preparing the soldering iron:**

- Place the soldering iron in its stand and plug in. The iron will take a few minutes to reach its operating temperature of about 400°C.
- Dampen the sponge in the stand.
- The best way to do this is to lift it out the stand and hold it under a cold tap for a moment, then squeeze to remove excess water. It should be damp, not dripping wet.
- Wait a few minutes for the soldering iron to warm up. You can check if it is ready by trying to melt a little solder on the tip.

- Wipe the tip of the iron on the damp sponge. This will clean the tip.
- Melt a little solder on the tip of the iron. This is called 'tinning' and it will help the heat to flow from the iron's tip to the joint. It only needs to be done when you plug in the iron, and occasionally while soldering if you need to wipe the tip clean on the sponge.

**You are now ready to start soldering:**

- 


- Hold the soldering iron like a pen, near the base of the handle.
- Imagine you are going to write your name! Remember to never touch the hot element or tip.
- Touch the soldering iron onto the joint to be made. Make sure it touches both the component lead and the track. Hold the tip there for a few seconds and...
- Feed a little solder onto the joint**.**
- It should flow smoothly onto the lead and track to form a volcano shape as shown in the diagram. Apply the solder to the joint, not the iron.
- Remove the solder, then the iron, while keeping the joint still.
- Allow the joint a few seconds to cool before you move the circuit board.
- Inspect the joint closely.
- It should look shiny and have a 'volcano' shape. If not, you will need to reheat it and feed in a little more solder. This time ensure that **both** the lead and track are heated fully before applying solder.

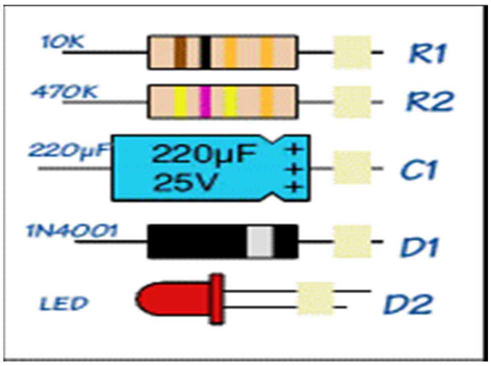
Crocodile clip

**Using a heat sink**

Some components, such as transistors, can be damaged by heat when soldering so if you are not an expert it is wise to use a heat sink clipped to the lead between the joint and the component body. You can buy a special tool, but a standard crocodile clip works just as well and is cheaper.

Soldering Advice for Components

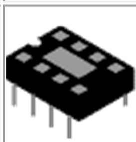
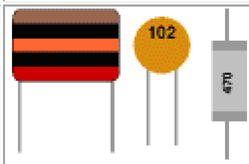
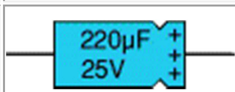
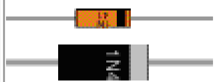
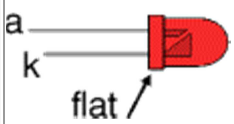
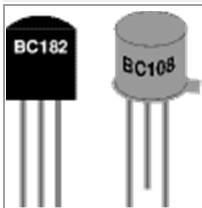
It is very tempting to start soldering components onto the circuit board straight away, but please take time to identify all the parts first. You are much less likely to make a mistake if you do this!

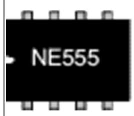



1. Stick all the components onto a sheet of paper using sticky tape**.**
2. Identify each component and write its name or value beside it.
3. Add the code (R1, R2, C1 etc.) if necessary.
4. Many projects from books and magazines label the components with codes (R1, R2, C1, D1 etc.) and you should use the project's parts list to find these codes if they are given.
5. Resistor values can be found using the resistor colour code which is explained on our Resistors page. You can print out and make your own Resistor Colour Code Calculator to help you.
6. Capacitor values can be difficult to find because there are many types with different labelling systems! The various systems are explained on our Capacitors page.

Some components require special care when soldering. Many must be placed the correct way round and a few are easily damaged by the heat from soldering. Appropriate warnings are given in the table below, together with other advice which may be useful when soldering.

For most projects it is best to put the components onto the board in the order given below:

| | Components | Pictures | Reminders and Warnings |
|---|---|---|---|
| 1 | **<u>Chip Holders</u>** (DIL sockets) |  | **Connect the correct way round** by making sure the notch is at the correct end. Do NOT put the ICs (chips) in yet. |
| 2 | **<u>Resistors</u>** |  | No special precautions are needed with resistors. |
| 3 | **<u>Small value capacitors</u>** (usually less than 1µF) |  | These may be connected either way round. Take care with polystyrene capacitors because they are easily damaged by heat. |
| 4 | **<u>Electrolytic capacitors</u>** (1µF and greater) |  | **Connect the correct way round.** They will be marked with a + or - near one lead. |
| 5 | **<u>Diodes</u>** |  | **Connect the correct way round.** Take care with germanium diodes (e.g. OA91) because they are easily damaged by heat. |
| 6 | **<u>LEDs</u>** |  | **Connect the correct way round.** The diagram may be labelled **a** or **+** for anode and **k** or **-** for cathode; yes, it really is k, not c, for cathode! The cathode is the short lead and there may be a slight flat on the body of round LEDs. |
| 7 | **<u>Transistors</u>** |  | **Connect the correct way round.** Transistors have 3 'legs' (leads) so extra care is needed to ensure the connections are correct. Easily damaged by heat. |
| 8 | **<u>Wire Links</u>** between points on the circuit board. |  single core wire | Use single core wire; this is one solid wire which is plastic-coated. If there is no danger of touching other parts you can use tinned copper wire, this has no plastic coating and looks just like solder but it is stiffer. |

| | | | |
|---|---|---|---|
| 9 | **Battery clips**, **buzzers** and other parts with their own wires | | **Connect the correct way round.** |
| 10 | **Wires** to parts off the circuit board, including **switches**, **relays**, **variable resistors** and **loudspeakers**. |  stranded wire | You should use stranded wire which is flexible and plastic-coated. Do not use single core wire because this will break when it is repeatedly flexed. |
| 11 | **ICs (chips)** |  | **Connect the correct way round. Many ICs are static sensitive.** Leave ICs in their antistatic packaging until you need them, then earth your hands by touching a metal water pipe or window frame before touching the ICs. **Carefully insert ICs in their holders**: make sure all the pins are lined up with the socket then push down firmly with your thumb. |

### What is solder?

Solder is an alloy (mixture) of tin and lead, typically 60% tin and 40% lead. It melts at a temperature of about 200°C. Coating a surface with solder is called 'tinning' because of the tin content of solder. Lead is poisonous and you should always wash your hands after using solder.

Reels of solder

Solder for electronics use contains tiny cores of flux, like the wires inside a mains flex. The flux is corrosive, like an acid, and it cleans the metal surfaces as the solder melts. This is why you must melt the solder actually on the joint, not on the iron tip. Without flux most joints would fail because metals quickly oxidize and the solder itself will not flow properly onto a dirty, oxidized, metal surface.

The best size of solder for electronics is 22swg (swg = standard wire gauge).

### Desoldering

At some stage you will probably need to desolder a joint to remove or re-position a wire or component. There are two ways to remove the solder:

1. **With a desoldering pump (solder sucker)**

- Set the pump by pushing the spring-loaded plunger down until it locks.
- Apply both the pump nozzle and the tip of your soldering iron to the joint.
- Wait a second or two for the solder to melt.
- Then press the button on the pump to release the plunger and suck the molten solder into the tool.
- Repeat if necessary to remove as much solder as possible.
- The pump will need emptying occasionally by unscrewing the nozzle.

2. **with solder remover wick (copper braid)**

- Apply both the end of the wick and the tip of your soldering iron to the joint.
- As the solder melts most of it will flow onto the wick, away from the joint.
- Remove the wick first, then the soldering iron.
- Cut off and discard the end of the wick coated with solder.

After removing most of the solder from the joint(s) you may be able to remove the wire or component lead straight away (allow a few seconds for it to cool). If the joint will not come apart easily apply your soldering iron to melt the remaining traces of solder at the same time as pulling the joint apart, taking care to avoid burning yourself.

**First Aid for Burns**

Most burns from soldering are likely to be minor and treatment is simple:

- Immediately cool the affected area under gently running cold water.
- Keep the burn in the cold water for at least 5 minutes (15 minutes is recommended). If ice is readily available this can be helpful too, but do not delay the initial cooling with cold water.
- Do not apply any creams or ointments**.**
- The burn will heal better without them. A dry dressing, such as a clean handkerchief, may be applied if you wish to protect the area from dirt.
- Seek medical attention if the burn covers an area bigger than your hand**.**

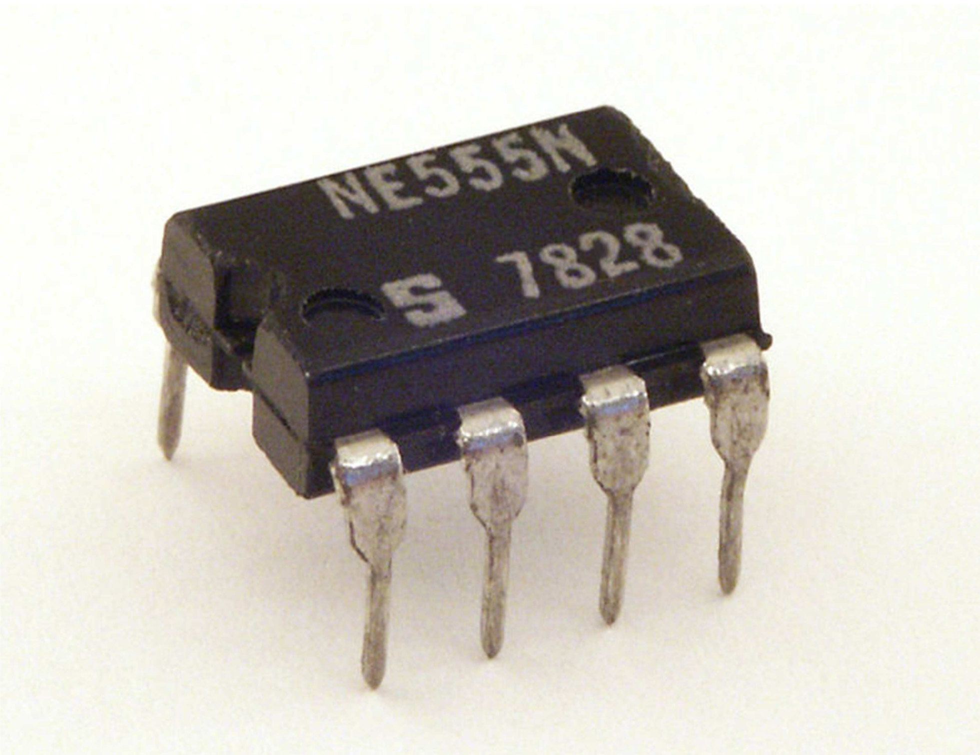
To reduce the risk of burns:

- Always return your soldering iron to its stand immediately after use.
- Allow joints and components a minute or so to cool down before you touch them.
- Never touch the element or tip of a soldering iron unless you are certain it is cold.

## LM555 TIMER

The 555 timer IC is an integrated circuit (chip) used in a variety of timer, pulse generation, and oscillator applications. The 555 can be used to provide time delays, as an oscillator, and as a flip-flop element. Derivatives provide up to four timing circuits in one package.

Introduced in 1972 by Signetics, the 555 is still in widespread use, thanks to its ease of use, low price, and good stability. It is now made by many companies in the original bipolar and also in low-power CMOS types. As of 2003, it was estimated that 1 billion units are manufactured every year.



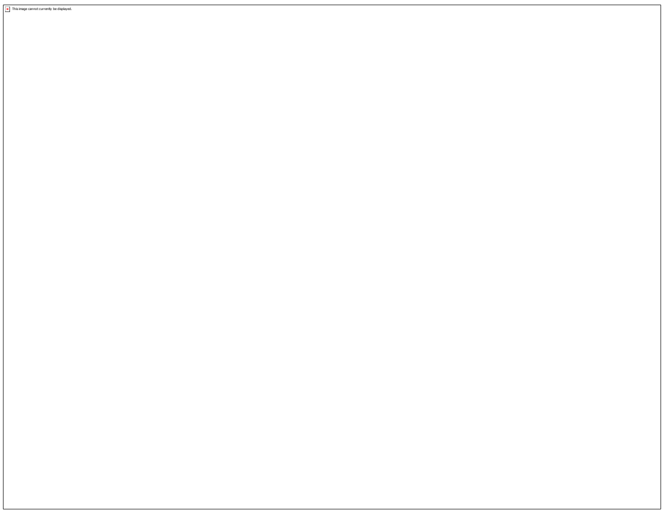

The IC was designed in 1971 by Hans Camenzind under contract to Signetics, which was later acquired by Philips.

Depending on the manufacturer, the standard 555 package includes 25 transistors, 2 diodes and 15 resistors on a silicon chip installed in an 8-pin mini dual-in-line package (DIP-8).[2] Variants available include the 556 (a 14-pin DIP combining two 555s on one chip), and the two 558 & 559s (both a 16-pin DIP combining four slightly modified 555s with DIS & THR connected internally, and TR is falling edge sensitive instead of level sensitive).

The NE555 parts were commercial temperature range, 0 °C to +70 °C, and the SE555 part number designated the military temperature range, −55 °C to +125 °C. These were available in both high-reliability metal can (T package) and inexpensive epoxy plastic (V package) packages. Thus the full part numbers were NE555V, NE555T, SE555V, and SE555T. It has been hypothesized that the 555 got its name from the three 5 kΩ resistors used within,[3] but Hans Camenzind has stated that the number was arbitrary.

Low-power versions of the 555 are also available, such as the 7555 and CMOS TLC555.[4] The 7555 is designed to cause less supply noise than the classic 555 and the manufacturer claims that it usually does not require a "control" capacitor and in many cases does not require a decoupling capacitor on the power supply. Such a practice should nevertheless be avoided, because noise produced by the timer or variation in power supply voltage might interfere with other parts of a circuit or influence its threshold voltages.

**Pins**



Pinout diagram

The connection of the pins for a DIP package is as follows:

| Pin | Name | Purpose |
|---|---|---|
| 1 | GND | Ground reference voltage, low level (0 V) |
| 2 | TRIG | The OUT pin goes high and a timing interval starts when this input falls below 1/2 of CTRL voltage (which is typically 1/3 of $V_{CC}$, when CTRL is open). |
| 3 | OUT | This output is driven to approximately 1.7V below $+V_{CC}$ or GND. |
| 4 | RESET | A timing interval may be reset by driving this input to GND, but the timing does not begin again until RESET rises above approximately 0.7 volts. Overrides TRIG which overrides THR. |
| 5 | CTRL | Provides "control" access to the internal voltage divider (by default, 2/3 $V_{CC}$). |
| 6 | THR | The timing (OUT high) interval ends when the voltage at THR is greater than that at CTRL. |
| 7 | DIS | Open collector output which may discharge a capacitor between intervals. In phase with output. |
| 8 | $V_{CC}$ | Positive supply voltage, which is usually between 3 and 15 V depending on the variation. |

Pin 5 is also sometimes called the CONTROL VOLTAGE pin. By applying a voltage to the CONTROL VOLTAGE input one can alter the timing characteristics of the device. In most applications, the CONTROL VOLTAGE input is not used. It is usual to connect a 10 nF capacitor between pin 5 and 0 V to prevent interference. The CONTROL VOLTAGE input can be used to build an astable with a frequency modulated output.

**Modes**

The 555 has three operating modes:

- **Monostable** mode: In this mode, the 555 functions as a "one-shot" pulse generator. Applications include timers, missing pulse detection, bouncefree switches, touch switches, frequency divider, capacitance measurement, pulse-width modulation (PWM) and so on.
- **Astable** (free-running) mode: The 555 can operate as an oscillator. Uses include LED and lamp flashers, pulse generation, logic clocks, tone generation, security alarms, pulse position modulation and so on. The 555 can be used as a simple ADC, converting an analog value to a pulse length. E.g. selecting a thermistor as timing resistor allows the use of the 555 in a temperature sensor: the period of the output pulse is determined by the temperature. The use of a microprocessor based circuit can then convert the pulse period to temperature, linearize it and even provide calibration means.
- **Bistable** mode or Schmitt trigger: The 555 can operate as a flip-flop, if the DIS pin is not connected and no capacitor is used. Uses include bounce-free latched switches.

**Operational amplifier LM358**

An operationalamplifier (op-amp)isa DC-coupled high-gain electronic voltage amplifier with a differential input and, usually, a single-ended output. An op-amp produces an output voltage that is typically hundreds of thousands of times larger than the voltage *difference* between its input terminals.

Operational amplifiers had their origins in analog computers, where they were used to do mathematical operations in many linear, non-linear and frequency-dependent circuits. Characteristics of a circuit using an op-amp are set by external components with little dependence on temperature changes or manufacturing variations in the op-amp itself, which makes op-amps popular building blocks for circuit design.

Op-amps are among the most widely used electronic devices today, being used in a vast array of consumer, industrial, and scientific devices. Many standard IC op-amps cost only a few cents in moderate production volume; however some integrated or hybrid operational amplifiers with special performance specifications may cost over $100 US in small quantities. Op-amps may be packaged as components, or used as elements of more complex integrated circuits.

The op-amp is one type of differential amplifier. Other types of differential amplifier include the fully differential amplifier (similar to the op-amp, but with two outputs), the instrumentation amplifier (usually built from three op-amps), the isolation amplifier (similar to the instrumentation amplifier, but with tolerance to common-mode voltages that would destroy an ordinary op-amp), and negative feedback amplifier (usually built from one or more op-amps and a resistive feedback network).

The circuit symbol for an op-amp is shown to the right, where:

- $V_+$: non-inverting input
- $V_-$: inverting input
- $V_{out}$: output
- $V_{s+}$: positive power supply
- $V_{s-}$: negative power supply

The power supply pins ($v_{s+}$ and $v_{s-}$) can be labeled in different ways. Often these pins are left out of the diagram for clarity, and the power configuration is described or assumed from the circuit.

## LM 358

Low Power Dual Operational Amplifiers

### General Description

The LM158 series consists of two independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, dc gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM158 series can be directly operated off of the standard +5V power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional ±15V power supplies.

The LM358 and LM2904 are available in a chip sized package (8-Bump micro SMD) using National's micro SMD package technology.

### Unique Characteristics

- In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage.
- The unity gain cross frequency is temperature compensated.
- The input bias current is also temperature compensated.
-

### Advantages

- Two internally compensated op amps
  Eliminates need for dual supplies

- Allows direct sensing near GND and VOUT also goes to GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

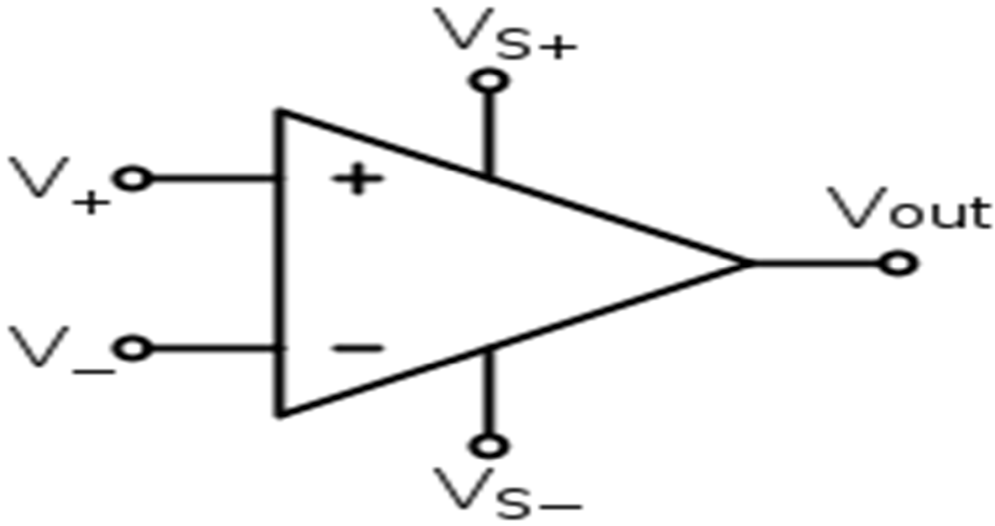
**Features**

- Available in 8-Bump micro SMD chip sized package,
- Internally frequency compensated for unity gain
- Large dc voltage gain: 100 db
- Wide bandwidth (unity gain): 1 mhz (temperature compensated)
- Wide power supply range:
  - — Single supply: 3V to 32V
  - — Or dual supplies: ±1.5V to ±16V
- Very low supply current drain (500 µa) — essentially independent of supply voltage
- Low input offset voltage: 2 mv
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Large output voltage swing

**Other applications**

- audio- and video-frequency pre-amplifiers and buffers
- differential amplifiers
- differentiators and integrators
- filters
- precision rectifiers
- precision peak detectors
- voltage and current regulators
- analog calculators
- analog-to-digital converters
- digital-to-analog converters
- voltage clamps
- oscillators and waveform generator

Most single, dual and quad op-amps available have a standardized pin-out which permits one type to be substituted for another without wiring changes. A specific op-amp may be chosen for its open loop gain, bandwidth, noise performance, input impedance, power consumption, or a compromise between any of these factors.


$V_{S+}$
$V_+$
+
$V_{out}$
$V_-$
−
$V_{S-}$

## IR BASED HOME AUTOMATION

### Code

```
#include<LiquidCrystal.h>
#include <IRremote.h>
const int RECV_PIN=14;
IRrecv irrecv(RECV_PIN);
decode_results results;
#include<LiquidCrystal.h>
LiquidCrystal lcd(6,7,8,9,10,11);

#define Fan 3
#define Light 4
#define TV 5

int i=0,j=0,k=0,n=0;

void setup()
{
  Serial.begin(9600);
  lcd.begin(16,2);
  pinMode(Fan, OUTPUT);
  pinMode(Light, OUTPUT);
  pinMode(TV, OUTPUT);
  //digitalWrite(13,HIGH);
  lcd.print("Remote Controlled");
  lcd.setCursor(0,1);
  lcd.print("Home Automation");
  delay(2000);
  lcd.clear();

lcd.print("System Ready...");
  delay(1000);
  irrecv.enableIRIn(); // Start the receiver
  irrecv.blink13(true);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Fan   Light  TV ");
  lcd.setCursor(0,1);
  lcd.print("OFF    OFF   OFF");
}

void loop()
{
  if (irrecv.decode(&results))
   {
     Serial.println(results.value,HEX);
```

```
    delay(100);
    lcd.setCursor(0,0);
    lcd.print("Fan   Light  TV");
    if(results.value==0x1FE00FF)
    {
      i++;
      int x=i%2;
      digitalWrite(Fan, x);
      lcd.setCursor(0,1);
      if(x)
      lcd.print("ON  ");
      else
      lcd.print("OFF ");
     // delay(200);
    }

    else if(results.value==0x1FEF00F)    //  key 1
{
      j++;
      int x=j%2;
      digitalWrite(Light, x);
      lcd.setCursor(6,1);
      if(x)
      lcd.print("ON   ");
      else
      lcd.print("OFF  ");
     // delay(200);
    }

    if(results.value==0x1FE9867)
    {
      k++;
      int x=k%2;
      digitalWrite(TV, x);
      lcd.setCursor(13,1);
      if(x)
      lcd.print("ON ");
      else
      lcd.print("OFF");
     // delay(200);
     }

      if(results.value==0x1FE48B7)
     {
      n++;
      int x=n%2;
```

```
        digitalWrite(TV, x);
        digitalWrite(Fan,x);
        digitalWrite(Light,x);
        lcd.setCursor(0,1);
        if(x)
        lcd.print("ON     ON    ON ");
        else
        lcd.print("OFF    OFF   OFF");
        //delay(200);
       }
     irrecv.resume(); // Receive the next value
     //delay(100);
   }
}
```