# Project Book

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# Read This First

Electronics Hobby Centre (EHC) is a "Vidnyan Kendra" activity. EHC promotes skill development in electronics assembly, fault finding and circuit testing. Acquiring these skills helps you get employment. If you are more ambitious, you can become an entrepreneur manufacturing these electronic products.

The book contains description of five electronic gadgets, and instructions to make them. At Vidnyan Kendra, we train people to implement these projects. These projects are:

1. Flasher: It is used for decoration. Flashes series of LEDs using a relay.

2. Twilight Switch: Uses optical sensor to sense darkness and turn on/off a relay.

3. Fan Speed Controller: A stepless fan speed controller which saves electricity.

4. Long Delay Timer: A micro controller based timer which can control domestic electrical gadgets for preset time. Users can preset the time.

5. LED based emergency light. Charges a 6V battery when electricity is available and when the power supply goes off, illuminates room for maximum 4 hours using LEDs.

Currently, these five projects are part of the EHC training programme. This programme trains participants to complete three out of the five projects. The first two are compulsory and the participant chooses one from the remaining three. The participant completes these three projects in 36 hours. If the participant wishes to make the remaining two, Vidyan Kendra teachers help him/her to do so at his/her own place.

These projects are selected in such a way that a layperson will become a hobbyist first. Further practice may turn the hobbyist into a professional.

Electronics Hobby Centre plans to train hobbyists and turn them into embedded programmers, manufacturers and entrepreneurs.

Some persons may not be able to attend this training at Vidnyan Kendra. For them, this book is useful. If you choose to learn by reading this book, you get support via email:
**editor@vidnyanlekhan.in**

Our website:

**https://vidnyan.vidnyanlekhan.in**

-Prasad Mehendale

# Chapter 1

# Preparation

All projects in this book need some basic knowledge of electronics. The following sections will prepare you for the fundamentals.

## 1.1 Basic Concepts

Some basic concept appear again and again while reading this book. They are explained in this section.

### 1.1.1 Circuit

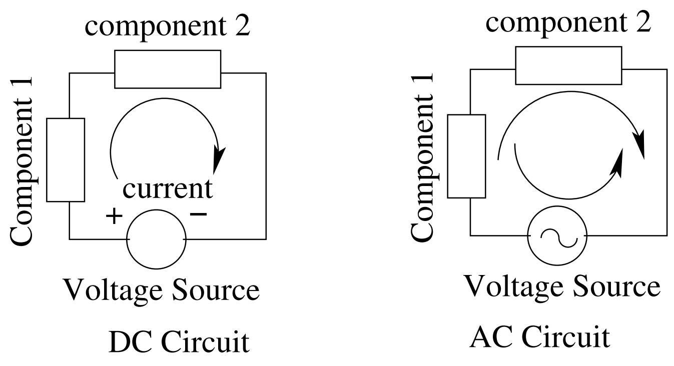


Figure 1.1: AC and DC Circuits

The word *circuit* is derived from the word circle. In an electrical/electronic circuit, charge starts to flow from the source and flows through circuit elements coming back to the source thus completing a "circle". It is assumed that electric charge flows from positive terminal of the source to the negative terminal in the external circuit. See the diagram 1.1 on page 5.

### 1.1.2 Voltage

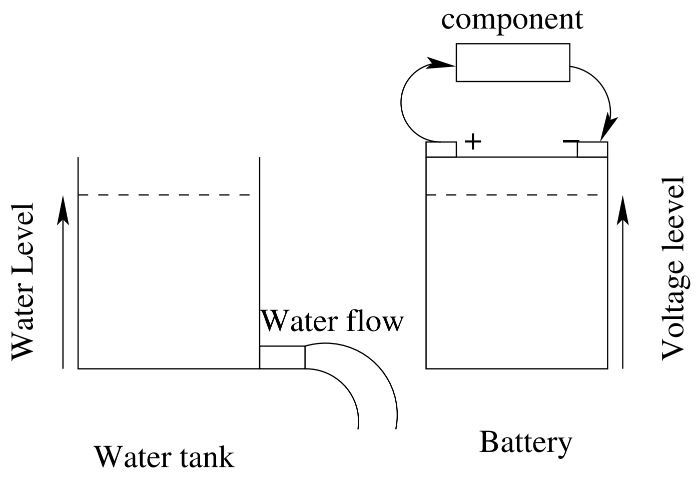


Figure 1.2: Voltage means electric level

Level of electric charge. Every point in an electric/electronic circuit has some voltage. It is measured with reference to some point. This point is called the ground or earth. Ground point is assumed to be at 0 Volts. *Voltage is a kind of force.* See the figure 1.2 on page 6. Compare water level with voltage level and note the similarities between them.

### 1.1.3 current

See the diagram 1.1 on page 5 again. Voltage forces electric charges flow through wires (called conductors). *The flow of charges is current.* Voltage drives the current. So voltage is the cause, current is the effect.

### 1.1.4 Load

While describing a circuit, the term *load* frequently appears. A load draws current from the voltage source, so in practice, the term *load* means current. If there is no load, there is no current.

### 1.1.5 AC and DC

AC stands for *Alternating Current.* DC stands for *Direct Current.*
See the diagram 1.1 on page 5 once again.
In the left figure, you will see that current flows in only one direction. It is also called uni-directional current.

In the right diagram, current is shown to flow in both directions alternately. This happens when electricity is generated by an alternator. This is known as **alternating current** or bi-directional current. For some time the current goes in one direction and then it goes in the opposite direction.

### 1.1.6 Frequency

Frequency means the number of times some action is repeated every second. For example, the ac power supply has a frequency of 50 Hz. This means the supply voltage changes its polarity 50 times in one second.

## 1.2 Components

You use different components in an electronic circuit. Each component has its own properties. Some important components are mentioned below.

### 1.2.1 Resistors

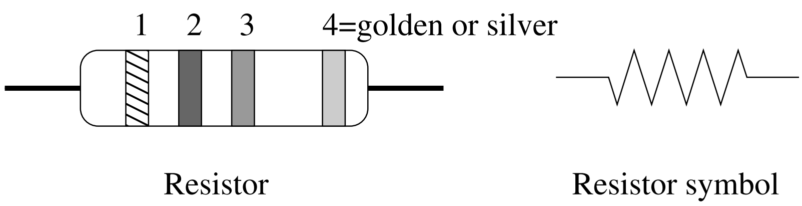


Figure 1.3: Resistor and its symbol

Resistors oppose electric current. While resisting, they convert electrical energy into heat. Resistor is a component. Resistance is its property. In most electronics circuits, you will use *carbon resistors*. A resistor is shown in the figure 1.3 on page 7

You will see four coloured bands on the resistor body. The bands are arranged in an order. The following table shows the colours and their values.

**Resitance is measured in Ohms**. The symbol is Ω. Use the following rules to find the resistance value.

1. Take the resistor in your hand such that the golden band is on your right side.
2. Write down first two values by colours on a piece of paper.

| Colour | Value |
|---:|---:|
| black | 0 |
| brown | 1 |
| red | 2 |
| orange | 3 |
| yellow | 4 |
| green | 5 |
| blue | 6 |
| violet | 7 |
| gray | 8 |
| white | 9 |

Table 1.1: Resistor colors and values

3. Find the value of the third colour and put **those many number of zeroes** in front of the number written. This is the value of your resistance, measured in ohms (Ω).

4. Convert the total value in terms of kilo-ohms or meg-ohms. 3 zeroes means kilo, 6 zeroes means meg. Use some arithmetic if required.

5. The last colour band represents error percentage. Will normally get a resistor with golden color band as the fourth band. This means you have got at the most 5% tolerance error in your resistor.

For example, a resistor has colours from left to right:
Red:Red:orange:Golden
The resistance value is: 22000 Ω. i.e. 22k Ω with 5% tolerance.
Take many resistors and find their values using the above table and some arithmetic.

### 1.2.2 Inductors

Inductor means a coil. When a conducting wire is wound on a core, it forms a coil. A coil opposes electric current *by creating a magnetic field around it.* The creation of magnetic field is known as induction and the coil is known as an *inductor*.
Normally, the core around which the wire is wound is made of some magnetic material like iron or ferrite. See the figure 1.4 on page 9.

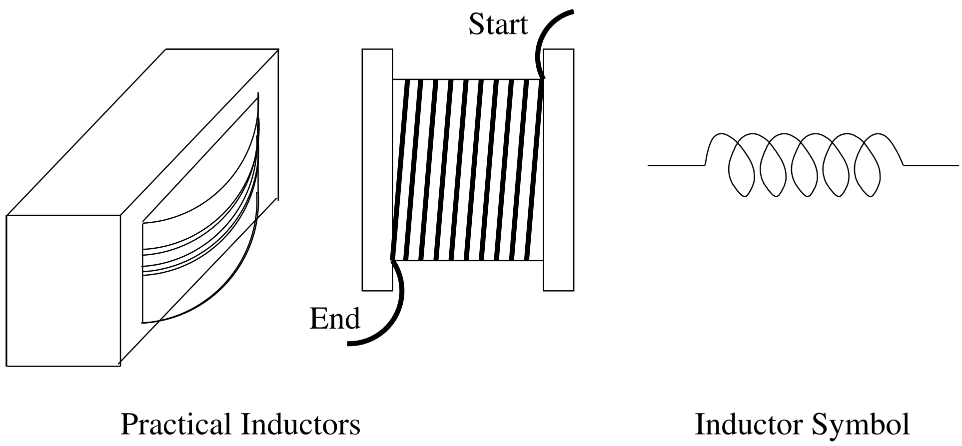


Figure 1.4: Inductor and its symbol

Inductance values are rarely indicated by colour codes. Some times, the value is printed on the coil or it must be measured by an inductance-metre. Inductance is measured in Henry. The symbol used is "H".

### 1.2.3 capacitor

Capacitor *temporarily* stores electric charge . It opposes electric current by creating an electrostatic field. Two types of capacitors are used in electronic circuits. One is polar, and has positive and negative terminals. The other is non-polar, whose both terminals are of the same type.

The figure 1.5 on page 10 shows practical capacitors and their symbols.

### 1.2.4 Diodes

See figure 1.6 on page 10.

Diodes are semiconductor devices. In a circuit they allow current to pass only in one direction. So they convert alternating current into direct or unidirectional current. This conversion process is called as *rectification*, and the diode is called as a rectifier. However, diodes also have other uses in electronics.
Notice the two electrodes: one is known as cathode, the other is known as anode. The current flows from anode to cathode.

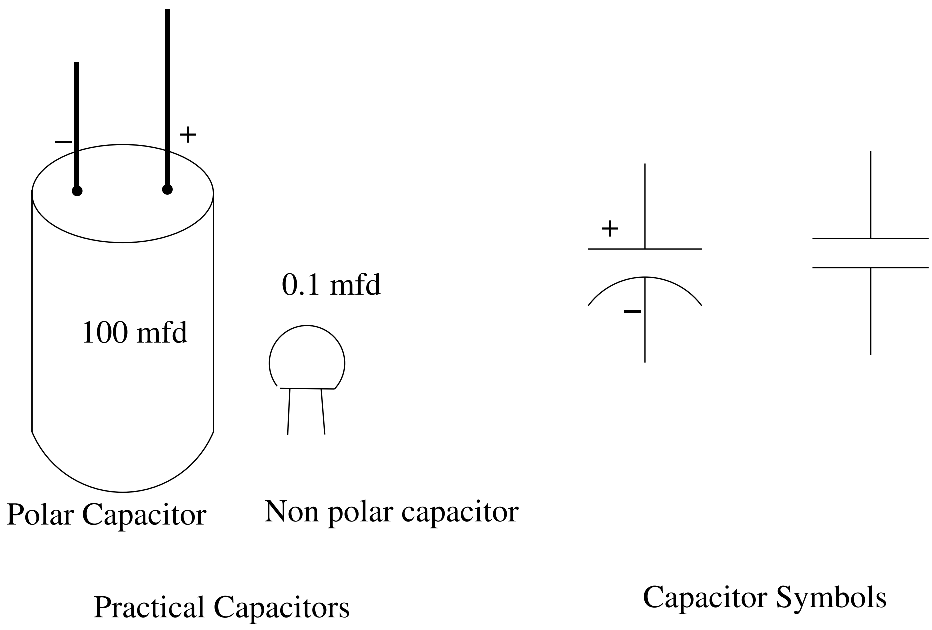


Figure 1.5: capacitor and its symbol

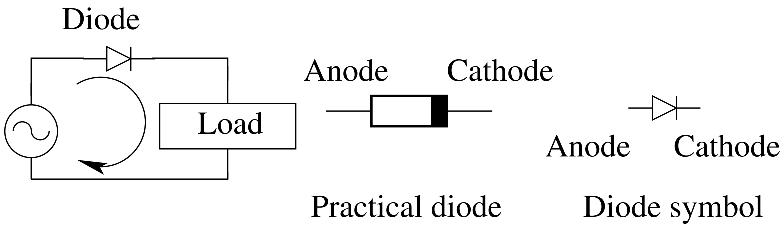


Figure 1.6: Practical Diode and its symbol

### 1.2.5 Transistors

Transistors also are semiconductor devices. They are mainly used as *amplifiers* and *switches* in electronics circuits. In this book, we are considering only bipolar junction transisotrs (BJT). There are two types of BJT transistors: PNP and NPN. In this book we have used only PNP transistors; however, NPN transistors also are used in electronics.

In the figure 1.7 on page 11, a practical transistor BC547 (a NPN transistor) is shown with its symbol. It has three electrodes: emitter, base and collector abbreviabted as E,B and C.

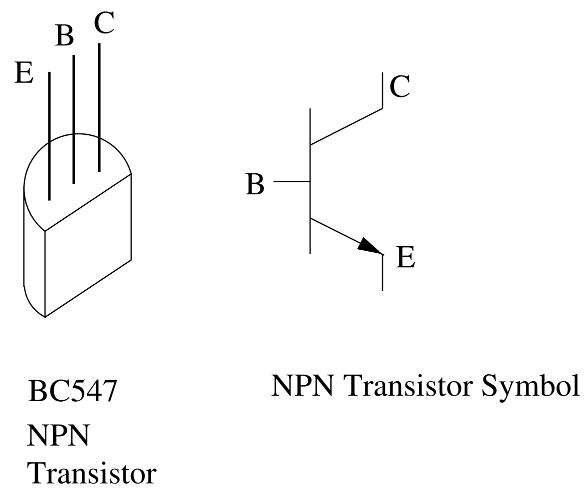


Figure 1.7: Practical Transistor and its symbol

### 1.2.6 Relay

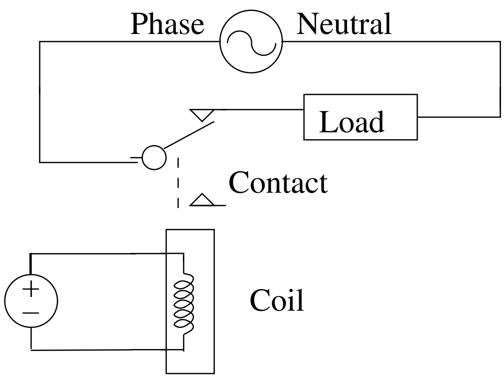


Figure 1.8: Relay

A relay is a switch. It makes the circuit ON or OFF. This switch is controlled by electrical signal. In figure 1.8 you can see the symbol of a relay. A relay has a coil and contracts. When the coil carries current, it magnetises its core and attracts the moving contact thus making or breaking the ciruit.

When voltage is applied to the coil, it attracts the moving contact and makes the connection. Observe that the contact circuit and the coil circuit are two separate circuits.

### 1.2.7 Integrated Circuit

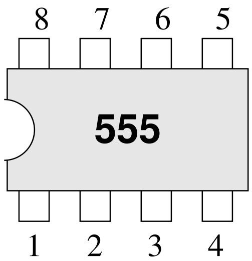


Figure 1.9: Integrated circuit

Integrated circuit has many transistors and diodes situated in a small area implementing a circuit. In practice we use its abbreviation "IC". There are literally thousands of ICs in market and are used for different applications.

In the figure 1.9 on page 12 an 8 pin IC 555 is shown. The IC is seen from the top. Notice how the pins are numbered. Different ICs may have different number of pins. However, the pin numbering method remains the same. To do that:

1. Put the ic on its pins, facing its number towards you.

2. Put the big notch of the ic on your left.

3. Start from the left-most pin as number 1 and proceed in the anti-clockwise direction.

In this chapter we have covered some basic concepts in electronics and common components. These preliminaries are sufficient to begin with the first project. If any additional information is required, you will read it in the specific project chapter. When doing the projects you will refer to this chapter as and when necessary.

### 1.2.8 Breadboard

See the figure 1.10 on page 13.

A breadboard simplifies circuit assembly. It is a perforated board. Some of the holes are internally connected. In the figure they are shown connected by dashed lines. We insert component leads to these holes such that

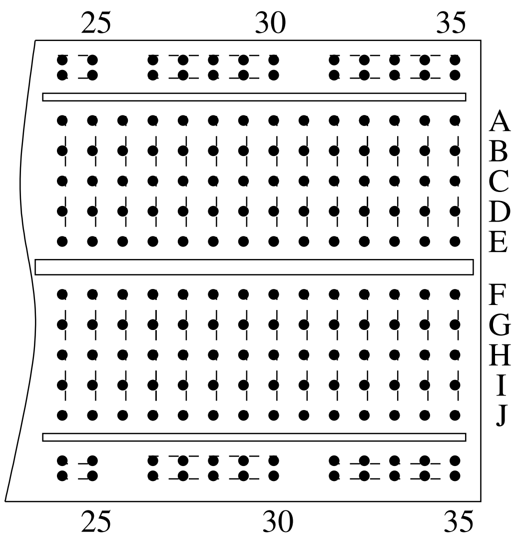


Figure 1.10: Breadboard structure

components are connected correctly to each other and circuit is implemented.

**Remember** that breadboards are used to implement circuits only *temporarily*. Breadboards are used to connect circuits quickly for testing purpose. Once the circuit functions well, it must be mounted on a printed circuit board, which is a permanent solution.

### 1.2.9 Multi-metre

Electronics as a hobby needs a multi-metre. You can measure voltage, current, resistance using a multi-metre. Additionally some metres allow you to check the transistor gain, diode polarity and continuity checking. The figure 1.11 on page 14 shows different features of a common multi-metre used by hobbyists. If you are a beginner, use a simple, low cost multi-meter. It offers you common, essential features.

A simple rule is used to measure *unknown* voltage or current or resistance. This protects your metre and allows you take most precise measurement. The rule is:

- Select correct feature on your metre. For example, to measure AC voltage, select AC range for the voltage.

- Always start from the highest range. If you don't get precise value and fits in the next lower range, shift to the next lower range.

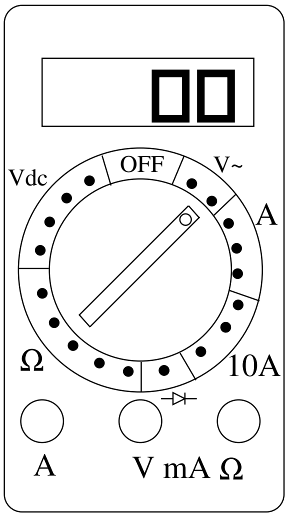


Figure 1.11: Multi metre

In this chapter, we have studied most necessary parts, concepts and tools to make an electronics project. In the next chapters, we implement these projects one by one.

# Chapter 2

# Flasher

You must have seen LED arrays used to decorate things on auspicious occasions and festivals. The flasher project can be used to make the LED array ON and OFF alternately using a simple electronic circuit.

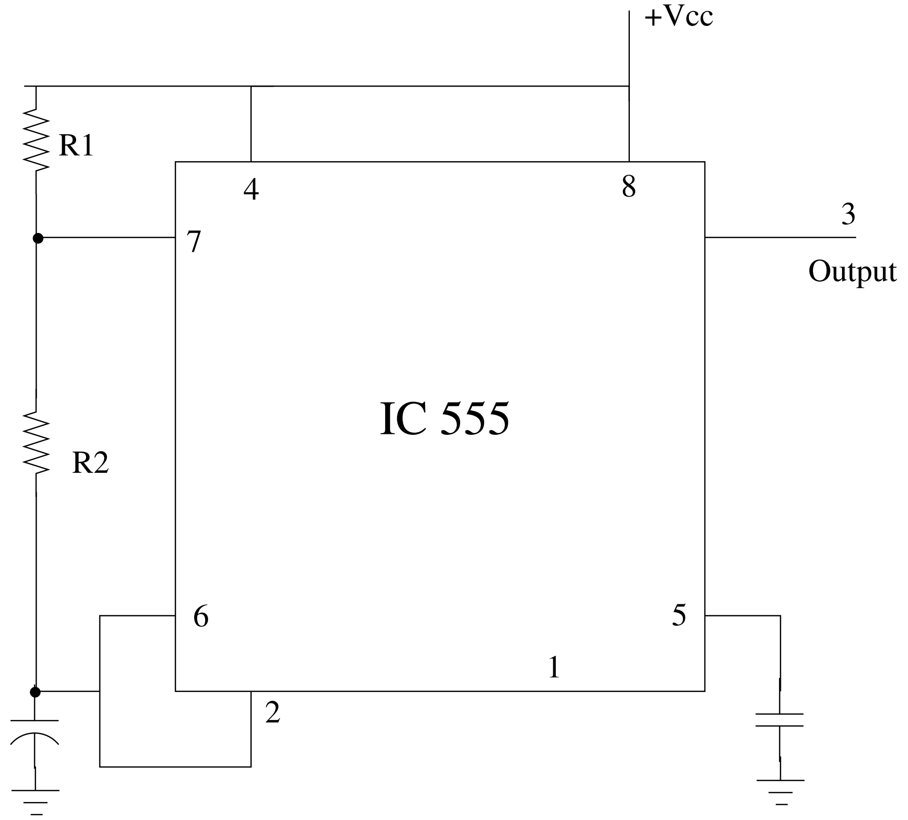


Figure 2.1: Flasher Circuit

The figure 2.1 on page 15 shows the circuit diagram for the project. Draw the circuit diagram in your notebook. Understanding circuit diagrams needs a lot of practice of sketching them.

## 2.1 Circuit Function

This section describes how the circuit functions in general.

- IC 555 controls the flashing operation. Its output at pin 3 goes ON and OFF. The ON and OFF timing is determined by the values of the capacitor C2 and resistors R1 and R2. By changing the values of R1, R2 and C2, you can change the ON time and OFF time of the circuit.
- Transistor Tr1 is used like a switch. It makes the Relay coil ON and OFF.
- Contacts of the relay work like a mechanical switch inserted in the power circuit. When the contact is closed, the LED array glows. When the contact is open, the LED array doesn't glow.

To decide the number of flashes per second (known as the flash frequency), following formula is useful.
$F = \frac{R1+R2}{(R1+2R2)C_2}$

## 2.2 Practical Considerations

This section describes how the circuit is implemented successfully in practice.

### 2.2.1 Breadboard Assembly

To test the circuit, use breadboard. Once, the circuit works correctly, solder it on the pcb (printed circuit board).

1. Before you begin to assemble the circuit on the breadboard, see that the power supply to the circuit is OFF.
2. Place the IC 555 in a convenient direction and locate its first pin.
3. Make connections of all the pins of the IC, one by one.

4. Notice where three component leads come together. This point is called as *node*. For example, pin number 8 of IC 555 is connected to: 12V power supply, 100k resistor, and connection from pin 4 of IC 555. Locate such other points in the circuit and mark them on your circuit diagram in your notebook.

5. While connecting components to form *nodes*, check the polarity of the component if any. Note, only diodes, transistors and polar capacitors have polar leads. Resistors are non polar.

6. Finally, connect the positive supply voltage and ground points to appropriate nodes in the circuit.

### 2.2.2 Confirm the connections

After connecting components on the breadboards, confirm that

1. Components of correct value are chosen.

2. All the connections are as per the circuit diagram.

3. Proper polarity of the components is selected while making connections.

4. All ground connections are done properly.

5. All +V connections are done properly.

### 2.2.3 Connect the power

Before you switch on the power, know what output you expect from the circuit. In this project, you will see that the LED at pin 3 of IC 555 must blink. Whether the LED blinks or not, check, touching every component by hand, if any component becomes hot. If the LED blinks, and no component is hot, it means your circuit is working properly.
After you confirm all the above, make the power switch ON.
If the LED doesn't blink, there is some error in the circuit connections. Inspect the circuit again till you rectify the error. Test the circuit again.
Once you confirm that the circuit works properly and as expected, you will build it on a printed circuiyt board.

### 2.2.4 Assembly on pcb

PCB means printed circuit board. Two types of PCBs can be used for projects.

- A general purpose pcb with standard printing of tracks and holes can be used. This pcb is readily available in the electronics market and is not costly. You will have to use some wire-links for some connections. It takes a little time to fabricate your circuit on this pcb but designing and fabricating a dedicated pcb takes more time. These pcbs are generally made of paper phenolic material.

- One which is specifically designed and printed for the project also can be used. Designing and fabricating a pcb dedicatded to a project takes more time. If you wish to produce the circuit in large quantity, then this method is convenient. Soldering your circuit on this pcb takes less time.

#### General Purpose Board Assembly

A hobbyist or a developer tests the circuit concept on a breadboard. Once proved, the circuit must be soldered using wires. If not, the circuit will not last for long due to lose connections. A general purpose board has tracks and holes of standard designs and formats. The holes are drilled such that any integrated circuit (IC) can be easily inserted in the holes. Other components must be connected as per the circuit diagram. These connections can be done using existing tracks or by using wire-links. You must take care while connecting the points and avoid short and open circuits.

#### Dedicated pcb Assembly

Assembling circuits on dedicated pcb is relatively easy. The dedicated printed circuit boards are designed in such a way, that this assembly becomes easier. You can just insert the components in the pretdesigned holes and solder them. Copper tracks are already laid on the pcb and you don't have to make any connections using wires.
You can design and fabricate a dedicated pcb by hand. The process is described here in short:

1. Draw a layout of your circuit on graph-paper. Consider exact mechanical dimensions of all the components. Input and output connector strips must be at the side of your pcb. Place all the components such

that they look either horizontal or vertical in the top view and never slant.

2. Determine the exact size of your pcb.
3. Cut a copper clad board of this size. Clean the board with rough cloth.
4. Mark component locations and pins by pencil on the copper board.
5. Drill the holes on the pin locations. Take care when drilling the ic pin-holes. This distance must be maintained to 2.5 mm.
6. According to your track layout, draw tracks using nail-polish or CD-writing pen. Let this map dry out.
7. Depending upon the size of the pcb, take a solution of Ferric Chloride (10gm of $FeCl_3$ in 100 ml of water). Stir the solution well and dip your pcb in the solution. Keep strirring the solution till the copper on the board vanishes. Copper only under the tracks is protected. Take out the board, dry the pcb and peel off the tracks.
8. You finished your dedicated pcb. You can assemble your circuit on this board now.

## 2.3 Function of IC 555

This section is optional. If you are not interested in the details of ic 555, you may skip this section. You can still complete the project successfully.
Please refer to the figure 2.2 on page 20.
IC 555 is a very mature integrated circuit. It is versatile. It has following subcircuits:

- Comparator: Comparator compares two voltages. Consider the upper comparator to understand operation of comparators.
  If the threshold voltage is more than the control voltage, the comparator output is high. If the control voltage is more than the threshold voltage, the output is low.
- Flip-flop: This is also known as the bistable multivibrator. As the name suggests, it is stable in both states, high and low. Once you set it as high, it remains high till you make it low and vice-versa.
- Output circuit: Output circuit enhances current delivering ability of the ic. In IC 555 it can drive load upto 200mA.

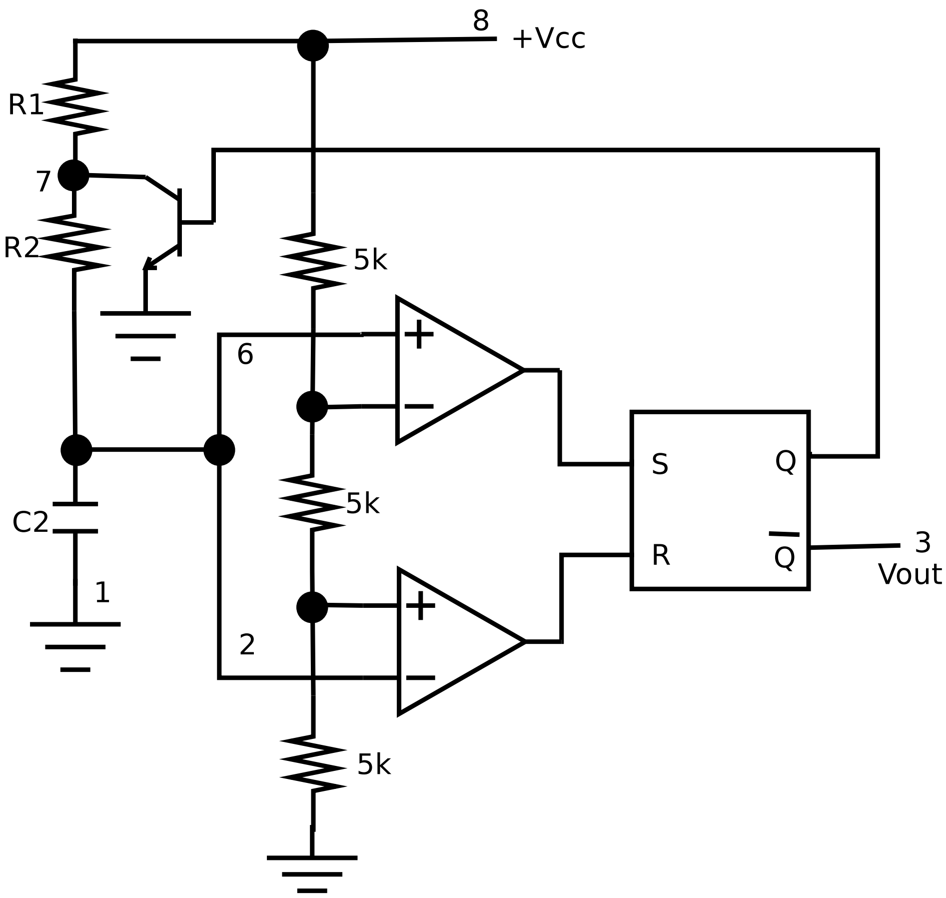


Figure 2.2: IC 555 blocks

- Potential Divider: Uses three equal-value-resistors (5k Ω each) to divide supply potential. As shown in figure, 2/3 of Vcc and 1/3 of Vcc is connected to the comparator as *reference voltage.*

The principle behind the flasher circuit is charging and discharging of capacitor. See figure 2.1. on page 15.

1. When Q is low, the transistor is cut off and the capacitor is charging through a total resistance of $R_1 + R_2$. Because of this, the total time constant is $(R_1 + R_2)C_2$
2. As the capacitor charges, the threshold voltage increases. Eventually, the threshold voltage exceeds $+2V_{cc}/3$.
3. Then the upper comparator has a high output, which sets the flip-flop and Q becomes HIGH.

4. Due to HIGH Q, the transistor saturates and grounds pin 7.

5. Now the capacitor discharges through $R_2$. So the discharging time constant is $R_2C$.

6. When the capacitor voltage drops down slightly below $V_{cc}/3$, the lower comparator has a high output and this resets the flip-flop.

7. All the above steps are repeated again and again to generate high-low-high-low transitions of the output pin creating the square wave at the output pin.

## 2.4 Applications

We name this project as *the flasher*, because it makes the load ON and OFF. To flash a load with low frequency (like 1Hz or so), relay is essential to switch the load. That also provides "isolation" of the control circuit from the power circuit. However, this project can be used for many purposes. Here is a list:

- If the flashing frequency is less than 1, you can use it to flash lights or beep sound.

- By choosing lesser value for C2, while keeping the values of R1 and R2 the same, you can use the same circuit as an oscillator. Depending on the frequency, it may produce sound from a speaker (if the frequency is withing the range 400Hz to 4000Hz).

- With frequencies upto 400Hz, you can use this circuit to drive an inverter transformer.

- Beyond 30KHz, the same oscillator can drive a ferrite core transformer inverter.

- **The flasher** project uses relay. This helps the circuit to handle power circuits with 230 Volts ac supply. Any switching power load upto 500Watt can be switched on or off using this project.

- The project can be modified very easily to a simple timer. This can keep the load ON for certain time and make it OFF automatically when the time lapses. We suggest that students search for the modifications in books and on internet.

# Chapter 3

# Twilight Switch

## 3.1 Using Twilight Switch

In the morning and in the evening we can switch ON or OFF electric lamps automatically. When the sun sets, our lamp should be ON and in the morning, when the sun is about to rise, it should be OFF. If we sense the daylight, this can be made automatically.

A circuit doing this, has *ldr* - light dependant resistor, a comparator and a relay can automatically switch ON or OFF a lamp at twilight times. (See the figure 3.1).

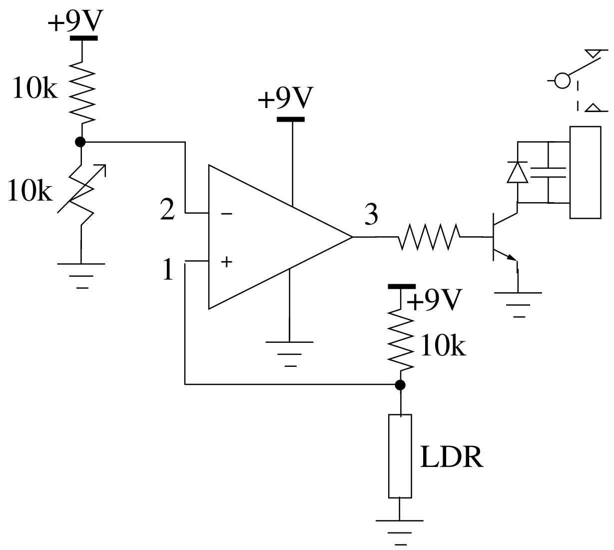


Figure 3.1: Twilight Switch Circuit

## 3.2 The components

Refer to the circuit as shown in figure 3.1.

### 3.2.1 Active components

Normally all components made up of semiconductor are active components. They are listed here.

- **Transistor:** We use BC547 transistor. It is a relay driver.
- **Diode:** 1N4007 is used, as shown, with the relay circuit.
- **Operational Amplifier:** One out of four op-amps in the ic LM324 is used. In this circuit, operational amplifier is used as a comparator. The ic LM324 contains 4 such op-amps. Only one of them at pins 1,2 and 3 is used in our circuit. Please note pin 4 is connected to +9V and pin 11 to ground. All the other pins are not connected anywhere.
- **LDR:** LDR means light dependent resistor. This is the main component of the circuit. When light falls on it, its resistance decreases. When it is in dark, it has very high resistance.

### 3.2.2 passive components

Resistors, inductors (not used in this circuit), capacitors, relays are the passive components used in this circuit.

- **Resistors:** All resistors are of 10k $\Omega$ value. All are of 0.25 Watt capacity.
- **Capacitor:** A disc type capacitor of 0.1 $\mu$F, used in the free wheeling relay circuit.
- **Relay:** A relay is a simple electromagnetic device. It is an electrically controlled switch. You need to know more about relay. It is an electromagnetic switch. See the diagram 1.8 on page 11.

## 3.3 Twilight Switch Function

Refer to the circuit diagram 3.1 on page 23 once again.

### 3.3.1 Operational Amplifier as a comparator

A comparator compares two voltages at the two inputs (inverting input is indicated by '-' sign and non-inverting input is indicated by '+' sign on the op-amp triangle). The voltage which is greater than the other, takes its sign to the output.

1. If the non-inverting input voltage is greater than the inverting input voltage, the output will be about 75% of the power supply voltage. In this case it will be about 7 volts.

2. If inverting input voltage is greater than the non-inverting input voltage, the output will be zero volts, because there is no negative voltage applied to the op-amp.

### 3.3.2 Potential Divider

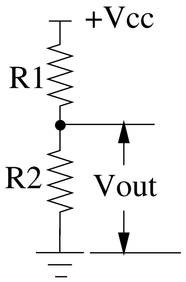


Figure 3.2: Potential Divider

This is a very important concept in electronics. Two resistances connected in series form a potential divider. See the diagram 3.2 on page 25. One end of the potential divider is connected to the +Vcc supply and the other is connected to the ground. The output voltage is given by

$$Vout = \frac{R2 * Vcc}{R1 + R2} \tag{3.1}$$

Now consider the twiligh circuit once again. You will see two different potential dividers in the circuit diagram 3.1 on page 23.

1. One potential divider is connected to the inverting input (indicated by - sign on the op-amp triangle). One resistor of $10k\Omega$ value is connected to +9V and the variable resistor (shown by an arrow on the symbol) is

connected to the ground. The junction of these resistors is connected to the inverting input terminal of the op-amp. You can change the value of the variable resistor within the range 0 to 10k ohm.

2. The other potential divider is connected to the non-inverting input (indicated by + sign on the op-amp triangel). The part connected to the ground is the *LDR*. Restistance of an LDR depends upon the light intensity that falls on the LDR. More is the light intensity lesser is the resistance. Thus when the sun sets, the resistance is high and when the sun rises, the resistance of the LDR goes low.

   If you use the formula, 3.1 you can calculate the Vout of each potential divider.

## 3.4 Circuit working

After understanding the components and the principle of potential divider, we can now understand how the twilight circuit works: refer to the diagram 3.1 on page 23.

1. When the sun rises, the LDR resistance decreases and the voltage across the LDR goes low. It is connected to pin 3 of the op-amp. This voltage is now less than the voltage at pin 2 of the op-amp. The op-amp compares the two voltages and the output becomes zero (See section 3.3.1). This makes the transistor OFF, relay is un-energised and the load is disconnected from the 220V power supply.

2. When the sun sets, the LDR resistance increases and the voltage across the LDR and the voltage at pin 3 is more than the voltage at pin 2. This makes output of op-amp at pin1 high (about 7V) (See section 3.3.1) the transistor ON, energises the relay and load is connected to 220V ac power.

   This is how at sunset, the 220V lamp glows automatically and is made off when sun rises.

## 3.5 Twilight Switch Product

In this section, we consider Twilight Switch as a product.

### 3.5.1 Bill of Materials

Following material is required to make a twilight switch.

| Component | Specification | Rate in Rs. | Quantity |
|---:|---:|---:|---:|
| Transformer | 230V,12V-500mA | 80 | 1 |
| IC LM324 | dip package | 10 | 1 |
| Transistor | BC547 | 1 | 1 |
| Diode | 1N4007 | 0.5 | 5 |
| Resistor | 3k3,0.25W, carbon | 0.25 | 1 |
| Resistor | 10k,0.25W, carbon | 0.25 | 2 |
| Preset Resistor | 10k | 5 | 1 |
| Capacitor | 1000mfd/25V | 5 | 1 |
| Capacitor | 0.1mfd, disk | 1 | 1 |
| Relay | 1CO,Cube type | 10 | 1 |
| PCB | Vidnyan Kendra Design | 25 | 1 |
| LDR | Standard | 35 | 1 |

Table 3.1: Material and price List

### 3.5.2 Pros and Cons

Using Twilight Switch has advantages and disadvantages.

#### Advantages

- Product making time is less, because the product contains only hardware and no software.
- Lamps can be automatically made ON. It doesn't require the sun to set and then only lamp glows. It happens any time when it is dark (say in rainy season).
- Production cost is not high. So the selling price can be affordable to customers.

#### Disadvantage

- If the sensor (LDR) is covered by dust or insects like cockroach, the circuit treats it as dark condition and glows the lamp. So it requires regular cleaning (say once in a week).

# Chapter 4

# Fan Speed Controller

We all need fans. They keep on stirring the room-air making our room comfortable, especially in summer. However, we very rarely run the fan on full speed. To reduce the fan speed, conventional resistance type speed regulators are used which themselves consume much energy. In this chapter we will describe an electronic circuit which controls the fan speed without consuming much energy.

## 4.1 The Principle

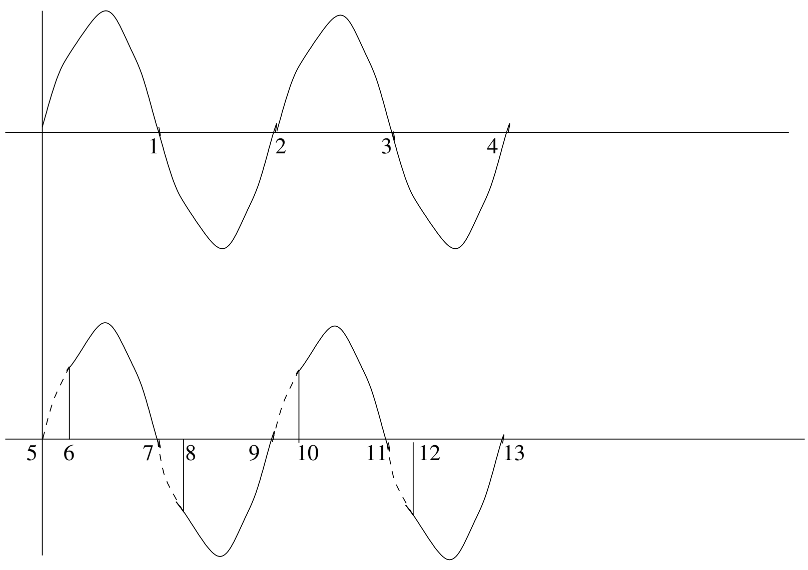


Figure 4.1: Phase Control Of AC wave

Our domestic power supply voltage varies sinusoidally as shown in the diagram 4.1. It continuously changes its polarity 50 times in one second. If we are able to stop part of the wave for some time, effective voltage applied to the fan will be reduced. That will reduce the fan speed. Fortunately, we have an electronic device which can stop (and "release") the AC wave.

Observe the figure on page 29 carefully. The upper part of the figure shows un-controlled ac supply. The lower part shows controlled ac.

Imagin that the ac is stopped between points 5 to 6 and released at point 6 till it reaches 7. Again at point 7, it is stopped upto point 8. It is released till it reaches point 9. Observe that the stopped part is shown by dotted lines in the diagram. Released part is shown by continuous line.

Now know some facts:

- Stopping and releasing the ac is achieved by using a special power electronics device known as *triac*.
- For short time (less than 10 milli seconds) the ac power is not applied to the fan. So in effect, it receives less power and the speed reduces.
- By controlling the triac, time for which the power is stopped in every cycle can be changed, changing the effective output voltage and thus regulating the fan speed.

## 4.2 The Circuit

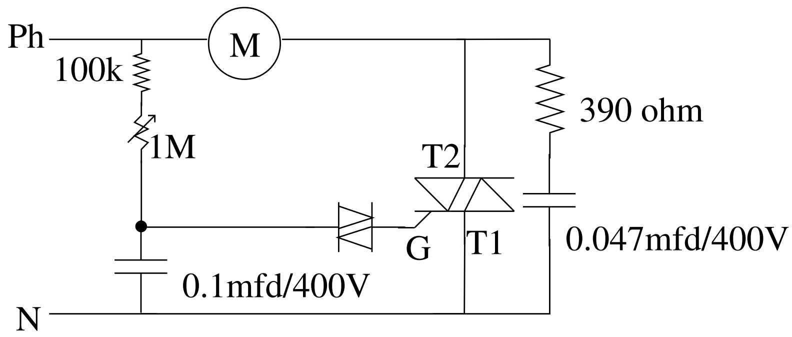


Figure 4.2: Triac Phase Control

See the circuit diagram 4.2 on page 30. You will see two new components *diac* and *triac*. Triac has three terminals: T1, T2 and G. Diac is a two terminal device connected to the gate (G) of the triac.

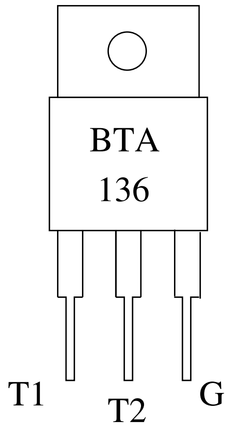


Figure 4.3: Triac Pins

### 4.2.1 Circuit Function

The circuit contains an important component: the *triac*. A triac works as explained below:

#### Triac

A triac has two main terminals T1 and T2. Current flows from T2 to T1. G is gate. Gate controls the current flowing through triac. When the triac gets a pulse at the gate, it conducts and continues to conduct till voltage across it becomes zero (points 7,9,11 in figure 4.1). Triac goes in non-conducting mode till it is triggered by the gate pulse (points 6,8,10).

See figure 4.3 to know the pins of the triac used in this project.

## 4.3 Fan Speed Control

After understanding how triac operates, you will now see how it can control the voltage applied to the fan motor.

1. Observe that the motor (M shown in a circle) is connected in series with the triac. Triac has two main terminals (T1 and T2). Gate controls triac conduction.

2. Every time the voltage crosses zero value (see points 1,2,3,4 in upper part of the figure), the ciruit waits for *some time* and then triggers the

triac to conduct. This *some time* is decided by the 100k $\Omega$ and 1M $\Omega$ resistors and the capacitor of $1\mu F$ capacitor. This time is always within the range of 0 to 10 mSec (1 mSec means 1000th part of a second).

3. After the triac is triggered, it conducts. The current flowing through the triac is also alternating and crosses zero 100 times in one second. When current through the triac is zero, it stops conducting further till it is triggered again at the gate terminal.

4. This trigger-conduction-cutoff process repeats 100 times in one second. Effectively, only part of the supply voltage is applied across the motor and its speed reduces.

5. If you want to decrease the fan speed, you increase the resistance value (1M$\Omega$ reistor is variable). This way the gate is triggered late and the fan voltage reduces.

6. If you want to increase the fan speed, you decrease the resistance value. This way the gate is triggered earlier and more voltage is applied to the motor.

## 4.4 Advantages and Disadvantages

This circuit is used to regulate fan speed. It has advantages as well as disadvantages.

### 4.4.1 Advantages

Advantages include following:

- The circuit is very light-weight as compared to the resistance based fan speed regulator.
- Triac in the circuit heats up but not as much as the resistances in the resistance based fan regulator.
- The 1M$\Omega$ resistance can be varied steplessly, changing the triac firing time. Due to this, the regulator can change the fan speed continuously. The conventional regulator can change the speed only in steps.
- The triac cuts a little power in every halft cycle. Every second 100 such half cycles are applied to the fan motor. This way the circuit is able to *save* the power.

### 4.4.2 Disadavantages

Disadvantages include following:

- Due to the power cut in every half cycle, chopped power supply voltage is applied to the fan motor. This creates harmonics and humming noise.
- Due to harmonics mentioned above, the fan motor life may decrease a little.

The same circuit can be used as a dimmer for incandescent lamps upto 100W.

## 4.5 Bill of Materials

| Component | Specification | Rate in Rs. | Quantity |
|---:|---:|---:|---:|
| Triac | bta 136 or bta 12/600 | 15 | 1 |
| Diac | standard | 2 | 1 |
| Resistor | 100k,0.25W, carbon | 0.25 | 1 |
| Resistor | 390 ohm,1 W, carbon | 0.25 | 2 |
| Potentiometer | 1M ohm metal shaft | 10 | 1 |

Table 4.1: Material and price List-Fan Speed Controller

# Chapter 5

# Long Delay Timer

## 5.1 Introduction

This project is very different from other projects in this book. It uses a microcontroller. The book doesn't cover any programming part of a microcontroller, so we assume that the chip is already been programmed.

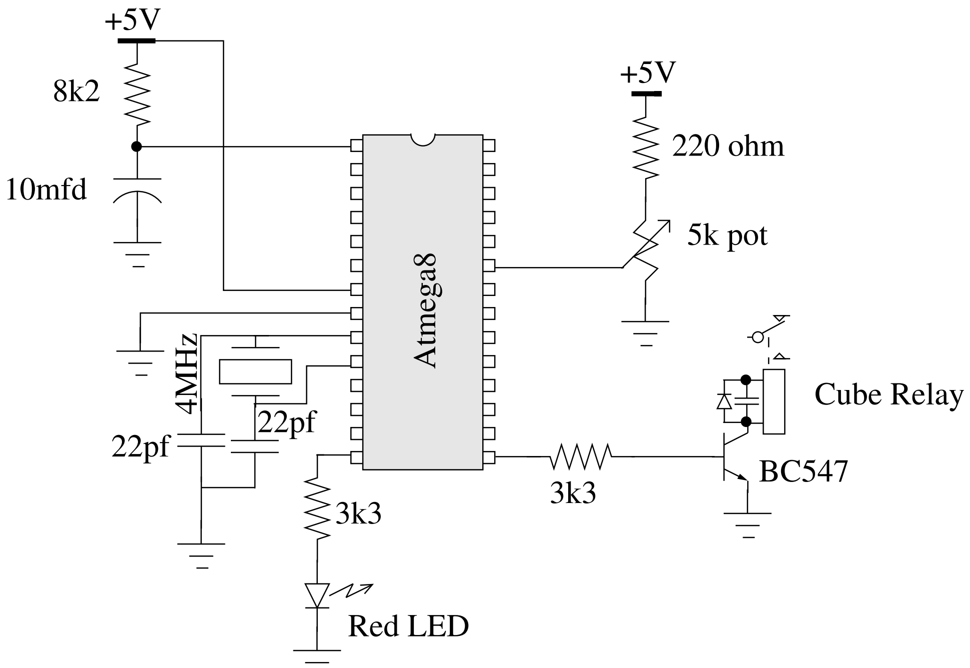


Figure 5.1: Microcontroller Based Timer

You will solder this chip on a pcb and directly use it in the circuit. The circuit diagram 5.1 on page 35. The other components are listed below:

- **The potentiometer:** It is used to set the time. A marked dial must be drawn to show time indications. The timing varies from 0 minutes to 31 minutes. The markings must be equi-spaced.
- **Relay with a driver transistor:** The relay ultimately switches electrical load on or off.
- **Crystal:** The crystal ciruit provides clock to the microcontroller.
- **Reset Circutit:** The RC circuit provides reset pulse to the microcontroller.
- **Power Supply:** Fixed +5V voltage supply is necessary and is implemented by IC 7805.

## 5.2 Fabrication

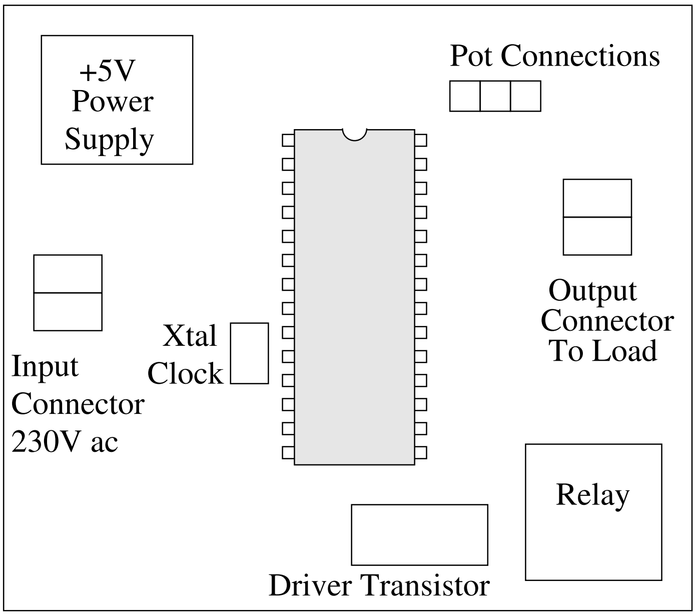


Figure 5.2: Fabrication Map

To fabricate this circuit, follow this procedure.

1. Gather each and every component mentioned in the circuit diagram.
2. On your general purpose pcb, place the microcontroller-socket (28 pin) at the centre.

3. Solder the other components at places shown in the diagram 5.2 on page 36.
4. Connect all the components as shown in the circuit diagram.
5. Check and modify the connections till they are exactly as shown in the circuit.
6. Test the fabricated circuit for expected voltages, without inserting the microcontroller in the ic socket.
7. Turn the power off and then insert the pre-programmed ic (atmega8) in the 28-pin-socket.
8. Turn the poweer on and check for different time settings.

## 5.3 Circuit Testing and Calibration

The project must be tested well before you use it in your home. The procedure is quite simple and is as follows:

1. **Calibration:** The Potentiometer rotates through 120 degrees. Divide this space in equal 16 parts and each part represents 2 minutes.
2. **Change the position** of the rotating knob 16 times and see for how much time the relay is kept ON. Also check the ON time for the position between two marks.
3. **Load Test:** Test the timer with a lamp of 500 Watt.
4. **Motor Test:** Test the timer for a domestic pump motor of 0.25HP. The relay in the circuit can handle current of this small motor only.

## 5.4 Bill of Materials

## 5.5 Applications:

The timer can be used for any electrically operated gadget. You can keep it ON for some preset time and then it will be automatically OFF. There are two limitations however:

- The relay contact rating is limited to 230V ac/ 4-Amp. Any electrical gadget **more than this can't be controlled** with this timer.

| **Component** | **Specification** | **Rate in Rs.** | **Quantity** |
|---:|---:|---:|---:|
| micro-controller | Atmega8 | 80 | 1 |
| Transistor | BC547 | 1 | 1 |
| Diode | 1N4007 | 0.5 | 5 |
| Resistor | 8k2,0.25W, carbon | 0.25 | 1 |
| Resistor | 3k3,0.25W, carbon | 0.25 | 1 |
| Resistor | 3k3,0.25W, carbon | 0.25 | 1 |
| Resistor | 3k3,0.25W, carbon | 0.25 | 1 |
| Potentiometer | 5k,16mm | 10 | 1 |
| Capacitor | 1000mfd/25V | 5 | 1 |
| Capacitor | 0.1mfd, disk | 1 | 1 |
| Capacitor | 10mfd, disk | 1 | 1 |
| Capacitor | 10mfd, disk | 1 | 1 |
| Capacitor | 10mfd, disk | 1 | 1 |
| Relay | 1CO,Cube type | 10 | 1 |
| PCB | General purpose P.P. | 25 | 1 |
| Crystal | 4MHz | 10 | 1 |

Table 5.1: Bill of Materials-Micro controller based Timer

- The timing is counted in minutes. So the least count is one minute. This means you can't measure time in seconds. For example, you can't control a gadget for 43 seconds say. For this to happen you will have to change the programme dumped in the micro-controller atmega8.

# Chapter 6

# LED Emergency Light

This is a very useful project. When our domestic electrical supply fails, this lamp illuminates the room. It uses a rechargeable battery and bright white LEDs to do this.

1. When electrical supply fails, the relay changes its state from NC to NO.

2. The LEDs are connected between battery and the NO contact.

3. Electrical voltage is applied across the LEDs and they glow.

## 6.1 The Circuit

Refer to the circuit diagram in figure 6.1. The circuit has three functions.

1. When domestic ac electric power is available, it charges the battery.

2. When the ac power fails, it changes the relay contact to battery and glows LED lamp.

3. When battery voltage goes below 4.8 Volts, it indicates it by glowing a red LED.

### 6.1.1 Battery Charger

1. When ac electric supply is available, the transformer and rectifier convert ac into 9V dc which charges the 6V battery.

2. When the battery is full, "trickle charge" continues to supply for the inherent battery leakage.

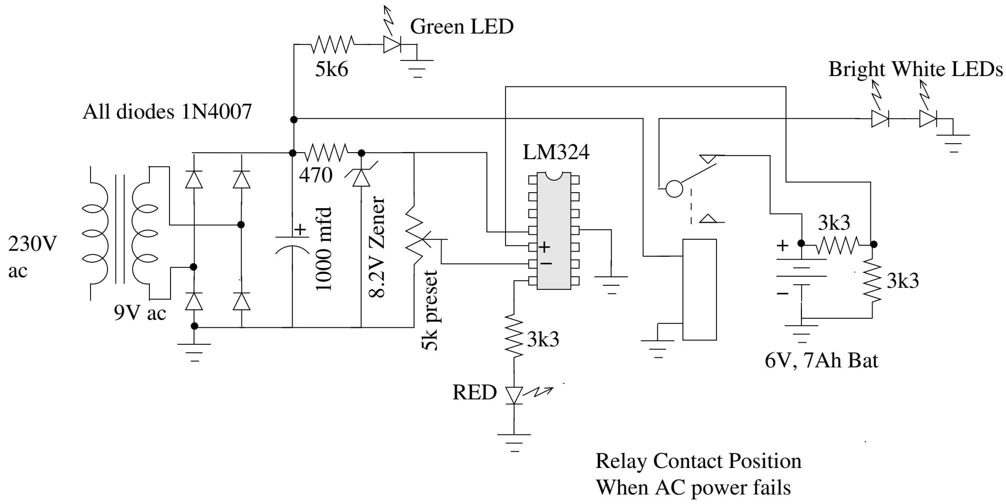


Figure 6.1: Emergency Light Circuit

### 6.1.2 Emergency Mode

When ac electricity fails, the relay coil is un-energised and releases the contact. This switches from charging mode to discharging mode. The battery can supply energy to the LEDs for approximately 4 hours.

### 6.1.3 Low Voltage Indication

While discharging, the battery may reach a state when the voltage is less than 5V. Further discharging the battery may ruin the battery cells. A red LED glows showing undervoltage condition. The user is expected to shutdown the LED by a manual button to save the battery thereafter.

## 6.2 Bill of Materials

| Component | Specification | Rate in Rs. | Quantity |
|---|---|---|---|
| Battery | 6V,4.5Ah | 300 | 1 |
| Comparator | LM324 | 10 | 1 |
| Diode | 1N4007 | 0.5 | 4 |
| Resistor | 10k,0.25W, carbon | 0.25 | 2 |
| Resistor | 3k3,0.25W, carbon | 0.25 | 3 |
| Resistor | 220 Ω,0.25W, carbon | 0.25 | 1 |
| Resistor | 5k6,0.25W, carbon | 0.25 | 1 |
| Resistor | 470Ω,0.25W, carbon | 0.25 | 1 |
| Zener | 8v2, 400mW | 5 | 1 |
| Preset | 5k,pcb mounted | 5 | 1 |
| Green LED | 5mm | 2 | 1 |
| Red LED | 5mm | 1 | 1 |
| LED lamp | 4W strip | 20 | 1 |
| Capacitor | 1000mfd/25V | 5 | 1 |
| Relay | 1CO,Cube type | 10 | 1 |
| PCB | General purpose P.P. | 25 | 1 |
| Transformer | 9V,500mA | 80 | 1 |

Table 6.1: Bill of Materials-Emergency Light