Implementation of Over-Voltage & Under-Voltage Protection System

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Implementation of Over-Voltage & Under-Voltage Protection System

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DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FACULTY OF SCINCE AND ENGINEERING

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APPROVAL

The project report on " Implementation of Over-Voltage & Under-Voltage Protection System " Submitted by Md. Helal Uddin Choudhury , ID :EEEE100100006 And Sarna Chakma , ID :EEEE100100007, to the department of Electrical and Electronic Engineering from Northern university Bangladesh has been accepted as satisfactory for the partial fulfillment of requirements for the degree of bachelor of Electrical and Electronics Engineering and approval as to its style and contents.

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DECLARATION

We hereby, declare that the work presented in this project is the outcome of the investigation performed by us under the supervision of Ashraful Arefin, Lecturer, Department of Electrical and Electronic Engineering, Northern University Bangladesh. We also declare that all part of this project has been submitted+ by us.

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Abstract

The on-time delay circuit not only protects the load from switching surges but also from quick changeover (off and on) effect of over/ Here is an inexpensive auto cut-off circuit, which is fabricated using transistor and other discrete components. It can be used to protect loads such as refrigerator, T.V., and VCR from undesirable over and under line voltages, as well as surges caused due to sudden failure/resumption of main power supply. This circuit can be used directly as a standalone circuit between the mains supply and the load, or it may be inserted between an existing automatic/manual stabilizer and the load. The over/under voltage cut-off with ON-Time delay provides various types of protection 1) Over-voltage protection. 2) Under-voltage protection. 3) Protection against transients. 4) Protection to load from frequent turning ON & OFF by providing time delay.

Acknowledgements

First of all we would like to thank the almighty Allah , Today we are successfully in completing our project work with such ease because Allah give us ability , chance and co- operating supervisor .we would like to thank all of our teachers for their help us a lot to make this project successfully .After that I would really thankful to our head of the department Engr.Md Badiuzzaman and our supervisor Ashraf Arefin ,our supervisor not only give us time but also his proper guidance and valuable advice was always with us whenever we faced problem .His comment and guidance helped us a lot to preparing our this report. We also thankful to our teachers who help us a lot in a number of ways by providing various resources and moral support and classmates and friend also who collected a lot of information to make this accomplished. Finally we are grateful to our family who always with us in every step of life.

The Author
January, 2013

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Chapter 1:
Introduction

1.1 Introduction

Here is an inexpensive auto cutoff circuit, which is fabricated using transistors and other discrete components. It can be used to protect loads such as refrigerator, TV, and VCR from undesirable over and under line voltages, as well as surges caused due to sudden failure/resumption of mains power supply. This circuit can be used directly as a standalone circuit between the mains supply and the load, or it may be inserted between an existing automatic/manual stabilizer and the load.

The on-time delay circuit not only protects the load from switching surges but also from quick changeover (off and on) effect of over-/under-voltage relay, in case the mains voltage starts fluctuating in the vicinity of under- or over-voltage preset points. When the mains supply goes out of preset (over- or under-voltage) limits, the relay/load is turned 'off' immediately, and it is turned 'on' only when AC mains voltage settles within the preset limits for a period equal to the 'on' time delay period. The on-time delay period is pre-settable for 5 seconds to 2 minutes duration. Using presets VR3 and VR4. For electronic loads such as TV and VCR, the on time delay may be set for 10 seconds to 20 seconds. For refrigerators, the delay should be preset for about 2 minute's duration, to protect the compressor motor from frequently turning 'on' and 'off'.

1.2Overview

The under/over voltage protection circuit with time delay presented here is a low cost and reliable circuit for protecting such equipments from damages. Whenever the power line is switched on it gets connected to the appliance only after a delay of a fixed time. If there is hi/low fluctuations beyond sets limits the appliance get disconnected. The system tries to connect the power back after the specific time delay, the delay being counted from the time of disconnection. If the power down time (time for which the voltage is beyond limits) is less than the delay time, the power resumes after the delay: If it is equal or more, then the power resumes directly.

This circuit has been designed, built and evaluated by me to use as a protector for my home refrigerator. This is designed around readily available semi-conductor devices such as standard bipolar medium power NPN transistor (D313/SL100/C1061), and NE555 timer IC. Its salient feature is that no relay hunting is employed. This drawback is commonly found in the proctors available in the market.
The complete circuit is consisting of various stages. They are: - Dual rail power supply, Reference voltage source, Time delay stage and Relay driver stage.

Chapter 2:
Major components

2.1Component Required:

- R1, 1K ohm
- R2, 470 ohm
- R3, 5.6K ohm
- R4, 1K ohm
- R5, 270K ohm
- R6, 470 ohm
- R7, 6.8K ohm
- R8, 5.6K ohm

- C1, 220uF/25v electrolyte cap

- C2, 100uF/25v electrolyte cap
- C3, 2200uF/25v electrolyte cap
- C4, 100uF/25v electrolyte cap

- D1, 6.8v Diode

- D2, 6.8v Diode
- D3, 9.1v Zener Diode
- D4, 6.8v Zener Diode

- VR1-VR2, 5K pot

- LEDs, Red (2), Green
- RL1, 12v Relay(2)
- X1, 230 to 12-0-12 500mA transformer
- IC NE555N timer

2.2 Ttransformers:

A transformer is a static electrical device that transfers energy by inductive coupling between two or more of its windings. A varying current in the primary winding creates a varying magnetic flux in the transformer's core and thus a varying magnetic flux through the secondary winding. This varying magnetic flux induces a varying electromotive force (EMF), or "voltage", in the secondary winding.

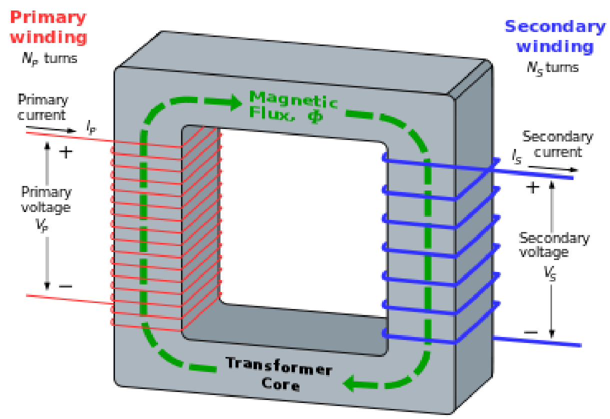
Transformers range in size from a thumbnail-sized coupling transformer hidden inside a stage microphone to huge units weighing hundreds of tons used in power stations, or to interconnect portions of power grids. All operate on the same basic principles, although the range of designs is wide. While new technologies have eliminated the need for transformers in some electronic circuits, transformers are still found in nearly all electronic devices designed for household ("mains") voltage. Transformers are essential for high-voltage electric power transmission, which makes long-distance transmission economically practical.

Basic principles

The transformer is based on two principles: first, that an electric current can produce a magnetic field (electromagnetism) and second that a changing magnetic field within a coil of wire induces a voltage across the ends of the coil (electromagnetic induction). Changing the current in the primary coil changes the magnetic flux that is developed. The changing magnetic flux induces a voltage in the secondary coil.

An ideal transformer is shown in the figure below. Current passing through the primary coil creates a magnetic field. The primary and secondary coils are wrapped around a core of very high magnetic permeability, such as iron, so that most of the magnetic flux passes through both the primary and secondary coils. If a load is connected to the secondary winding, the load current and voltage will be in the directions indicated, given the primary current and voltage in the directions indicated (each will be alternating current in practice).

Induction law:



An ideal voltage step-down transformer. The secondary current arises from the action of the secondary EMF on the (not shown) load impedance.

The voltage induced across the secondary coil may be calculated from Faraday's law of induction, which states that:

$$V_s = N_s \frac{\mathrm{d}\Phi}{\mathrm{d}t},$$

where Vs is the instantaneous voltage, Ns is the number of turns in the secondary coil and Φ is the magnetic flux through one turn of the coil. If the turns of the coil are oriented perpendicularly to the magnetic field lines, the flux is the product of the magnetic flux density B and the area A through which it cuts. The area is constant, being equal to the cross-sectional area of the transformer core, whereas the magnetic field varies with time according to the excitation of the primary. Since the same magnetic flux passes through both the primary and secondary coils in an ideal transformer

The instantaneous voltage across the primary winding equals

$$V_{\mathrm{P}} = N_{\mathrm{P}} \frac{\mathrm{d}\Phi}{\mathrm{d}t}.$$

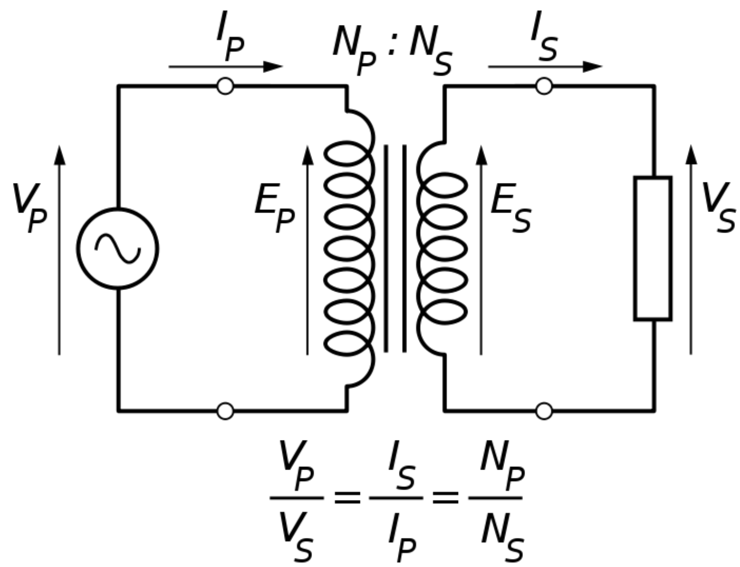
Taking the ratio of the two equations for V_s and V_p gives the basic equation for stepping up or stepping down the voltage

$$\frac{V_{\mathrm{s}}}{V_{\mathrm{P}}} = \frac{N_{\mathrm{s}}}{N_{\mathrm{P}}}.$$

Np/Ns is known as the turns ratio, and is the primary functional characteristic of any transformer. In the case of step-up transformers, this may sometimes be stated as the reciprocal, Ns/Np. Turns ratio is commonly expressed as an irreducible fraction or ratio: for example, a transformer with primary and secondary windings of, respectively, 100 and 150 turns is said to have a turn's ratio of 2:3 rather than 0.667 or 100:150.

Ideal power equation:

The ideal transformer as a circuit element



If a load is connected to the secondary winding, current will flow in this winding, and electrical energy will be transferred from the primary circuit through the transformer to the load. Transformers may be used for AC-to-AC conversion of a single power frequency, or for conversion of signal power over a wide range of frequencies, such as audio or radio frequencies.

In an ideal transformer, the induced voltage in the secondary winding (Vs) is in proportion to the primary voltage (Vp) and is given by the ratio of the number of turns in the secondary (Ns) to the number of turns in the primary (Np) as follows:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

By appropriate selection of the ratio of turns, a transformer thus enables an alternating current (AC) voltage to be “stepped up” by making Ns greater than Np, or “stepped down” by making Ns less than Np. The windings are coils wound around a ferromagnetic core, air-core transformers being a notable exception.

If the secondary coil is attached to a load that allows current to flow, electrical power is transmitted from the primary circuit to the secondary circuit. Ideally, the transformer is perfectly efficient. All the incoming energy is transformed from the primary circuit to the magnetic field and into the secondary circuit. If this condition is met, the input electric power must equal the output power:

$$P_{\text{incoming}} = I_{\text{p}} V_{\text{p}} = P_{\text{outgoing}} = I_{\text{s}} V_{\text{s}},$$

giving the ideal transformer equation

$$\frac{V_{\text{s}}}{V_{\text{p}}} = \frac{N_{\text{s}}}{N_{\text{p}}} = \frac{I_{\text{p}}}{I_{\text{s}}}.$$

This formula is a reasonable approximation for commercial transformers.

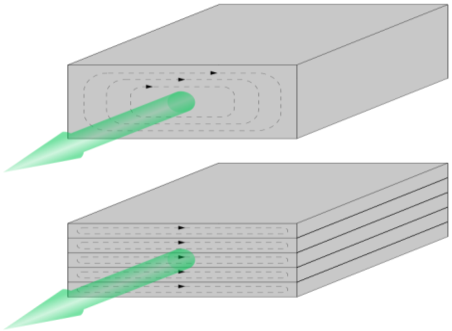
If the voltage is increased, then the current is decreased by the same factor. The impedance in one circuit is transformed by the square of the turns ratio.[36] For example, if an impedance Zs is attached across the terminals of the secondary coil, it appears to the primary circuit to have an impedance of (Np/Ns)2Zs. This relationship is reciprocal, so that the impedance Zp of the primary circuit appears to the secondary to be (Ns/Np)2Zp.

Cores

Laminated steel cores

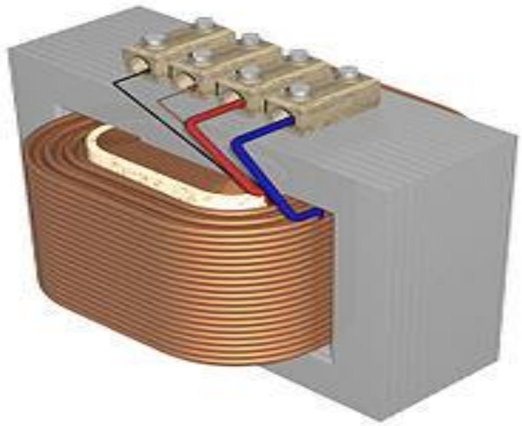
Laminated core transformer showing edge of laminations at top of photo

Transformers for use at power or audio frequencies typically have cores made of high permeability silicon steel.[59] The steel has a permeability many times that of free space and the core thus serves to greatly reduce the magnetizing current and confine the flux to a path which closely couples the windings. Early transformer developers soon realized that cores constructed from solid iron resulted in prohibitive eddy-current losses, and their designs mitigated this effect with cores consisting of bundles of insulated iron wires. Later designs constructed the core by stacking layers of thin steel laminations, a principle that has remained in use. Each lamination is insulated from its neighbors by a thin non-conducting layer of insulation. The universal transformer equation indicates a minimum cross-sectional area for the core to avoid saturation.



Laminating the core greatly reduces eddy-current losses

Windings:

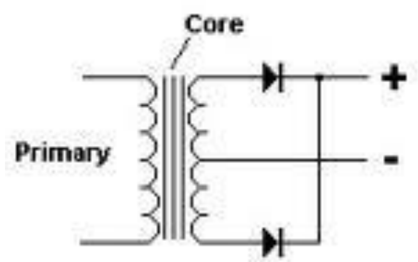


Windings are usually arranged concentrically to minimize flux leakage.

The conducting material used for the windings depends upon the application, but in all cases the individual turns must be electrically insulated from each other to ensure that the current travels throughout every turn. For small power and signal transformers, in which currents are low and the potential difference between adjacent turns is small, the coils are often wound from enameled magnet wire, such as Forever wire. Larger power transformers operating at high voltages may be wound with copper rectangular strip conductors insulated by oil-impregnated paper and blocks of pressboard.

Center taps Transformer:

In electronics, a center tap is a connection made to a point halfway along a winding of a transformer or inductor, or along the element of a resistor or a potentiometer. Taps are sometimes used on inductors for the coupling of signals, and may not necessarily be at the half-way point, but rather, closer to one end. A common application of this is in the Hartley oscillator. Inductors with taps also permit the transformation of the amplitude of alternating current (AC) voltages for the purpose of power conversion, in which case, they are referred to as autotransformers, since there is only one winding. An example of an autotransformer is an automobile ignition coil. Potentiometer tapping provides one or more connections along the device’s element, along with the usual connections at each of the two ends of the element, and the slider connection. Potentiometer taps allow for circuit functions that would otherwise not be available with the usual construction of just the two end connections and one slider connection.

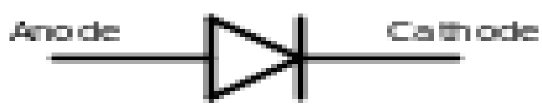


Full-wave rectifier using centre-tapped transformer

2.3 Diode:

A diode is a two-terminal electronic component with an asymmetric transfer characteristic, with low (ideally zero) resistance to current flow in one direction, and high (ideally infinite) resistance in the other. A semiconductor diode, the most common type today, is a crystalline piece of semiconductor material with a p-n junction connected to two electrical terminals.[5] A vacuum tube diode is a vacuum tube with two electrodes, a plate (anode) and heated cathode.

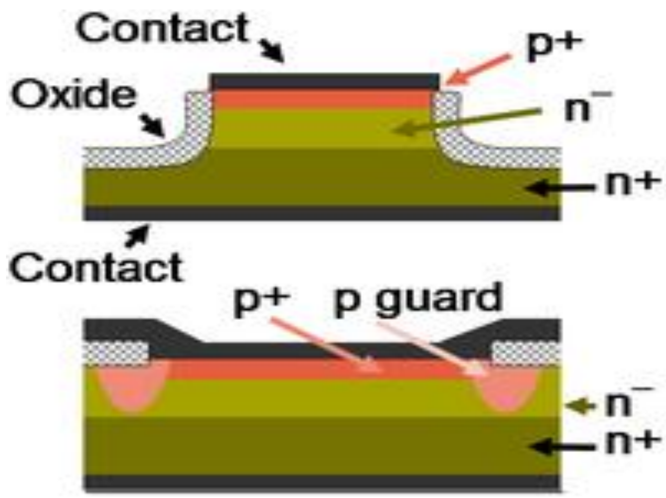
The most common function of a diode is to allow an electric current to pass in one direction (called the diode's forward direction), while blocking current in the opposite direction (the reverse direction). Thus, the diode can be viewed as an electronic version of a check valve. This unidirectional behavior is called rectification, and is used to convert alternating current to direct current, including extraction of modulation from radio signals in radio receivers—these diodes are forms of rectifiers.



Electronic symbols

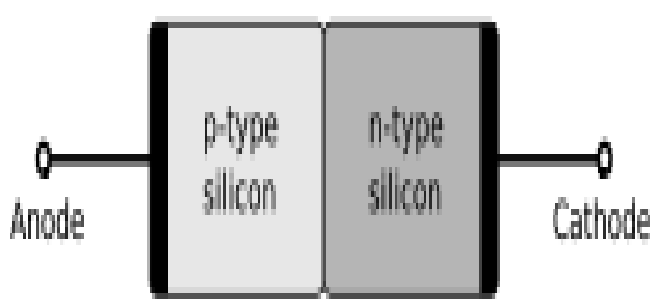
P–N junction diode:

A p–n junction diode is made of a crystal of semiconductor. Impurities are added to it to create a region on one side that contains negative charge carriers (electrons), called n-type semiconductor, and a region on the other side that contains positive charge carriers (holes), called p-type semiconductor. When two materials i.e. n-type and p-type are attached together, a momentary flow of electrons occur from n to p side resulting in a third region where no charge carriers are present. It is called Depletion region due to the absence of charge carriers (electrons and holes in this case). The diode's terminals are attached to each of these regions. The boundary between these two regions, called a p–n junction, is where the action of the diode takes place. The crystal allows electrons to flow from the N-type side (called the cathode) to the P-type side (called the anode), but not in the opposite direction.



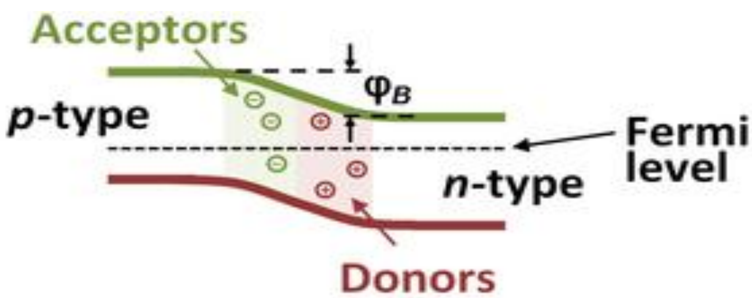
Operation:

Here, the operation of the abrupt p–n diode is considered. By “abrupt” is meant that the p- and n-type doping exhibit a step function discontinuity at the plane where they encounter each other. The objective is to explain the various bias regimes in the figure displaying current-voltage characteristics. Operation is described using band-bending diagrams that show how the lowest conduction band energy and the highest valence band energy vary with position inside the diode under various bias conditions. For additional discussion, see the articles Semiconductor and Band diagram.

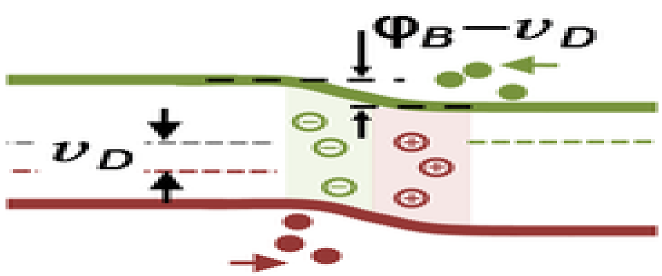


Zero bias:

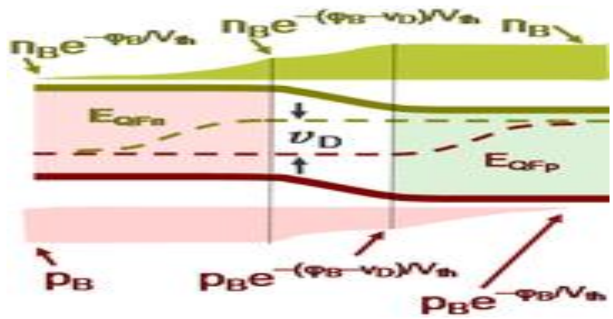
The figure shows a band bending diagram for a p–n diode; that is, the band edges for the conduction band (upper line) and the valence band (lower line) are shown as a function of position on both sides of the junction between the p-type material (left side) and the n-type material (right side). When a p-type and an n-type region of the same semiconductor are brought together and the two diode contacts are short-circuited, the Fermi half-occupancy level (dashed horizontal straight line) is situated at a constant level. This level insures that in the field-free bulk on both sides of the junction the hole and electron occupancies are correct. (So, for example, it is not necessary for an electron to leave the n-side and travel to the p-side through the short circuit to adjust the occupancies.)



Forward bias:



Band-bending diagram for *p–n* diode in forward bias. Diffusion drives carriers across the junction.

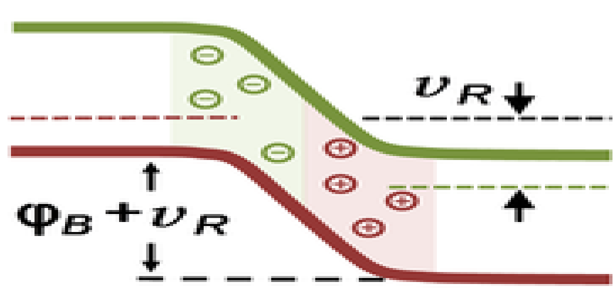


Quasi-Fermi levels and carrier densities in forward biased *p*–*n*- diode. The figure assumes recombination is confined to the regions where majority carrier concentration is near the bulk values, which is not accurate when recombination-generation centers in the field region play a role.

In forward bias, electrons are injected into the *p*-material and holes into the *n*-material. The electrons in the *n*-type material are called *majority* carriers on that side, but any that make it to the *p*-type side are called *minority* carriers. The same descriptors apply to holes: they are majority carriers on the *p*-type side, and minority carriers on the *n*-type side.

Reverse bias:

In reverse bias the occupancy level for holes again tends to stay at the level of the bulk *p*-type semiconductor while the occupancy level for electrons follows that for the bulk *n*—type. In this case, the *p*-type bulk band edges are raised relative to the *n*-type bulk by the reverse bias v_R, so the two bulk occupancy levels are separated again by an energy determined by the applied voltage. As shown in the diagram, this behavior means the step in band edges is increased to $\varphi_B + v_R$, and the depletion region widens as holes are pulled away from it on the *p*-side and electrons on the *n*-side.



Current–voltage characteristic:

A semiconductor diode's behavior in a circuit is given by its current–voltage characteristic, or I–V graph (see graph below). The shape of the curve is determined by the transport of charge carriers through the so-called depletion layer or depletion region that exists at the p–n junction between differing semiconductors. When a p–n junction is first created, conduction-band (mobile) electrons from the N-doped region diffuse into the P-doped region where there is a large population of holes (vacant places for electrons) with which the electrons "recombine". When a mobile electron recombines with a hole, both hole and electron vanish, leaving behind an immobile positively charged donor (dopant) on the N side and negatively charged acceptor (doping) on the P side. The region around the p–n junction becomes depleted of charge carriers and thus behaves as an insulator.

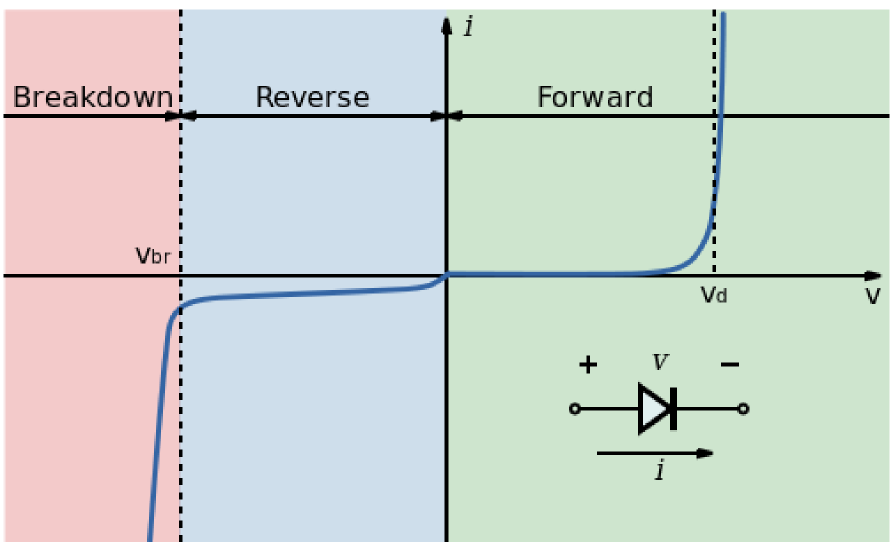


Figure : I–V characteristics of a p–n junction diode (not to scale—the current in the reverse region is magnified compared to the forward region, resulting in the apparent slope discontinuity at the origin; the actual I–V curve is smooth across the origin).

2.4 Capacitor:

A capacitor is a passive two-terminal electrical component used to store energy in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric (insulator); for example, one common construction consists of metal foils separated by a thin layer of insulating film. Capacitors are widely used as parts of electrical circuits in many common electrical devices.

When there is a potential difference (voltage) across the conductors, a static electric field develops across the dielectric, causing positive charge to collect on one plate and negative charge on the other plate. Energy is stored in the electrostatic field. An ideal capacitor is characterized by a single constant value, capacitance, measured in farads. This is the ratio of the electric charge on each conductor to the potential difference between them.

The capacitance is greatest when there is a narrow separation between large areas of conductor, hence capacitor conductors are often called plates, referring to an early means of construction. In practice, the dielectric between the plates passes a small amount of leakage current and also has an electric field strength limit, resulting in a breakdown voltage, while the conductors and leads introduce an undesired inductance and resistance.

Theory of operation:

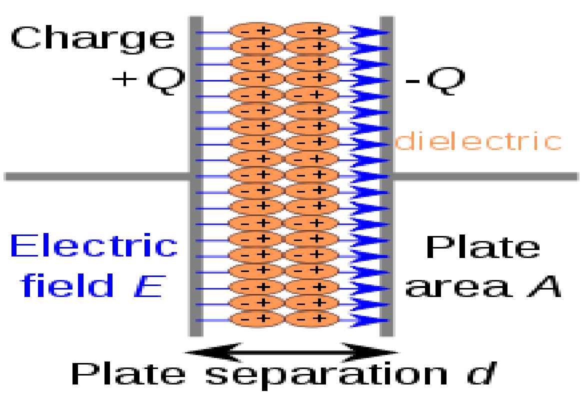
A capacitor consists of two conductors separated by a non-conductive region.[9] The non-conductive region is called the dielectric. In simpler terms, the dielectric is just an electrical insulator. Examples of dielectric media are glass, air, paper, vacuum, and even a semiconductor depletion region chemically identical to the conductors. A capacitor is assumed to be self-contained and isolated, with no net electric charge and no influence from any external electric field. The conductors thus hold equal and opposite charges on their facing surfaces,[10] and the dielectric develops an electric field. In SI units, a capacitance of one farad means that one coulomb of charge on each conductor causes a voltage of one volt across the device.

The capacitor is a reasonably general model for electric fields within electric circuits. An ideal capacitor is wholly characterized by a constant capacitance C, defined as the ratio of charge ±Q on each conductor to the voltage V between them:

$$C = \frac{Q}{V}$$

Sometimes charge build-up affects the capacitor mechanically, causing its capacitance to vary. In this case, capacitance is defined in terms of incremental changes:

$$C = \frac{\mathrm{d}q}{\mathrm{d}v}$$



Charge separation in a parallel-plate capacitor causes an internal electric field. A dielectric (orange) reduces the field and increases the capacitance.

Energy of electric field:

Work must be done by an external influence to "move" charge between the conductors in a capacitor. When the external influence is removed, the charge separation persists in the electric field and energy is stored to be released when the charge is allowed to return to its equilibrium position. The work done in establishing the electric field, and hence the amount of energy stored

$$W = \int_0^Q V\,\mathrm{d}q = \int_0^Q \frac{q}{C}\,\mathrm{d}q = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2 = \frac{1}{2}VQ.$$

Here Q is the charge stored in the capacitor, V is the voltage across the capacitor, and C is the capacitance.

In the case of a fluctuating voltage V(t), the stored energy also fluctuates and hence power must flow into or out of the capacitor. This power can be found by taking the time derivative of the stored energy:

$$P = \frac{\mathrm{d}W}{\mathrm{d}t} = \frac{\mathrm{d}}{\mathrm{d}t}\left(\frac{1}{2}CV^2\right) = CV(t)\frac{\mathrm{d}V}{\mathrm{d}t}.$$

Current-voltage relation:

The current I(t) through any component in an electric circuit is defined as the rate of flow of a charge Q(t) passing through it, but actual charges—electrons—cannot pass through the dielectric layer of a capacitor. Rather, an electron accumulates on the negative plate for each one that leaves the positive plate, resulting in an electron depletion and consequent positive charge on one electrode that is equal and opposite to the accumulated negative charge on the other. Thus the charge on the electrodes is equal to the integral of the current as well as proportional to the voltage, as discussed above. As with any ant derivative, a constant of integration is added to represent the initial voltage V(t0). This is the integral form of the capacitor equation

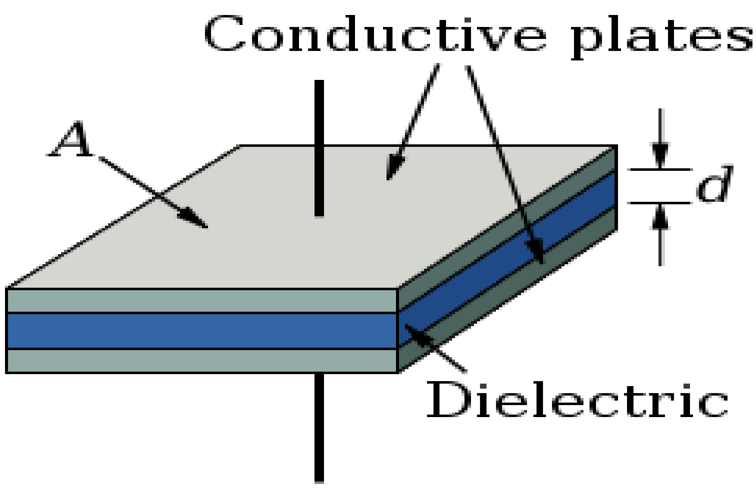
$$V(t) = \frac{Q(t)}{C} = \frac{1}{C}\int_{t_0}^{t} I(\tau)\,\mathrm{d}\tau + V(t_0).$$

Taking the derivative of this and multiplying by *C* yields the derivative form

$$I(t) = \frac{\mathrm{d}Q(t)}{\mathrm{d}t} = C\frac{\mathrm{d}V(t)}{\mathrm{d}t}.$$

Parallel-plate model:

The simplest capacitor consists of two parallel conductive plates separated by a dielectric with permittivity ε (such as air). The model may also be used to make qualitative predictions for other device geometries. The plates are considered to extend uniformly over an area A and a charge density $\pm\rho = \pm Q/A$ exists on their surface. Assuming that the width of the plates is much greater than their separation d, the electric field near the centre of the device will be uniform with the magnitude $E = \rho/\varepsilon$. The voltage is defined as the line integral of the electric field between the plates



$$V = \int_0^d E \, \mathrm{d}z = \int_0^d \frac{\rho}{\varepsilon} \, \mathrm{d}z = \frac{\rho d}{\varepsilon} = \frac{Qd}{\varepsilon A}.$$

Solving this for *C* = *Q*/*V* reveals that capacitance increases with area and decreases with separation

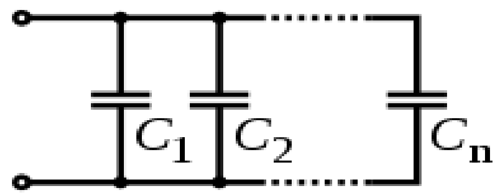
$$C = \frac{\varepsilon A}{d}$$

The capacitance is therefore greatest in devices made from materials with a high permittivity, large plate area, and small distance between plates.

Networks:

For capacitors in parallel

Capacitors in a parallel configuration each have the same applied voltage. Their capacitances add up. Charge is apportioned among them by size. Using the schematic diagram to visualize parallel plates, it is apparent that each capacitor contributes to the total surface area.

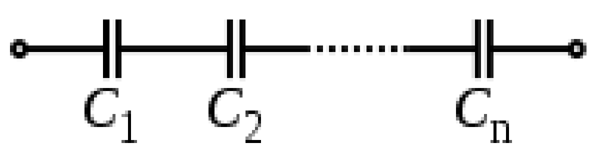


Several capacitors in parallel.

$$C_{\text{eq}} = C_1 + C_2 + \cdots + C_n$$

For capacitors in series

Connected in series, the schematic diagram reveals that the separation distance, not the plate area, adds up. The capacitors each store instantaneous charge build-up equal to that of every other capacitor in the series. The total voltage difference from end to end is apportioned to each capacitor according to the inverse of its capacitance. The entire series acts as a capacitor *smaller* than any of its components.

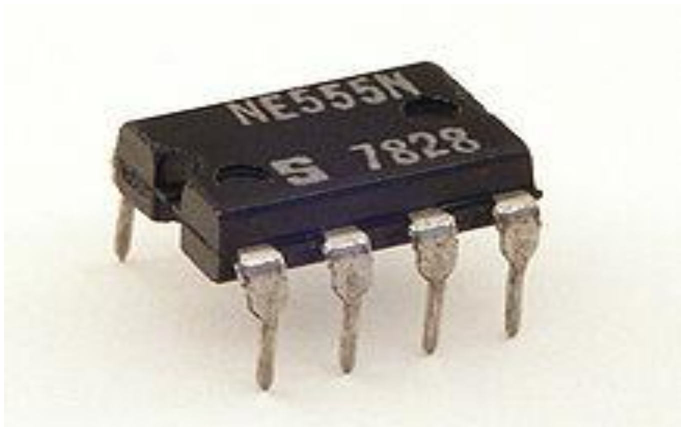


Several capacitors in series.

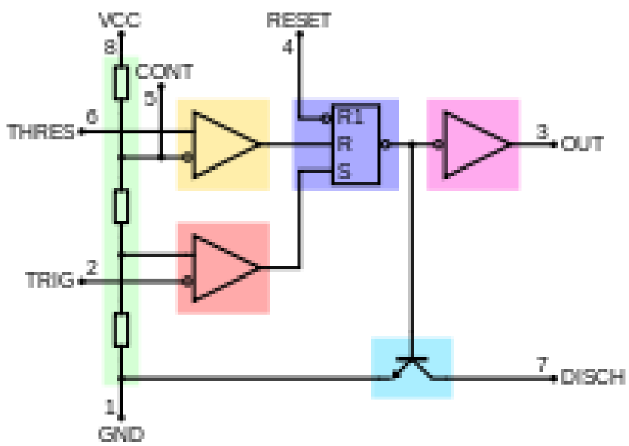
$$\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}$$

2.5 Timer IC (NE555N):

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.

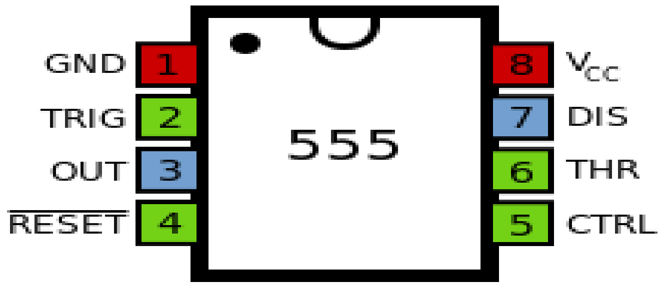


NE555 from Signe tics in dual-in-line package



Internal block diagram

Pins:



Pin out 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.

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, bounce free 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 thermostat 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.

Monostable:

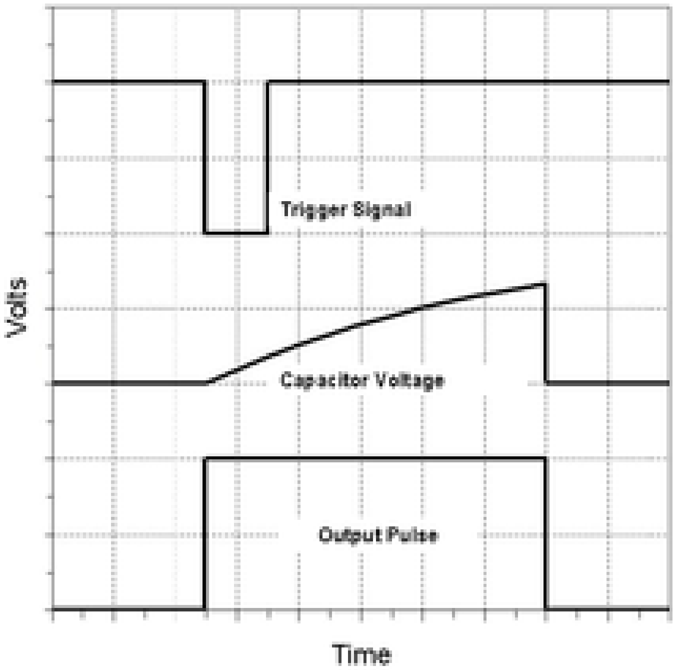
In the monostable mode, the 555 timer acts as a "one-shot" pulse generator. The pulse begins when the 555 timer receives a signal at the trigger input that falls below a third of the voltage supply. The width of the output pulse is determined by the time constant of an RC network, which consists of a capacitor (C) and a resistor (R). The output pulse ends when the voltage on the capacitor equals 2/3 of the supply voltage. The output pulse width can be lengthened or shortened to the need of the specific application by adjusting the values of R and C.

The output pulse width of time t, which is the time it takes to charge C to 2/3 of the supply voltage, is given by

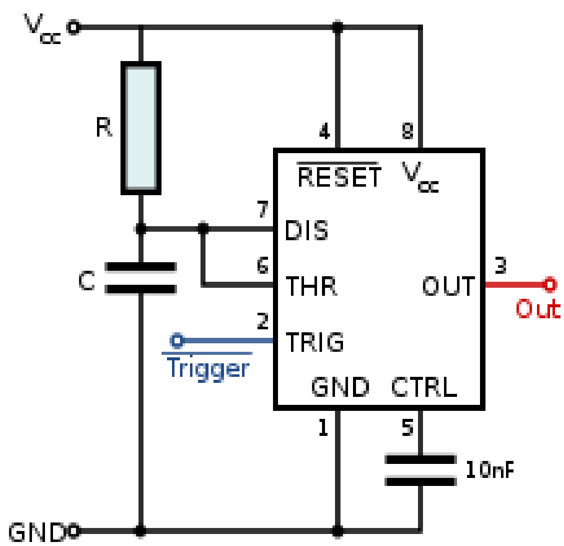
$$t = RC\ln(3) \approx 1.1RC$$

where t is in seconds, R is in ohms and C is in farads.

While using the timer IC in monostable mode, the main disadvantage is that the time span between any two triggering pulses must be greater than the RC time constant



The relationships of the trigger signal, the voltage on C and the pulse width in monostable mode



Schematic of a 555 in monostable mode

Specifications:

These specifications apply to the NE555. Other 555 timers can have different specifications depending on the grade (military, medical, etc.).

Supply voltage (V_{CC})	4.5 to 15 V
Supply current (V_{CC} = +5 V)	3 to 6 mA
Supply current (V_{CC} = +15 V)	10 to 15 mA
Output current (maximum)	200 mA
Maximum Power dissipation	600 mW
Power consumption (minimum operating)	30 mW@5V, 225 mW@15V
Operating temperature	0 to 70 °C

Time delay:

We've selected the 555 timer due to following reasons.

1. Timing from microseconds through hours.
2. Ability to operate from wide range of supply voltages.
3. High temperature stability.
4. Easily Available.
5. Its triggering circuit is quite sensitive.

This is basically a monostable. The external timing capacitor C2 is held initially discharged by the timer. The circuit triggers upon receiving a pulse to its pin 2 when the level reaches 1/3 Vcc. Once triggered., the circuit will remain in that state until the set time is elapsed or power to the circuit cuts off. The delayed period in seconds is 1.1 C2.R1 where R1 is in megohms and C2 is in microfarads. In practice, R1 should not exceed 20 M. If you use an electrolytic capacitor for C2, select a unit for low leakage. The time delay may have to be adjusted by varying R1 to compensate for the wide tolerance of electrolytic.

2.6 Potentiometer:

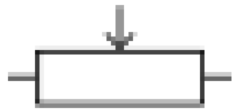
A potentiometer informally a pot is a three-terminal resistor with a sliding contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat.

A potentiometer measuring instrument is essentially a voltage divider used for measuring electric potential (voltage); the component is an implementation of the same principle, hence its name.

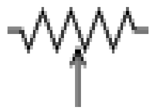
Potentiometers are commonly used to control electrical devices such as volume controls on audio equipment. Potentiometers operated by a mechanism can be used as position transducers, for example, in a joystick. Potentiometers are rarely used to directly control significant power (more than a watt), since the power dissipated in the potentiometer would be comparable to the power in the controlled load.

A typical single-turn potentiometer

Electronic symbol



(International)



(US)

Potentiometer construction:

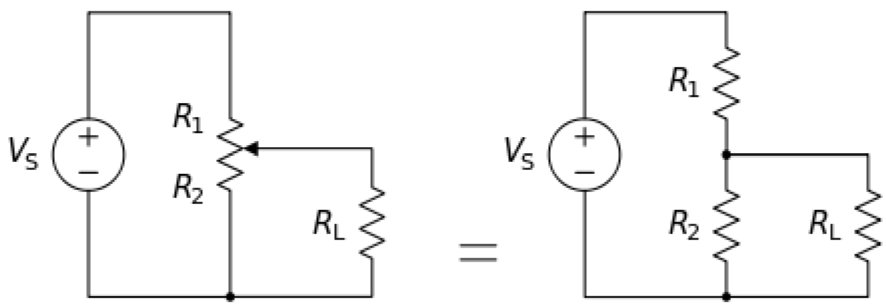
Potentiometers comprise a resistive element, a sliding contact (wiper) that moves along the element, making good electrical contact with one part of it, electrical terminals at each end of the element, a mechanism that moves the wiper from one end to the other, and a housing containing the element and wiper.

Many inexpensive potentiometers are constructed with a resistive element formed into an arc of a circle usually a little less than a full turn, and a wiper rotating around the arc and contacting it. The resistive element, with a terminal at each end, is flat or angled. The wiper is connected to a third terminal, usually between the other two. On panel potentiometers, the wiper is usually the center terminal of three. For single-turn potentiometers, this wiper typically travels just under one revolution around the contact. The only point of ingress for contamination is the narrow space between the shaft and the housing it rotates in.

Potentiometer applications:

Potentiometers are rarely used to directly control significant amounts of power (more than a watt or so). Instead they are used to adjust the level of analog signals (for example volume controls on audio equipment), and as control inputs for electronic circuits. For example, a light dimmer uses a potentiometer to control the switching of a TRIAC and so indirectly to control the brightness of lamps

Theory of operation:



A potentiometer with a resistive load, showing equivalent fixed resistors for clarity.

The potentiometer can be used as a voltage divider to obtain a manually adjustable output voltage at the slider (wiper) from a fixed input voltage applied across the two ends of the potentiometer. This is the most common use of them.

The voltage across R_{L}can be calculated by:

$$V_{\mathrm{L}} = \frac{R_2 R_{\mathrm{L}}}{R_1 R_{\mathrm{L}} + R_2 R_{\mathrm{L}} + R_1 R_2} \cdot V_s.$$

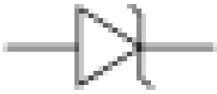
If $R_{\mathrm{L}}$is large compared to the other resistances the output voltage can be approximated by the simpler equation:

$$V_{\mathrm{L}} = \frac{R_2}{R_1 + R_2} \cdot V_s.$$

2.7 Zener Diode:

A Zener diode is a diode which allows current to flow in the forward direction in the same manner as an ideal diode, but will also permit it to flow in the reverse direction when the voltage is above a certain value known as the breakdown voltage, "zener knee voltage" or "zener voltage" or "Avalanche point".

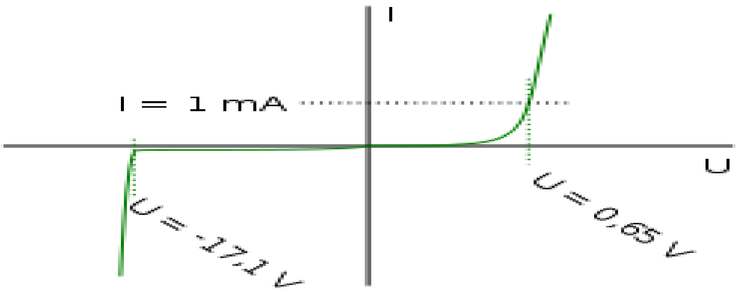
Zener diode



Electronic symbol

Operation:

A conventional solid-state diode will allow significant current if it is reverse-biased above its reverse breakdown voltage. When the reverse bias breakdown voltage is exceeded, a conventional diode is subject to high current due to avalanche breakdown. Unless this current is limited by circuitry, the diode will be permanently damaged due to overheating. A zener diode exhibits almost the same properties, except the device is specially designed so as to have a reduced breakdown voltage, the so-called zener voltage.

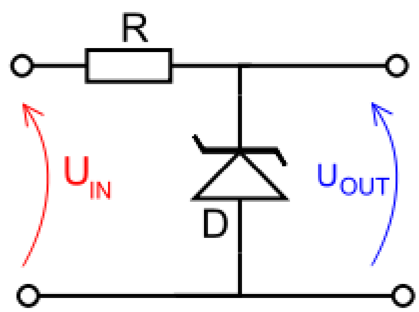


Construction:

The zener diode's operation depends on the heavy doping of its p-n junction. The depletion region formed in the diode is very thin (<0.000001 m) and the electric field is consequently very high (about 500000 V/m) even for a small reverse bias voltage of about 5 V, allowing electrons to tunnel from the valence band of the p-type material to the conduction band of the n-type material.

Uses:

Zener diodes are widely used as voltage references and as shunt regulators to regulate the voltage across small circuits. When connected in parallel with a variable voltage source so that it is reverse biased, a zener diode conducts when the voltage reaches the diode's reverse breakdown voltage. From that point on, the relatively low impedance of the diode keeps the voltage across the diode at that value.

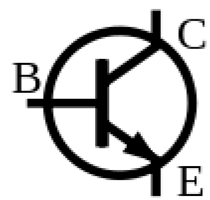


In this circuit, a typical voltage reference or regulator, an input voltage, UIN, is regulated down to a stable output voltage UOUT. The breakdown voltage of diode D is stable over a wide current range and holds UOUT relatively constant even though the input voltage may fluctuate over a fairly wide range. Because of the low impedance of the diode when operated like this, resistor R is used to limit current through the circuit.

2.7 Transistor:

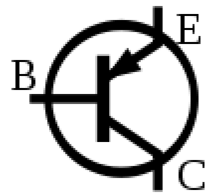
A transistor is a semiconductor device used to amplify and switch electronic signals and electrical power. It is composed of semiconductor material with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current flowing through another pair of terminals. Because the controlled (output) power can be higher than the controlling (input) power, a transistor can amplify a signal. Today, some transistors are packaged individually, but many more are found embedded in integrated circuits.

Types:



The symbol of an NPN BJT. The symbol is "*n*ot *p*ointing i*n*."

NPN is one of the two types of bipolar transistors, consisting of a layer of P-doped semiconductor (the "base") between two N-doped layers. A small current entering the base is amplified to produce a large collector and emitter current. That is, when there is a positive potential difference measured from the emitter of an NPN transistor to its base (i.e., when the base is high relative to the emitter) as well as positive potential difference measured from the base to the collector, the transistor becomes active. In this "on" state, current flows between the collector and emitter of the transistor. Most of the current is carried by electrons moving from emitter to collector as minority carriers in the P-type base region. To allow for greater current and faster operation, most bipolar transistors used today are NPN because electron mobility is higher than hole mobility.



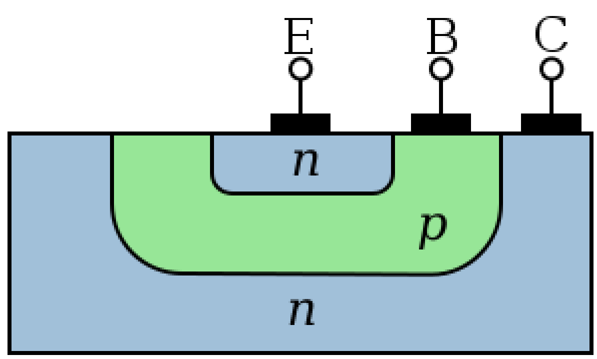
The symbol of a PNP BJT. The symbol "*p*oints i*n* *p*roudly."

PNP The other type of BJT is the PNP, consisting of a layer of N-doped semiconductor between two layers of P-doped material. A small current leaving the base is amplified in the collector output. That is, a PNP transistor is "on" when its base is pulled low relative to the emitter.

The arrows in the NPN and PNP transistor symbols are on the emitter legs and point in the direction of the conventional current flow when the device is in forward active mode.

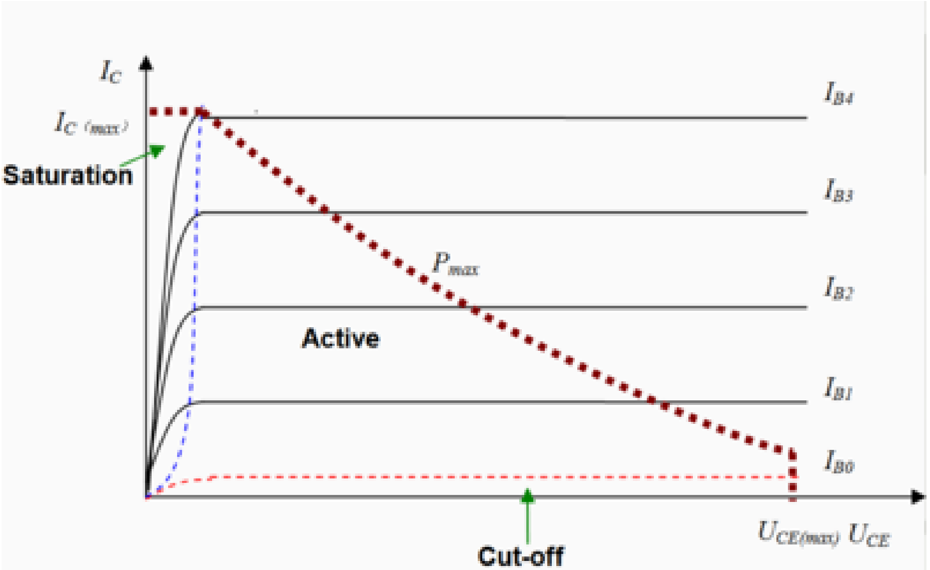
Construction

The first BJTs were made from germanium (Ge). Silicon (Si) types currently predominate but certain advanced microwave and high performance versions now employ the compound semiconductor material gallium arsenide (GaAs) and the semiconductor alloy silicon germanium (SiGe). Single element semiconductor material (Ge and Si) is described as elemental.



Simplified cross section of a planar *NPN* bipolar junction transistor

Regions of operation:



The relationship between I_C, $U_{CE}$and I_B.

Bipolar transistors have five distinct regions of operation, defined by BJT junction biases.

The modes of operation can be described in terms of the applied voltages (this description applies to NPN transistors; polarities are reversed for PNP transistors):

Forward-active: base higher than emitter, collector higher than base (in this mode the collector current is proportional to base current by \beta_F).

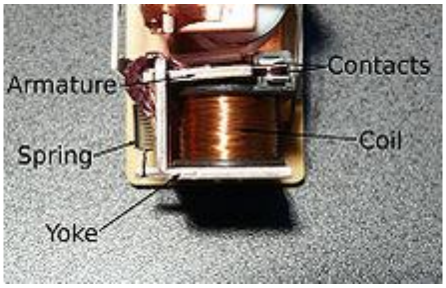
Saturation: base higher than emitter, but collector is not higher than base.

Cut-Off: base lower than emitter, but collector is higher than base. It means the transistor is not letting conventional current to go through collector to emitter.

Reverse-active: base lower than emitter, collector lower than base: reverse conventional current goes through transistor.

2.8 Relay:

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and re-transmitting it to another. Relays were used extensively in telephone exchanges and early computers to perform logical operations.



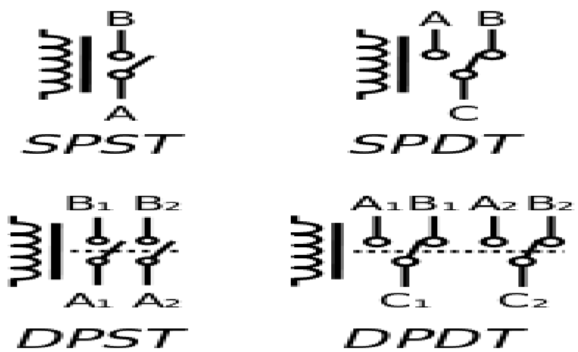
Automotive-style miniature relay, dust cover is taken off

Pole and throw:

Normally-open (NO) contacts connect the circuit when the relay is activated; the circuit is disconnected when the relay is inactive. It is also called a Form A contact or "make" contact. NO contacts may also be distinguished as "early-make" or NOEM, which means that the contacts close before the button or switch is fully engaged.

Normally-closed (NC) contacts disconnect the circuit when the relay is activated; the circuit is connected when the relay is inactive. It is also called a Form B contact or "break" contact. NC contacts may also be distinguished as "late-break" or NCLB, which means that the contacts stay closed until the button or switch is fully disengaged.

Change-over (CO), or double-throw (DT), contacts control two circuits: one normally-open contact and one normally-closed contact with a common terminal. It is also called a Form C contact or "transfer" contact ("break before make"). If this type of contact utilizes a "make before break" functionality, then it is called a Form D contact.



Circuit symbols of relays. (C denotes the common terminal in SPDT and DPDT types.)

The following designations are commonly encountered:

SPST – Single Pole Single Throw. These have two terminals which can be connected or disconnected. Including two for the coil, such a relay has four terminals in total. It is ambiguous whether the pole is normally open or normally closed. The terminology "SPNO" and "SPNC" is sometimes used to resolve the ambiguity.

SPDT – Single Pole Double Throw. A common terminal connects to either of two others. Including two for the coil, such a relay has five terminals in total.

DPST – Double Pole Single Throw. These have two pairs of terminals. Equivalent to two SPST switches or relays actuated by a single coil. Including two for the coil, such a relay has six terminals in total. The poles may be Form A or Form B (or one of each).

DPDT – Double Pole Double Throw. These have two rows of change-over terminals. Equivalent to two SPDT switches or relays actuated by a single coil. Such a relay has eight terminals, including the coil.

Applications:

Relays are used to and for:Amplify a digital signal, switching a large amount of power with a small operating power. Some special cases are:

A telegraph relay, repeating a weak signal received at the end of a long wire

Controlling a high-voltage circuit with a low-voltage signal, as in some types of modems or audio amplifiers,

Relay Driver

The output from the voltage level detectors cannot directly drive the relay and hence the relay driver is used.

Circuit diagram:

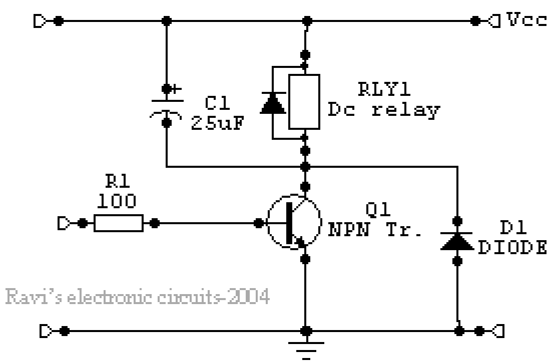


Figure 5.

In this a relay (12V <500 ohms) is connected to the collector of NPN transistor. The out put voltage from the comparator is applied to the base of NPN transistor through a resistance R1. When the output from the comparator is low the transistor is in OFF state and the relay is in de-energized state. Similarly when the output from the comparator goes high the transistor switches ON and the flow of current from the collector to emitter of transistor energizes the relay. Generally in a relay driver circuit, parallel to the relay coil, a diode or a capacitor is used. This is to eliminate the back e.m.f generated by the relay coil when currents are suddenly broken. Capacitor C1 is connected in parallel to the coil, which filters out the back emf but it, slows down the working of relay.

A better method is to connect two diodes (as shown in the figure 5) that stop the relay – transistor junction swinging more than 600mV above the positive rail or below the zero-volt rail. During normal operation the diodes are reverse biased and have no effect on the performance of circuit. But when back emf is induced, the diodes conduct heavily and absorb all transient voltages. However, I have employed the both methods.

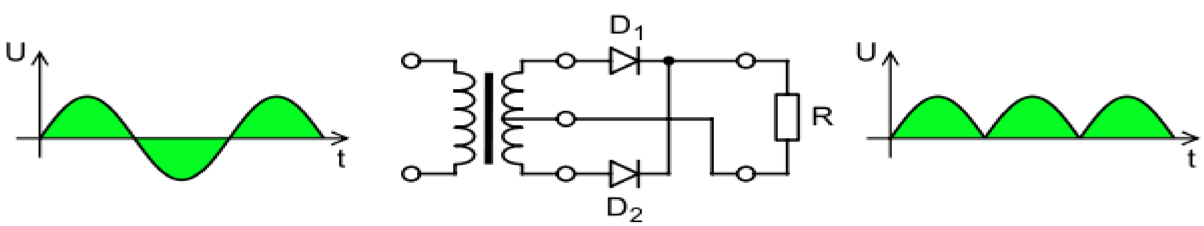
Chapter 3:
Circuit Implementation &
Hardware Implementation

3.1 Rectifier Circuit:

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification.

A full-wave rectifier converts the whole of the input waveform to one of constant polarity (positive or negative) at its output. Full-wave rectification converts both polarities of the input waveform to DC (direct current), and yields a higher mean output voltage. Two diodes and a center tapped transformer, or four diodes in a bridge configuration and any AC source (including a transformer without center tap), are needed.[2] Single semiconductor diodes, double diodes with common cathode or common anode, and four-diode bridges, are manufactured as single components.

For single-phase AC, if the transformer is center-tapped, then two diodes back-to-back (cathode-to-cathode or anode-to-anode, depending upon output polarity required) can form a full-wave rectifier. Twice as many turns are required on the transformer secondary to obtain the same output voltage than for a bridge rectifier, but the power rating is unchanged.



Full-wave rectifier using a center tap transformer and 2 diodes.

The average and root-mean-square no-load output voltages of an ideal single-phase full-wave rectifier are:

$$V_{\mathrm{dc}} = V_{\mathrm{av}} = \frac{2V_{\mathrm{peak}}}{\pi}$$

$$V_{\mathrm{rms}} = \frac{V_{\mathrm{peak}}}{\sqrt{2}}$$

3.2 Circuit Diagram:

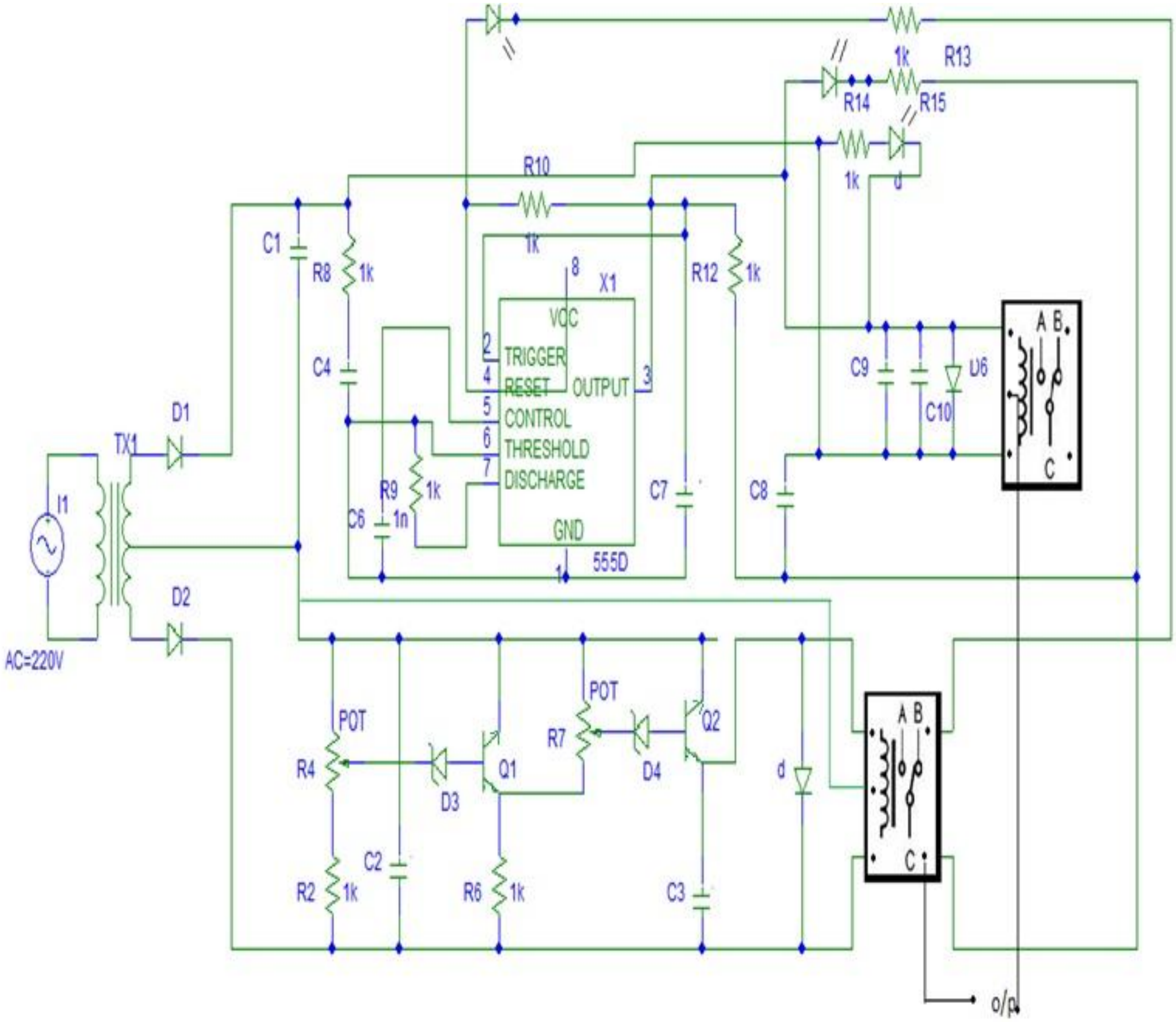


Fig : Circuit diagram of over & under voltage protector

When the mains supply goes out of preset (over or under voltage) limits, the relay/load is turned off immediately and it is turned on only when A.C. mains voltage settles within the presets limits for a period equal to the on time delay period. The on-time delay period is preset able for 5 seconds to 2 minutes duration using presets VR3 and VR4. For refrigerators the delay should be preset for about 2 minutes duration to protect the compressor motor from frequently turning on and off. In this circuit the on-time and off-time delay depends on charging and discharging time of capacitor C1. Here the discharge time of capacitors C1 is quite less to suit our requirement. We want that on switching off of the supply to the load, the circuit should immediately be ready to provide the required on-time delay when A.C. mains resumes after a brief interrupted for a short period due to over-/under voltage cut-off operation. This circuit is also useful against frequent power supply interruption resulting from loose electrical connections; be it at the pole or switch or relay contact, or due to any other reason. Here supply for the over- and under- voltage sampling part of the circuit [marked +12 v(b)] and that required for the rest of the circuit [marked +12 v(a)] are derived separately from lower half and upper half respectively of centre-tapped secondary of step-down transformer X1.if we use common 12 volt DC to this circuit would fall below preset low cut-off voltage and thus affects the proper operation of the sampling circuit. The value of filtering capacitor C4 is so chosen that a fall in mains voltage may quickly activate under-voltage sensing circuit, should the mains voltage reach the low cut-off limit. In the sampling of the circuit, wired around transistor T1, presets VR1 and VR2 are used for presetting over or under voltage cut off limits respectively. The limits are set according to load voltage requirement as per as manufactures specifications. Once the limits have been set, zener D1 will conduct if upper limit has been exceeded resulting in cut-off of transistor T2. The same condition can also result when mains voltage falls below the under-voltage setting as zener D2 stops conducting. Thus in either case transistor T2 is cut-off or transistor T3 is forward biased via resistor R3. This causes LED 1 to be on. Simultaneously, capacitor C2 quickly discharges via diode D5 and transistor T3. As collector of transistor T3 is pulled low, transistor T4 and T5 are both cut-off, as also transistor T5. Thus, LED2 and LED3 are off and the relay is De-energized. Now, when the mains voltage comes within the acceptable range, transistor T2 conducts to cut-off transistor T5 gets forward biased and LED2 becomes on.

3.3 Hardware Implementation:

Fig : Hardware implementation of over & under voltage protector

Chapter 4:

Discussion

4.1 Advantage:

- Over-voltage protection
- Under-voltage protection
- Protection against transients
- High reliability
- High performance
- Low Cost
- Protection to load from frequent turning ON & OFF by providing time delay. Under-voltage relay, in case the mains voltage starts fluctuating in the vicinity of under or over voltage preset points.
- It can be used to protect loads such as refrigerator, T.V., and VCR from undesirable over and under line voltages.

4.2 Future work:

- In the future we will try to improve our design by high voltage
- As well as we will try to minimize the time delay
- In future we will try to increase performance and reliability

4.3 Conclusion:

It is an inexpensive auto cutoff circuit, which is fabricated using transistors and other discrete components. It can be used to protect loads such as refrigerator, TV, and VCR from undesirable over and under line voltages, as well as surges caused due to sudden failure/resumption of mains power supply

4.4 Reference:

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