**Control of DC fan using Thermistor**

**Table of Contents**

**Acknowledgment iii**

**Abstract iv**

**List of Illustrations vi**

**1 An Introduction 1**

1.1 Aim of the project 1

1.2Circuit Diagram 1

**2.Component Selectio** **2**

2.1 criterion 2

2.2 final components 2

**3.Simulation 3**

**4. Transformer Design 5**

**5 Testing 6**

5.1 Testing of transformer 6

5.1.1 Wave forms 6

5.2 Circuit Testing 7 5.2.1 Wave forms 7

**6. Characteristics of Thermistor 11 Result & Further future implementation 12 Appendix 13 Bibliography 29**

**List of Illustrations**

Fig:01- main circuit 1

Fig: 02-Simulation circuit made in psim 3

Fig 03:- Output waveforms from simulation circuit (When R=400Ω) 4

Fig 04:- Output waveforms from simulation circuit (When R=500Ω) 4

Fig:5-Characterstics graph of a thermistor 11

Fig: 06 - DC Fan 12 Volt 13

Fig: 07 - Motor and Blade used in Fan 14

Fig: 08- Thermistor 14

Fig: 09 -Thermistor symbol 15

Fig: 10 - Semiconductor diode schematic symbol 18

Fig: 11 -Bridge rectifier: a full-wave rectifier using 4 diodes. 21

Fig: 12- Full-wave rectifier using a transformer and 2 diodes. 22

Fig: 13- Full-wave rectifier output waveform 22

Fig: 14-LED(Light Emitting Diode) 25

Fig: 15- LED internal parts 26

1. **Introduction**

B.K.Birla Institute of Engineering and Technology is a newly established institution in the field of Engineering and Technology. Since last few years ago it is representing itself as a leading institute in Rajasthan.

The minor project is one of the most important courses offered by the Rajasthan Technical University for the final year student in Engineering Field. It gives a way to work and apply the practical knowledge in an appropriate way.

**1.1 Aim of the project**

The focused aim of the project is to control a 12V DC fan using a power electronic circuit works on the operation of Thermistor. A rectified 12V DC input is given to the circuit which contains an arrangement of Thermistor, Relay, Potentiometer and various other electronic components like Diode, Transistor and Resistors.

**1.2 Circuit Diagram**

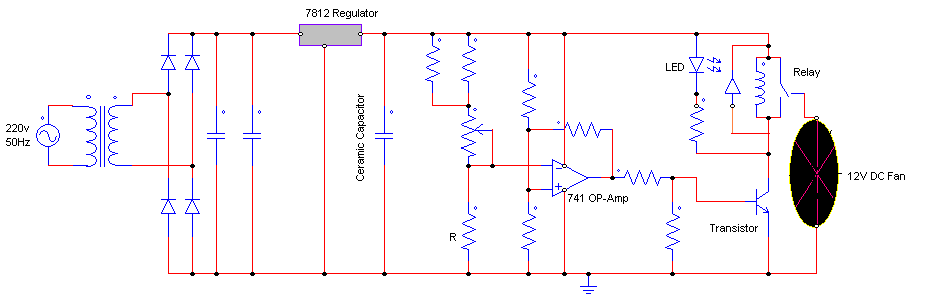


Fig:01- main circuit

**2.Component Selection**

**2.1 criterion**

In this we have a particular criteria for the selsction of of various components as

**1.Transformer:-**230V /12V

**2.Potentiometer:-**1k to 10k

**3.Op-Amp:-** +12V / 0 V

**4.Relay:-** 12 V to 20V

**5.Thermistor :-** 1KΩ to 100KΩ depending upon the value of resistors

**2.2 final selected components**

The various electronic components used in this project are tabulated below

|  |  |  |
| --- | --- | --- |
| **S.No.** | **Components** | **Specification** |
| **1.** | Resistors | 270Ω,470 Ω,10K Ω ,10K Ω,150K Ω, 4k7 K Ω,  1.8K Ω, 1K Ω |
| **2.** | Capacitor | 3\*(1000µf ,0.7 threshold Voltage ) |
| **3.** | Ceramic C | 1000µf ,0.7 threshold Voltage |
| **4.** | Fan | 12V DC |
| **5.** | Transformer | 220/12 zero 12 (Center tapped) |
| **6.** | Diode | p-n junction diode |
| **7.** | Transistor | npn type |
| **8.** | Regulator | 7812 for regulated supply |
| **9.** | Op-Amp | IC 741 , 12 V + and 0 ground |
| **10.** | Variable resistor | 1K Ω |
| **11.** | Relay | 12V DC |
| **12.** | LED | [Passive](http://en.wikipedia.org/wiki/Passive_component) Red, [optoelectronic](http://en.wikipedia.org/wiki/Optoelectronic) Green |
| **13.** | Thermistor | ntc type,1K Ω |

**3.Simulation**

The simulation of the circuit is done in the psim software. The simulation circuit diagrame is shown below

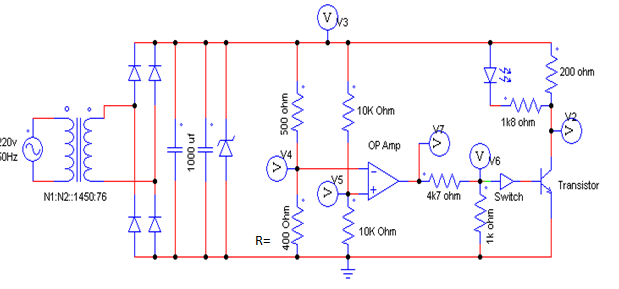
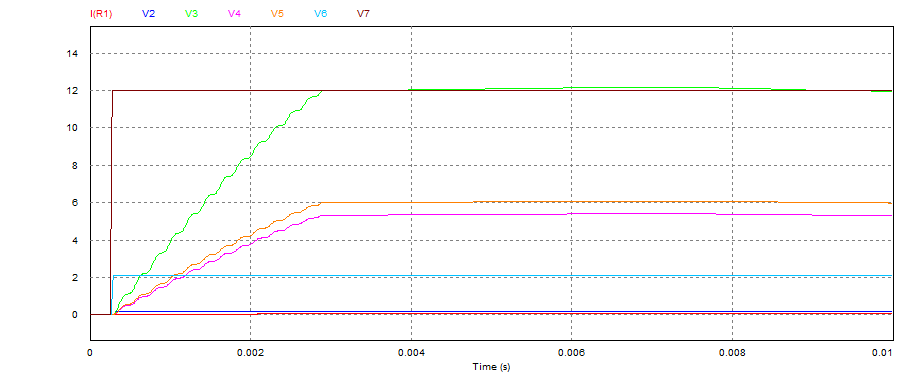


Fig: 02-Simulation circuit made in psim

 Fig 03:- Output waveforms from simulation circuit (When R=400Ω)

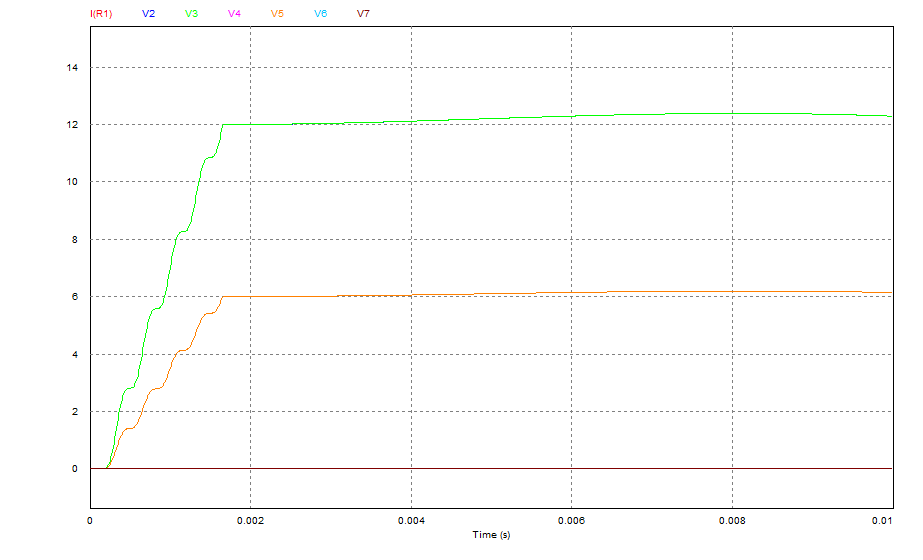


Fig 04:- Output waveforms from simulation circuit (When R=500Ω)

**4. Transformer Design**

For the construction of the transformer we have the following calculations are made:-

Primary Voltage=230V

Secondary Voltage=12V

Secondary Current=500mA

Core area=1.152\*√ (output voltage\*output current) square cm

Now, we have

Turns per volt=1/ (4.44\*0.0001\*frequency\*core area\*flux density)

The current in primary winding is given by

Primary current=sum of(output volts\* output amps)/(primary volt\*efficiency)

The number of turns in primary winding is given by

Primary turns=Turns per volt\*Primary volts

Primary Winding area= primary turns/Turns per sq. cm.

Secondary turns=1.03(turns per volt\*secondary volts)

The window area for secondary winding is

Secondary window area =secondary turns/turns per square cm.

**Core area:**

Total window area=Primary Window area+ Sum of Secondary Window areas+ space for former and insulation

Gross core area=core area/0.9 sq. cm

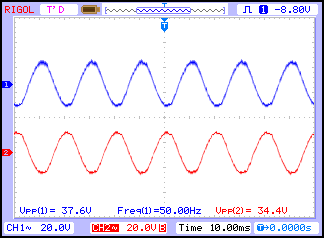
Tongue width=√Gross core area cm

Stack height=Gross core Area/Actual Tounge Width cm.

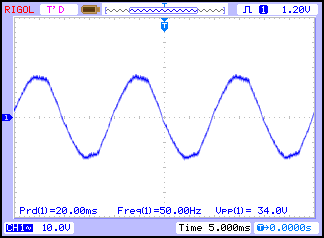
**5 Testing**

**5.1 Testing of transformer**

We have given 230 volt input supply to the primary winding of the transformer and on the output terminals i.e. secondary winding of the transformer we get 12 volt output supply.



**1.1 Center tapped transformer output before rectification**

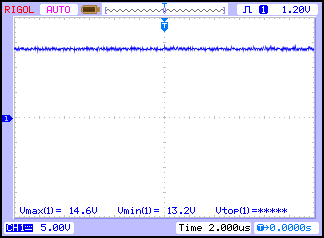


**1.2 AC input 12 volt to rectifier circuit by transformer**

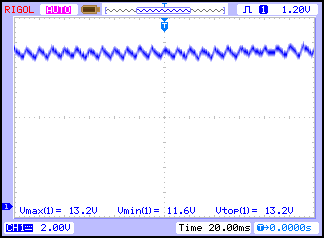
**5.2 Circuit Testing**

**5.2.1 Wave forms**

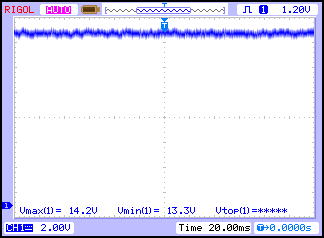
The Various wave forms taken from the digital oscilloscope in this project are given below



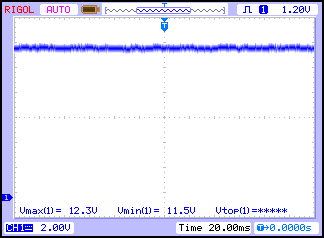
**1.3 DC output 12 volt by rectifier circuit to main circuit**



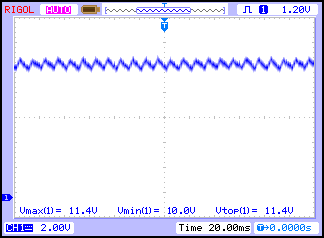
**1.4 Rectified input to the main circuit without load**



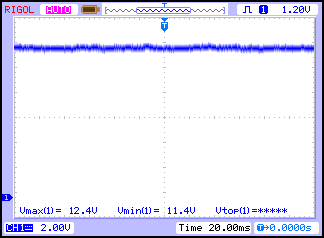
**1.5 Rectified input to the main circuit with load**

****

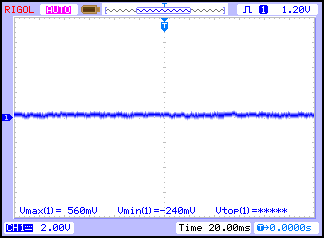
**1.6 Regulator output without fan load**

****

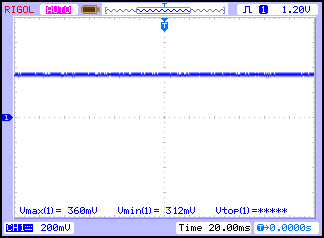
**1.7 Regulator output with fan load**



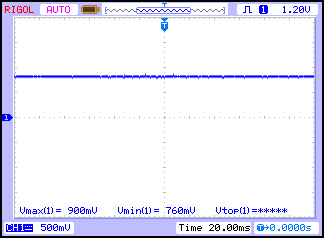
**1.8 Vec when transistor is off**



**1.9 Vec when transistor is on**



**1.10 Vbe when transistor is off**



**1.11 Vbe when transistor is on**

**6. Characteristics of Thermistor**

We have practically obtained the following characteristics of Thermistor between the resistance of the Thermistor and the temperature and by varying the temperature we get the following characteristics as:-

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Temperature(in ᶱ C) | 17.2 | | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 |
| Resistance(in KΩ) | 1.32 | | 1.29 | 1.18 | 1.16 | 1.11 | 1.03 | 1.01 | .95 | .89 | .80 | .76 | .68 | .66 | .63 | .60 | .61 |
| 95 | 100 | | 105 |
| .50 | .43 | | .41 |

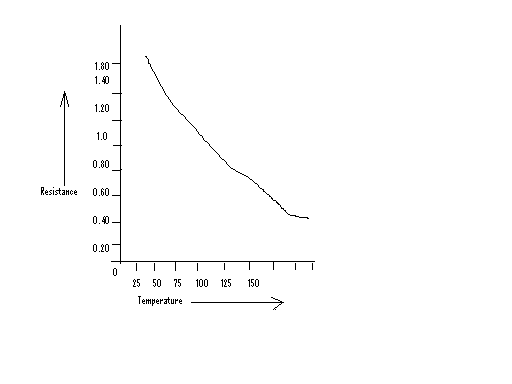


Fig:5-Characterstics graph of a thermistor

**Result**

When 230V input supply is given to the transformer then we get 12V Output supply at the Secondary terminals, this output voltage is given to the rectifier circuit and it rectifies the 12 volt ac to dc and this rectified voltage is given to the main circuit and our circuit operates and according to the variation in the temperature Thermistor gives the signal to the internal circuit and the speed of the fan is controlled.

**Further future implementation**

In future such type of circuit can be implemented for designing smart house concept by including various other sensors. This circuit can also be further implemented for designing temperature sensing fan which can vary its speed as per the requirement of the human beings

**Appendix**

**1 DC FAN:-**

The operation of 12 volt DC cooling fans typically used to supply cooling air to electronic equipment: These fans are typically based on two-phase Brushless DC (BLDC) motors drawing between 1 and 50 watts of power. Single-phase brushless DC motors are also used in fans, but this is outside the scope of this application note. Further discussion describes the addition of an 

Fig: 06 - DC Fan 12 Volt

Atmel ATtiny13 microcontroller and the benefits this offers, such as variable speed by external Thermistor input. An additional input is a PWM pulse width-varying signal, which also controls fan speed.

**1.1 Theory of Operation**

12-volt DC cooling fans consist of a rotor-blade assembly containing a permanent magnet, and a 2- or more pole stator. A magnetic sensor, called a Hall sensor, detects the rotating magnetic field and switches 12VDC from one stator coil to another. Varying the supplied DC voltage can vary the speed of most fans. A 12VDC fan might start rotating with 4-5 VDC applied, and increase its speed when increasing voltage is supplied.



Fig: 07 - Motor and Blade used in Fan

**2. Thermistor**

A **Thermistor** is a type of [resistor](http://en.wikipedia.org/wiki/Resistor) whose [resistance](http://en.wikipedia.org/wiki/Electrical_resistance) varies significantly (more than in standard resistors) with [temperature](http://en.wikipedia.org/wiki/Temperature). The word is a [portmanteau](http://en.wikipedia.org/wiki/Portmanteau) of [*thermal*](http://en.wikipedia.org/wiki/Thermal_(disambiguation)) and [*resistor*](http://en.wikipedia.org/wiki/Resistor). Thermistor are widely used as inrush [current](http://en.wikipedia.org/wiki/Electric_current) limiters, temperature [sensors](http://en.wikipedia.org/wiki/Sensors), self-resetting over current protectors, and self-regulating [heating elements](http://en.wikipedia.org/wiki/Heating_element).

[](http://en.wikipedia.org/wiki/File:NTC_bead.jpg)

Fig: 08- Thermistor

Thermistor differ from [resistance temperature detectors](http://en.wikipedia.org/wiki/Resistance_temperature_detector) (RTD) in that the material used in a Thermistor is generally a ceramic or polymer, while RTDs use pure metals. The temperature response is also different; RTDs are useful over larger temperature ranges, while Thermistor typically achieve a higher precision within a limited temperature range [usually −90 °C to 130 °C].

[](http://en.wikipedia.org/wiki/File:Thermistor.svg)

Fig: 09 -Thermistor symbol

Assuming, as a first-order approximation, that the relationship between resistance and temperature is [linear](http://en.wikipedia.org/wiki/Linear), then:

\Delta R=k\Delta T \,

Where

Δ*R* = change in resistance

Δ*T* = change in temperature

*k* = first-order temperature coefficient of resistance

Thermistor can be classified into two types, depending on the sign of *k*. If *k* is [positive](http://en.wikipedia.org/wiki/Positive_number), the resistance increases with increasing temperature, and the device is called a [positive temperature coefficient](http://en.wikipedia.org/wiki/Temperature_coefficient#Positive_temperature_coefficient_of_resistance) (**PTC**) Thermistor, or **posistor**. If *k* is negative, the resistance decreases with increasing temperature, and the device is called a [negative temperature coefficient](http://en.wikipedia.org/wiki/Temperature_coefficient#Negative_temperature_coefficient) (**NTC**) Thermistor. Resistors that are not Thermistor are designed to have a *k* as close to zero as possible (smallest possible k), so that their resistance remains nearly constant over a wide temperature range.

Instead of the temperature coefficient *k*, sometimes the *temperature coefficient of resistance* α (alpha) or α*T* is used. It is defined as

\alpha_T = \frac{1}{R(T)} \frac{dR}{dT}.

For example, for the common PT100 sensor, α = 0.00385 or 0.385 &percent; /°C. This α*T* coefficient should not be confused with the α parameter below.

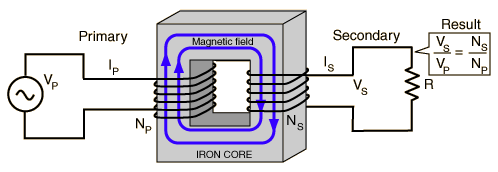
The Thermistor used in this project is of NTC type with the value of 1KΩ.

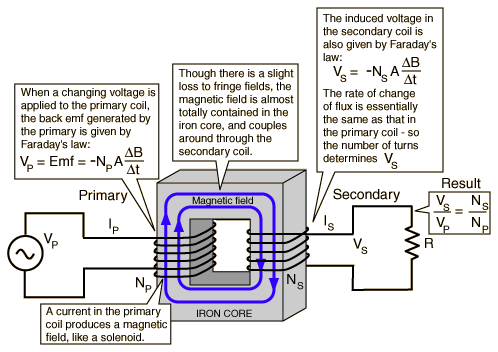
**3. Transformer**

A transformer makes use of [Faraday's law](http://hyperphysics.phy-astr.gsu.edu/hbase/electric/farlaw.html#c1) and the [ferromagnetic](http://hyperphysics.phy-astr.gsu.edu/hbase/solids/ferro.html#c4) properties of an [iron core](http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/elemag.html#c4) to efficiently raise or lower AC voltages. It of course cannot increase [power](http://hyperphysics.phy-astr.gsu.edu/hbase/electric/powerac.html#c1) so that if the voltage is raised, the current is proportionally lowered and vice versa.

We used the transformer of the input 220 volt and the output is 12V which is supplied to the rectifier circuit.

|  |  |
| --- | --- |
| C:\Documents and Settings\Er.Prashant Agarwal\Desktop\Transformer_files\tran.gif |  |





**5. DIODE**

A *diode* is an electrical device allowing current to move through it in one direction with far greater ease than in the other. The most common kind of diode in modern circuit design is the semiconductor diode, although other diode technologies exist. Semiconductor diodes are symbolized in schematic diagrams such as Figure [below](http://www.allaboutcircuits.com/vol_3/chpt_3/1.html#03246.png). The term “diode” is customarily reserved for small signal devices, I ≤ 1 A. The term rectifier is used for power devices, I > 1 A.

-C:\Documents and Settings\Er.Prashant Agarwal\Desktop\Introduction   DIODES AND RECTIFIERS_files\03246.png

Diode (Symbol)

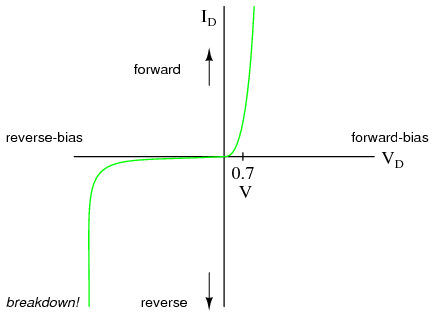
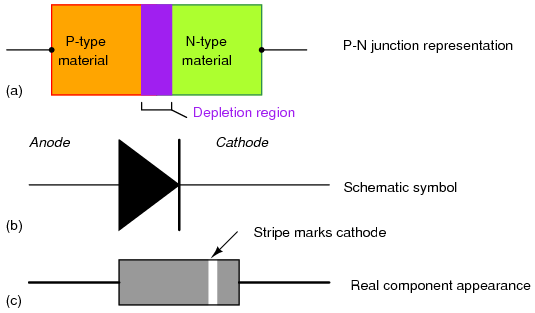
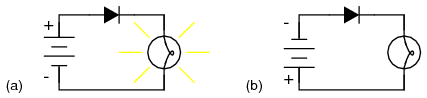
**

Fig: 10 -Semiconductor diode schematic symbol: Arrows indicate the direction of electron current flow



When placed in a simple battery-lamp circuit, the diode will either allow or prevent current through the lamp, depending on the polarity of the applied voltage.



Diode operation: (a) Current flow is permitted; the diode is forward biased. (b) Current flow is prohibited; the diode is reversed biased.

**6. Variable Resistors**

The variable resistor known as potentiometer used in this project is of 1K Ω

**Construction of Variable Resistor**

|  |
| --- |
| variable resistor track and wiper |
| variable resistor |
| Standard Variable Resistor |

Variable resistors consist of a resistance **track** with connections at both ends and a **wiper** which moves along the track as you turn the spindle. The track may be made from carbon, cermet (ceramic and metal mixture) or a coil of wire (for low resistances). The track is usually rotary but straight track versions, usually called sliders, are also available.

Variable resistors may be used as a [rheostat](http://www.kpsec.freeuk.com/components/vres.htm#rheostat) with **two** connections (the wiper and just one end of the track) or as a [potentiometer](http://www.kpsec.freeuk.com/components/vres.htm#potentiometer) with all **three** connections in use. Miniature versions called [presets](http://www.kpsec.freeuk.com/components/vres.htm#presets) are made for setting up circuits which will not require further adjustment.

Variable resistors are often called **potentiometers** in books and catalogues. They are specified by their maximum resistance, linear or logarithmic track, and their physical size. The standard spindle diameter is 6mm.

Some variable resistors are designed to be mounted directly on the circuit board, but most are for mounting through a hole drilled in the case containing the circuit with stranded wire connecting their terminals to the circuit board. 

**Potentiometer** Variable resistors used as potentiometers have all **three terminals** connected.

potentiometer symbol

This arrangement is normally used to **vary voltage**, for example to set the switching point of a circuit with a sensor, or control the volume (loudness) in an amplifier circuit. If the terminals at the ends of the track are connected across the power supply then the wiper terminal will provide a voltage which can be varied from zero up to the maximum of the supply. 

**7. Rectifier**

A rectifier is an electrical device that converts [alternating current](http://en.wikipedia.org/wiki/Alternating_current) (AC), which periodically reverses direction, to [direct current](http://en.wikipedia.org/wiki/Direct_current) (DC), which is in only one direction, a process known as rectification. Rectifiers have many uses including as components of [power supplies](http://en.wikipedia.org/wiki/Power_supply) and as [detectors](http://en.wikipedia.org/wiki/Detector_(radio)) of [radio](http://en.wikipedia.org/wiki/Radio) signals. Rectifiers may be made of [solid state](http://en.wikipedia.org/wiki/Solid_state_(electronics)) [diodes](http://en.wikipedia.org/wiki/Diode), [vacuum tube](http://en.wikipedia.org/wiki/Vacuum_tube) diodes, [mercury arc valves](http://en.wikipedia.org/wiki/Mercury_arc_valve), and other components.

A device which performs the opposite function (converting DC to AC) is known as an [inverter](http://en.wikipedia.org/wiki/Inverter_(electrical)).

When only one diode is used to rectify AC (by blocking the negative or positive portion of the [waveform](http://en.wikipedia.org/wiki/Wave)), the difference between the term diode and the term rectifier is merely one of usage, i.e., the term rectifier describes a diode that is being used to convert AC to DC. Almost all rectifiers comprise a number of diodes in a specific arrangement for more efficiently converting AC to DC than is possible with only one diode. Before the development of silicon semiconductor rectifiers, vacuum tube diodes and [copper (I) oxide](http://en.wikipedia.org/wiki/Copper(I)_oxide) or [selenium](http://en.wikipedia.org/wiki/Selenium) rectifier stacks were used.

Early radio receivers, called [crystal radios](http://en.wikipedia.org/wiki/Crystal_radio), used a "[cat's whisker](http://en.wikipedia.org/wiki/Cat%27s_whisker)" of fine wire pressing on a crystal of [galena](http://en.wikipedia.org/wiki/Galena) (lead sulfide) to serve as a point-contact rectifier or "[crystal detector](http://en.wikipedia.org/wiki/Cat%27s-whisker_detector)". Rectification may occasionally serve in roles other than to generate direct current per se. For example, in gas heating systems flame rectification is used to detect presence of flame. Two metal electrodes in the outer layer of the flame provide a current path, and rectification of an applied alternating voltage will happen in the plasma, but only while the flame is present to generate it

**Full-wave rectifier:-**

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 is more efficient. However, in a circuit with a non-[center tapped](http://en.wikipedia.org/wiki/Center_tap) [transformer](http://en.wikipedia.org/wiki/Transformer), four diodes are required instead of the one needed for half-wave rectification. (See [semiconductors](http://en.wikipedia.org/wiki/Semiconductor), [diode](http://en.wikipedia.org/wiki/Diode)). Four diodes arranged this way are called a [diode bridge](http://en.wikipedia.org/wiki/Diode_bridge) or bridge rectifier.

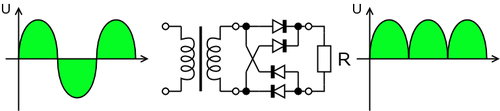
[](http://en.wikipedia.org/wiki/File:Gratz.rectifier.en.png)

Fig: 11 -Bridge rectifier: a full-wave rectifier using 4 diodes.

For single-phase AC, if the transformer is center-tapped, then two diodes back-to-back (i.e. anodes-to-anode or cathode-to-cathode) can form a full-wave rectifier. Twice as many windings are required on the transformer secondary to obtain the same output voltage compared to the bridge rectifier above.

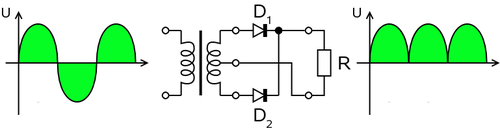
[](http://en.wikipedia.org/wiki/File:Fullwave.rectifier.en.png)

Fig: 12- Full-wave rectifier using a transformer and 2 diodes.

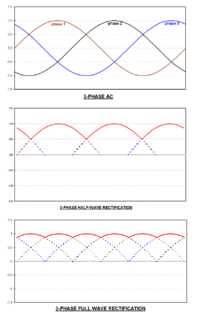
[](http://en.wikipedia.org/wiki/File:3_phase_rectification_2.png)

Fig: 13- Full-wave rectifier output waveform

The [average](http://en.wikipedia.org/wiki/Average) and [root-mean-square](http://en.wikipedia.org/wiki/Root-mean-square) output voltages of an ideal single phase full wave rectifier can be calculated as:

V_{dc}=V_{av}=\frac{2V_p}{\pi}

V_{rms}=\frac {V_p}{\sqrt 2} 

Where:

Vdc, Vav - the average or DC output voltage,

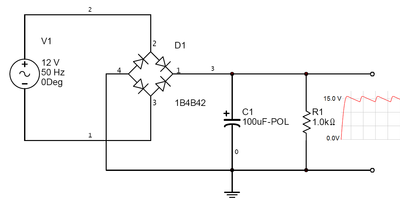
VP - the peak value of half wave,

Vrms - the root-mean-square value of output voltage.

π = ~ 3.14159

An aspect of most rectification is a loss from the peak input voltage to the peak output voltage, caused by the built-in voltage drop across the diodes (around 0.7 V for ordinary silicon p-n-junction diodes and 0.3 V for [Schottky diodes](http://en.wikipedia.org/wiki/Schottky_diode)). Half-wave rectification and full-wave rectification using two separate secondaries will have a peak voltage loss of one diode drop. Bridge rectification will have a loss of two diode drops. This may represent significant power loss in very low voltage supplies. In addition, the diodes will not conduct below this voltage, so the circuit is only passing current through for a portion of each half-cycle, causing short segments of zero voltage to appear between each "hump"

While half-wave and full-wave rectification suffice to deliver a form of DC output, neither produces constant-voltage DC. In order to produce steady DC from a rectified AC supply, a smoothing circuit or [filter](http://en.wikipedia.org/wiki/Electronic_filter) is required. In its simplest form this can be just a [reservoir capacitor](http://en.wikipedia.org/wiki/Reservoir_capacitor) or smoothing capacitor, placed at the DC output of the rectifier. There will still remain an amount of AC [ripple](http://en.wikipedia.org/wiki/Ripple_(electrical)) voltage where the voltage is not completely smoothed.

[](http://en.wikipedia.org/wiki/File:RC_Filter.png)

**RC-Filter Rectifier**

Sizing of the capacitor represents a tradeoff. For a given load, a larger capacitor will reduce ripple but will cost more and will create higher peak currents in the transformer secondary and in the supply feeding it. In extreme cases where many rectifiers are loaded onto a power distribution circuit, it may prove difficult for the power distribution authority to maintain a correctly shaped sinusoidal voltage curve.

For a given tolerable ripple the required capacitor size is proportional to the load current and inversely proportional to the supply frequency and the number of output peaks of the rectifier per input cycle. The load current and the supply frequency are generally outside the control of the designer of the rectifier system but the number of peaks per input cycle can be affected by the choice of rectifier design.

A half-wave rectifier will only give one peak per cycle and for this and other reasons is only used in very small power supplies. A full wave rectifier achieves two peaks per cycle and this is the best that can be done with single-phase input. For three-phase inputs a three-phase bridge will give six peaks per cycle and even higher numbers of peaks can be achieved by using transformer networks placed before the rectifier to convert to a higher phase order.

To further reduce this ripple, a [capacitor-input filter](http://en.wikipedia.org/wiki/Capacitor-input_filter) can be used. This complements the reservoir capacitor with a [choke](http://en.wikipedia.org/wiki/Choke_(electronics)) (inductor) and a second [filter capacitor](http://en.wikipedia.org/wiki/Filter_capacitor), so that a steadier DC output can be obtained across the terminals of the filter capacitor. The choke presents a high [impedance](http://en.wikipedia.org/wiki/Electrical_impedance) to the ripple current.[]](http://en.wikipedia.org/wiki/Rectifier#cite_note-dcp-1)

A more usual alternative to a filter, and essential if the DC load is very demanding of a smooth supply voltage, is to follow the reservoir capacitor with a [voltage regulator](http://en.wikipedia.org/wiki/Voltage_regulator). The reservoir capacitor needs to be large enough to prevent the troughs of the ripple getting below the voltage the DC is being regulated to. The regulator serves both to remove the last of the ripple and to deal with variations in supply and load characteristics. It would be possible to use a smaller reservoir capacitor (these can be large on high-current power supplies) and then apply some filtering as well as the regulator, but this is not a common strategy. The extreme of this approach is to dispense with the reservoir capacitor altogether and put the rectified waveform straight into a choke-input filter. The advantage of this circuit is that the current waveform is smoother and consequently the rectifier no longer has to deal with the current as a large current pulse, but instead the current delivery is spread over the entire cycle. The downside is that the voltage output is much lower – approximately the average of an AC half-cycle rather than the peak Multipliers.

**8. Light-emitting diode (LED**)

A LED is a [semiconductor](http://en.wikipedia.org/wiki/Semiconductor) light source. LEDs are used as indicator lamps in many devices, and are increasingly used for [lighting](http://en.wikipedia.org/wiki/Lighting). Introduced as a practical electronic component in 1962, early LEDs emitted low-intensity red light, but modern versions are available across the [visible](http://en.wikipedia.org/wiki/Visible_spectrum), [ultraviolet](http://en.wikipedia.org/wiki/Ultraviolet) and [infrared](http://en.wikipedia.org/wiki/Infrared) wavelengths, with very high brightness.

[](http://en.wikipedia.org/wiki/File:RBG-LED.jpg)

Fig: 14-LED

When a light-emitting [diode](http://en.wikipedia.org/wiki/Semiconductor_diode) is forward biased (switched on), [electrons](http://en.wikipedia.org/wiki/Electrons) are able to [recombine](http://en.wikipedia.org/wiki/Carrier_generation_and_recombination) with [electron holes](http://en.wikipedia.org/wiki/Electron_hole) within the device, releasing energy in the form of [photons](http://en.wikipedia.org/wiki/Photon). This effect is called [electroluminescence](http://en.wikipedia.org/wiki/Electroluminescence) and the [color](http://en.wikipedia.org/wiki/Color) of the light (corresponding to the energy of the photon) is determined by the [energy gap](http://en.wikipedia.org/wiki/Energy_gap) of the semiconductor. An LED is often small in area (less than 1 mm2), and integrated optical components may be used to shape its radiation pattern.

LEDs present many [advantages](http://en.wikipedia.org/wiki/Led#Advantages) over incandescent light sources including [lower energy consumption](http://en.wikipedia.org/wiki/Energy_conservation), longer [lifetime](http://en.wikipedia.org/wiki/Service_life), improved robustness, smaller size, faster switching, and greater durability and reliability. LEDs powerful enough for room lighting are relatively expensive and require more precise current and [heat management](http://en.wikipedia.org/wiki/Thermal_management_of_high-power_LEDs) than compact [fluorescent lamp](http://en.wikipedia.org/wiki/Fluorescent_lamp) sources of comparable output.

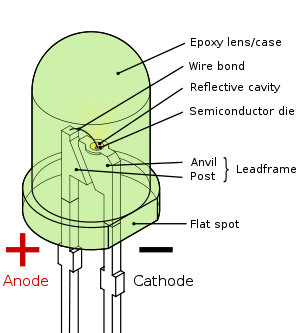
[](http://en.wikipedia.org/wiki/File:LED,_5mm,_green_(en).svg)

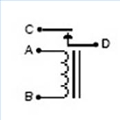
Fig: 15- LED internal parts

Light-emitting diodes are used in applications as diverse as replacements for [aviation lighting](http://en.wikipedia.org/wiki/Navigation_light#Aviation_navigation_lights), [automotive lighting](http://en.wikipedia.org/wiki/Automotive_lighting#Light_emitting_diodes_.28LED.29) (particularly brake lamps, turn signals and [indicators](http://en.wikipedia.org/wiki/LED#Indicators_and_signs)) as well as in [traffic signals](http://en.wikipedia.org/wiki/Traffic_signal). The compact size, the possibility of narrow bandwidth, switching speed, and extreme reliability of LEDs has allowed new text and video displays and sensors to be developed, while their high switching rates are also useful in advanced communications technology. [Infrared](http://en.wikipedia.org/wiki/Infrared) LEDs are also used in the [remote control](http://en.wikipedia.org/wiki/Remote_control) units of many commercial products including televisions, DVD players, and other domestic appliances

**9. Relay**

A relay is an electrically operated switch that isolates one electrical circuit from another. In its simplest form, a relay consists of a coil used as an electromagnet to open and close switches contacts. Since the two circuits are isolated, a lower voltage circuit can be used to trip a relay, which will control a separate circuit that requires a higher voltage or amperage. A 12-volt relay requires 12 volts direct current (DC) to energize the coil. Relays can be found in early telephone exchange equipment, in industrial control circuits, as a starter solenoid in [automobiles](http://www.ehow.com/cars/), on water pumps, in high-power audio amplifiers, and as protection devices.

## A Relay Is an Electromagnetic Switch



Power is applied to Points A and B to "energize" the coil.

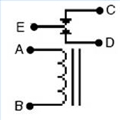
Power is applied to the coil of a relay in a specified voltage to "energize" it. Shown as Points A and B on the schematic diagram, when 12 volts DC are applied across the terminals, associated switch contacts change their state.

## Switch Contacts Can Be Normally Open or Closed

Switch contacts on a relay can be in one of two states, normally open (NO) or normally closed (NC). When the coil is at rest and not energized (no current flowing through it), the switch contacts are given the designation NO or NC. In an open circuit, no current flows, such as a wall light switch in your home in the down position when the light is off. In a closed circuit, metal switch contacts touch each other to complete a circuit, and current flows, similar to flipping up a wall light switch to the "On" position.

In the accompanying schematic diagram, Points C and D connect to the switch. When a voltage is applied across the coil at Points A and B, an electromagnetic field is created, which attracts a lever in the switch, causing it to make or break contact in the circuit at Points C and D (depending if the design is NO or NC). The switch contacts remain in this state until the voltage to the coil is removed.

## Relays Come in Different Switch Configurations



Relays come in different switch configurations. The switches may have more than one pole, or switch contact. The diagram shows a single-pole single-throw configuration, referred to as SPST. This is similar to a wall light switch in your home. With a single throw of the switch, the circuit is closed.

Other common configurations include double-pole single-throw and double-pole double-throw. Relays are especially valuable in circuits where a small voltage can control the On/Off state of a separate circuit that uses high voltage or high amperage.

For example, a furnace in a home's basement may require 220 volts to power it. A switch can be located upstairs, but does not require that a 220-volt line be run to it. A simple low voltage wire can connect the switch to a relay located downstairs on the furnace. The relay can be activated with typically a low voltage 12-volt source. The switch upstairs can turn on the relay downstairs. The relay's switch contacts will turn on or off the higher voltage 220-volt circuit.

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