GRD Journal for Engineering | Volume 2 | Issue 5 | April 2017
ISSN: 2455-5703

Design & Modeling of Automatic Phase Changer

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Abstract

Automation plays a predominant role in the modern scientific world. Automatic phase changer finds application in small offices, residences where single phase equipment's are used during phase failure, this unit automatically take the available phase lines and distribute to the non-available phase lines. The circuit is built around a transformer, micro-controller, voltage divider, & relay. Three identical sets of the circuit, one for each of three phases are used .The power supply provided to the transformers is stepped down at the level of 12volt which is rectified by the diodes and filtered by a capacitor to produce the ripple free operating voltage. Depending upon the voltage at the output of IC the relay gets energized or de-energized and with this phase can be chooses. Using Automatic phase changer we can operate all our equipment when the voltage in any of the phase fluctuates from rated voltage.
Keywords- Automatic Phase Changer (APC), Micro-Controller, Voltage Divider, Relay, IC

I. INTRODUCTION

A. Overview

In modern technology continuous supply of power is necessary for industrial, domestic and commercial purpose. If single phase load required uninterrupted power supply then automatic phase changer is helpful. The circuit provides required voltage in the same power supply lines through relays from the other phase where proper voltage is available. Using it we can operate all our equipment even when rated voltage is available on a single phase in the building. The circuit is built around a voltage divider, micro-controller, relay driver and relay. [8]

In order to provide uninterrupted power supply to the single phase loads an automatic phase changer can be used. If there, any phase is available in three phases we can supply uninterrupted power to the load by use of automatic phase changer.

An automatic phase changer continuously measures the voltage level and compare with remaining two other phase voltages. If the voltage is low from permissible value automatic phase changer changes the phase and supply is continue without any interruption. [1]

The main equipment of automatic phase changer is micro-controller which compares the voltage level and generates appropriate signals for further uses. It generates the signal for relay driver which drives the relay. [7] Relay driver receives signal from micro-controller and according to micro-controller's signal it sends the ON and OFF command to the relays which are connected to it. Electromagnetic relays are used as a switch in this circuit and outputs of these relays are shorted because only one relay operates at a time.

An automatic phase changer can be effectively used in railways, hospitals, small factories, commercial offices, bank/ATMs etc. to provide uninterrupted power supply.

II. METHODOLOGY

A. Working Principle

The available three phases are R , Y and B which has voltage of 220v each. Voltage dividers are connected from each phases. Two resistances R1 (1 K ohm) and R2 (125 K ohm) are used in voltage divider circuit. Voltage across resistance R2 is 216v and across R1 is 4v obtained. Where 216v is grounded by diode IN1004 and 4v is fed to micro-controller Atmega-16 through 104 ceramic disc capacitor 0.1 micro Faraday or 104 ceramic disc capacitor is used to provide smoothness to the AC voltage smoothed voltage form each phase is directly fed to the pin no. 1,2and 3 of micro-controller(Atmega-16).

A 12 volt dc battery is used to energize the micro-controller. The operating voltage of micro-controller is 2.3v to 5v. In order to regulate the voltage from 12v to 5v a voltage regulator C-7805 is used which regulates the voltage from 12v to 5v. This 5v supply from voltage regulator is given to micro-controller.

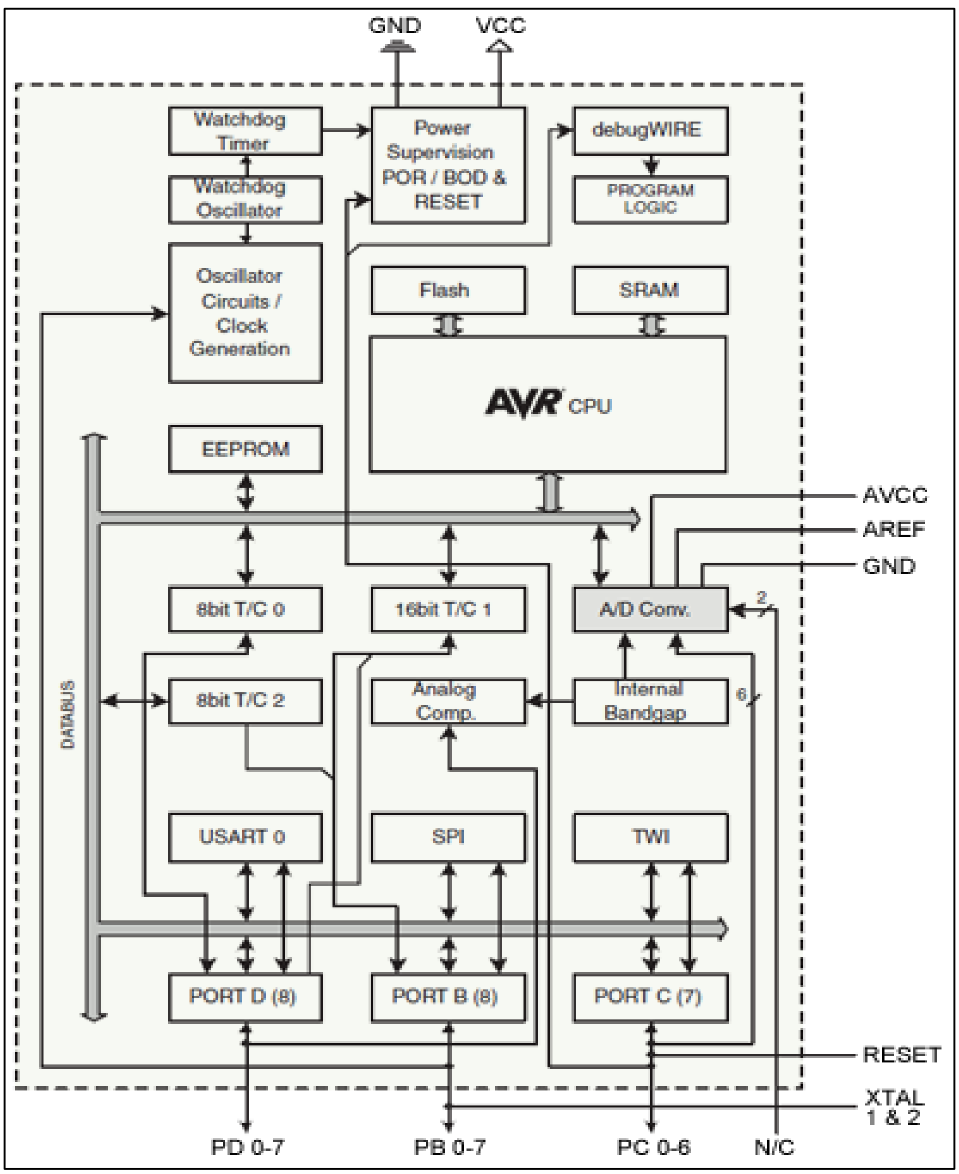
Micro-controller generates three output signals which are given to relay driver ULN2803 from micro-controller's pin no. 16, 17 and 18. ULN2803 relay driver receives those signals from its pin no. 2, 3 and 4. Pin no. 1 is used for the supply.

A 12v dc supply is also given to the electromagnetic relay to energize them. Relay driver generates output signal according to input. Three LEDs are also connected from the output of relay driver which indicates the healthy phase. At a time only one relay operates and give output signal. The output from relay is given to single phase load which is a 5watt bulb.

In this project of automatic phase changer in place of 12v dc battery we used a single phase step down transformer which is supplied from any one phase of the available three phases. A rectifier unit is also used which rectifies the ac output of transformer and convert it to dc. The 220v ac supply is then stepped down to 12v ac and after rectification we obtained 12v dc. This 12v dc supply used to energize the electromagnetic relay and after voltage regulation used to energize the micro-controller.

Let us consider a case when load is supplied from one phase if there is a voltage reduction takes place on that phase due to some unwanted reason micro-controller measures it and generate a signal for relay driver to change the phase. Micro-controller continuously compares the voltages of each phase and determines the healthy phase and generates appropriate signal for relay driver. Relay driver changes the phase by switching of electromagnetic relays. Relay driver send ON signal to the relay which is connected from healthy phase and OFF signal to other phase while one of the two relay connected to the healthy phase thus only one relay operates at a time. If there are two healthy phases and one unhealthy phase is available then micro-controller sets the priority for the operation of relay. Switching of relay is based on priority level of micro-controller. If three out of three phases are healthy then highest priority relay operated first and so on.

B. Block Diagram



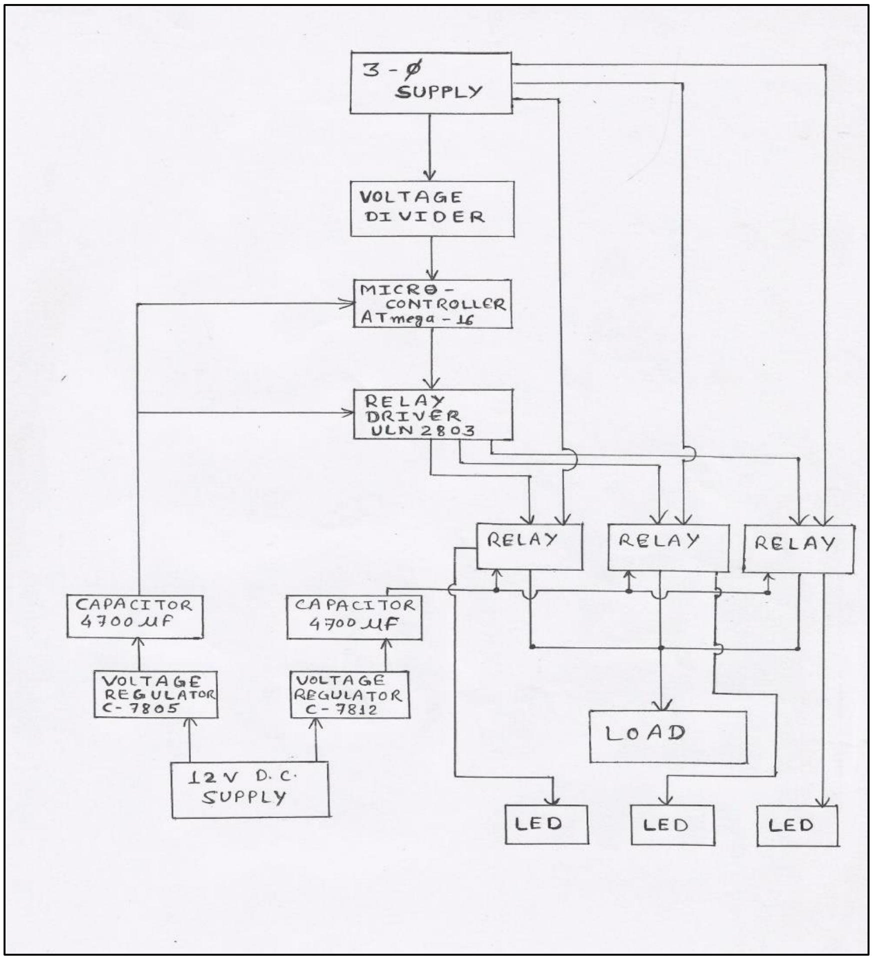


Fig. 1: Block Diagram of Automatic Phase Changer

C. AVR Architecture

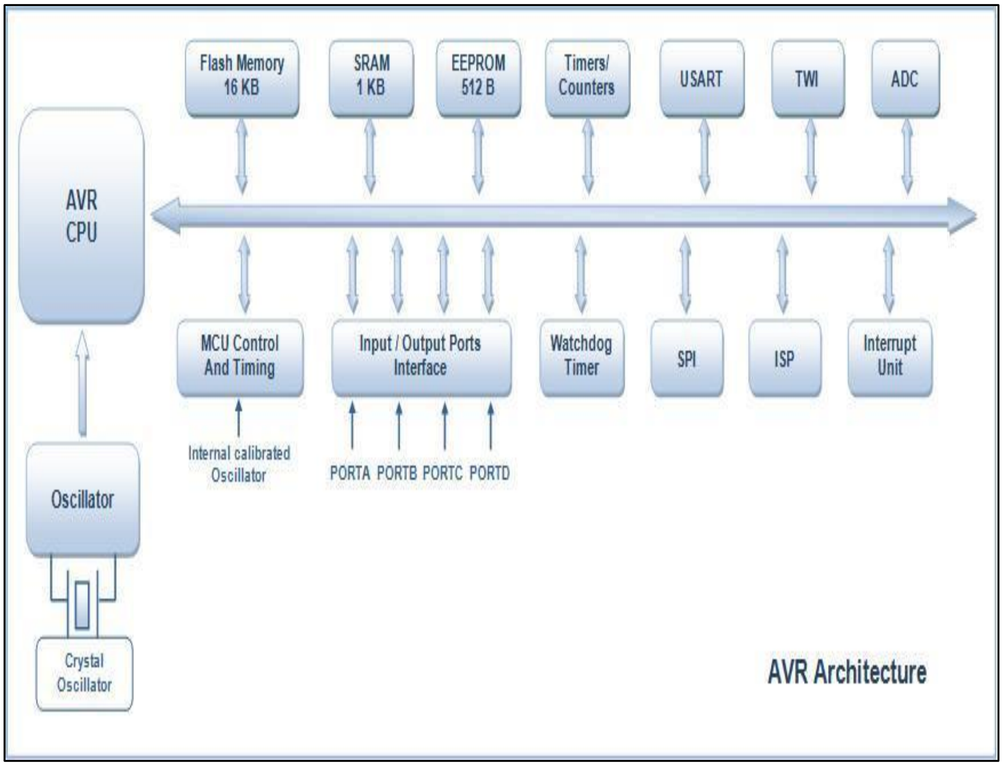


Fig. 2: AVR Architecture of Micro-Controller Atmega-16

III. PERIPHERALS OF MODEL

A. Micro-Controller

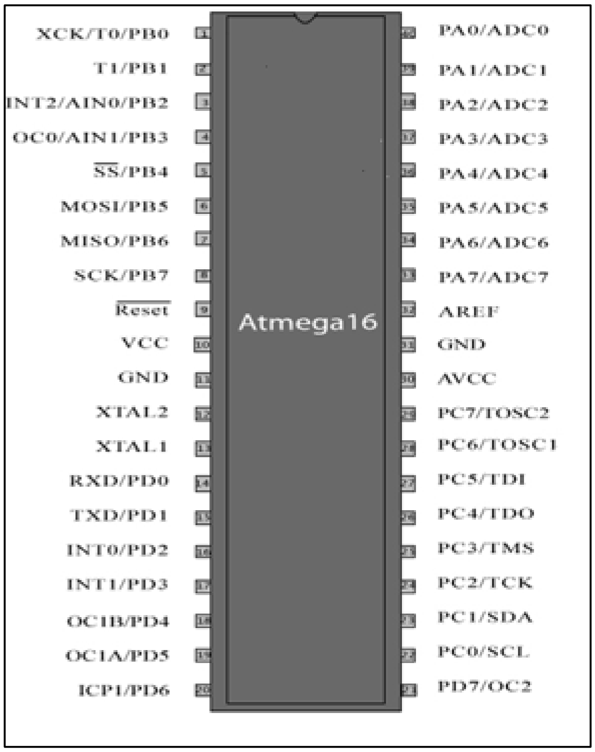


Fig. 3: Pin Diagram of Micro-Controller Atmega-16

1) Pins used

1) Pin number 1, 2&3 are used as input.
2) Pin number 16,17&18 are used as output
3) Pin number 31 is used as ground.
4) Pin number 10 takes +5V dc supply to activate micro - controller.[2]

B. Relay Driver

A ULN2803 is an Integrated Circuit (IC) chip. It allows you to interface TTL signals with higher voltage/current loads. In general the chip takes low level signals (TLL, CMOS, PMOS, NMOS - which operate at low voltages and low currents) and acts as a relay of sorts itself, switching ON or OFF a higher level signal on the opposite side.[3]

A TTL signal operates from 0-5V, with everything between 0.0 and 0.8V considered "low" or OFF, and 2.2 to 5.0V being considered "high" or ON. The maximum power available on a TTL signal depends on the type, but generally does not exceed 25mW (~5mA @ 5V), so it is not useful for providing power to something like a relay coil. Computers and other electronic devices frequently generate TTL signals.[3]On the output side the ULN2803 is generally rated at 50V/500mA, so it can operate small loads directly.

Alternatively, it is frequently used to power the coil of one or more relays, which in turn allow even higher voltages/currents to be controlled by the low level signal. In electrical terms, the ULN2803 uses the low level (TTL) signal to switch ON/turn OFF the higher voltage/current signal on the output side.

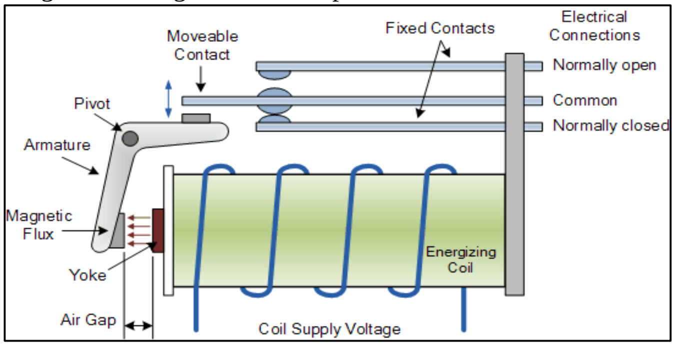


Fig. 4: Construction of Electromagnetic Relay

Normally Closed or Make and Break Contacts refer to the state of the electrical contacts when the relay coil is "de-energized", i.e. no supply voltage connected to the inductive coil. An example of this arrangement is given below.

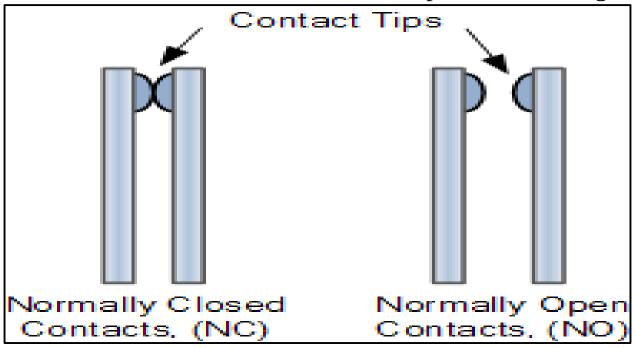


Fig. 5: Closing and Opening of Relay Contacts

C. Voltage Regulator

A voltage regulator is designed to automatically maintain a constant voltage level. A voltage regulator may be a simple "feed-forward" design or may include negative feedback control loops. It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages. [1]

Electronic voltage regulators are found in devices such as computer power supplies where they stabilize the DC voltages used by the processor and other elements. In automobile alternators and central power station generator plants, voltage regulators control the output of the plant. In an electric power distribution system, voltage regulators may be installed at a substation or along distribution lines so that all customers receive steady voltage independent of how much power is drawn from the line. [4]

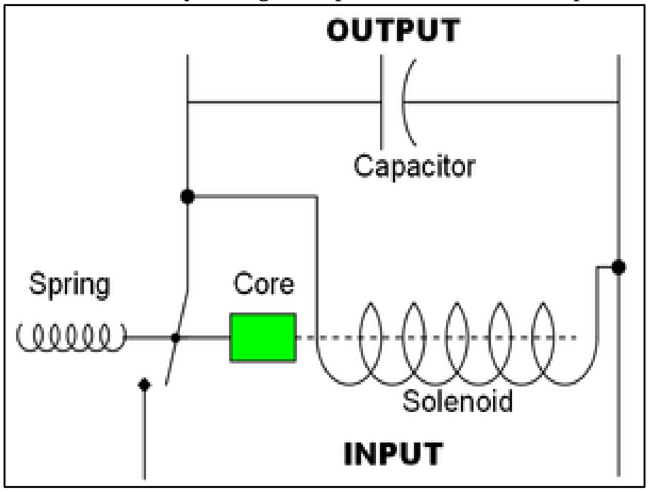


Fig. 6: Voltage Regulator

Circuit design for a simple electromechanical voltage regulator

Fig. 7: Voltage Stabilizing Unit

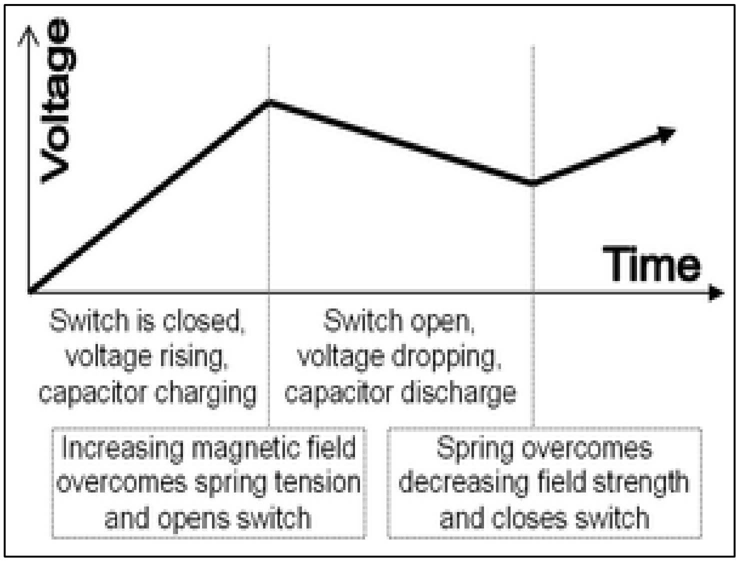


Fig. 8: Graph of Voltage Output on a Time Scale

D. Capacitor

Just like the Resistor, the Capacitor, sometimes referred to as a Condenser, is a simple passive device. The capacitor is a component which has the ability or "capacity" to store energy in the form of an electrical charge producing a potential difference (Static Voltage) across its plates, much like a small rechargeable battery. In its basic form, a capacitor consists of two or more parallel conductive (metal) plates which are not connected or touching each other, but are electrically separated either by air or by some form of insulating material such as paper, mica, ceramic or plastic and which is commonly called the capacitors Dielectric.[6]

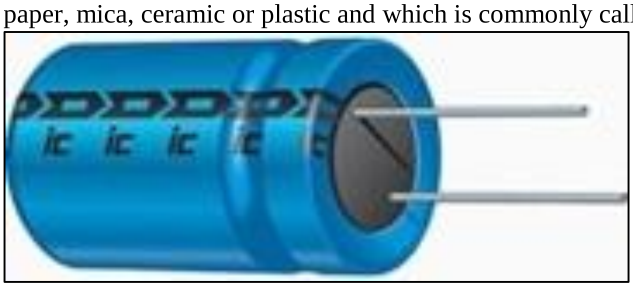


Fig. 9: Capacitor

By applying a voltage to a capacitor and measuring the charge on the plates, the ratio of the charge Q to the voltage V will give the capacitance value of the capacitor and is therefore given as: $C = Q/V$ this equation can also be re-arranged to give the more familiar formula for the quantity of charge on the plates as: $Q = C \times V$[5]

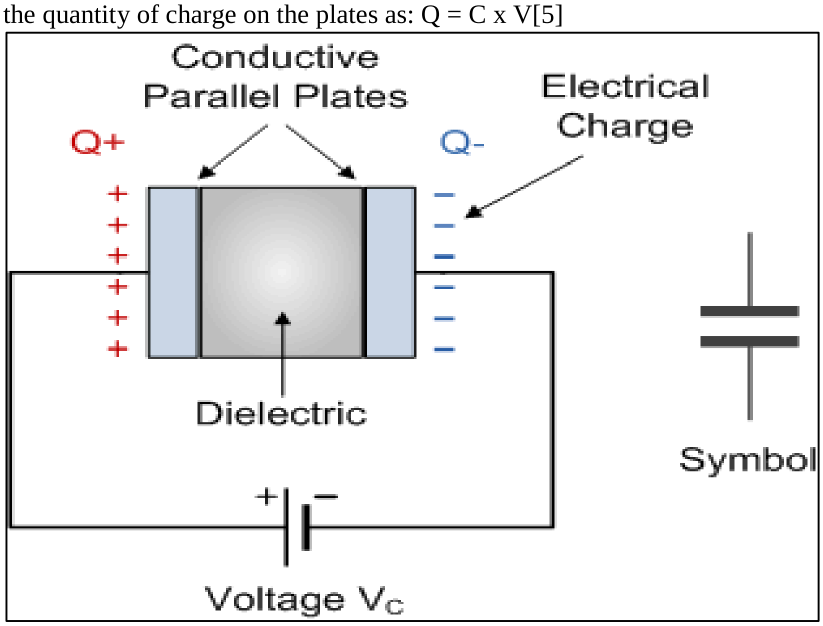


Fig. 10: Construction of Capacitor

E. Transformer

A transformer is a static electrical device that transfers energy by inductive coupling between its winding circuits. 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. [8]

Transformers range in size from thumbnail-sized units hidden inside microphones to units weighing hundreds of tons interconnecting the power grid. A wide range of transformer designs are used in electronic and electric power applications. Transformers are essential for the transmission, distribution, and utilization of electrical energy. [7]

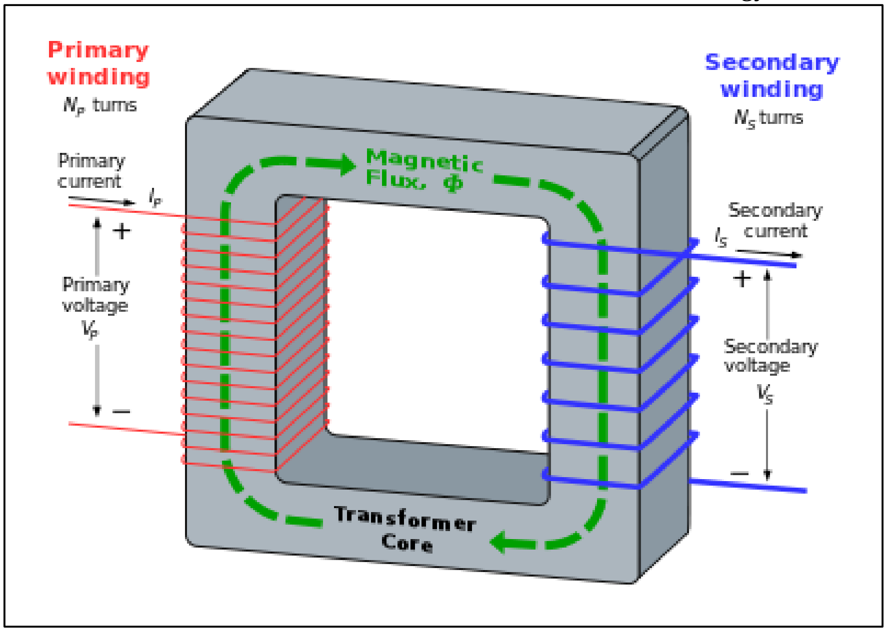


Fig. 11: Transformer

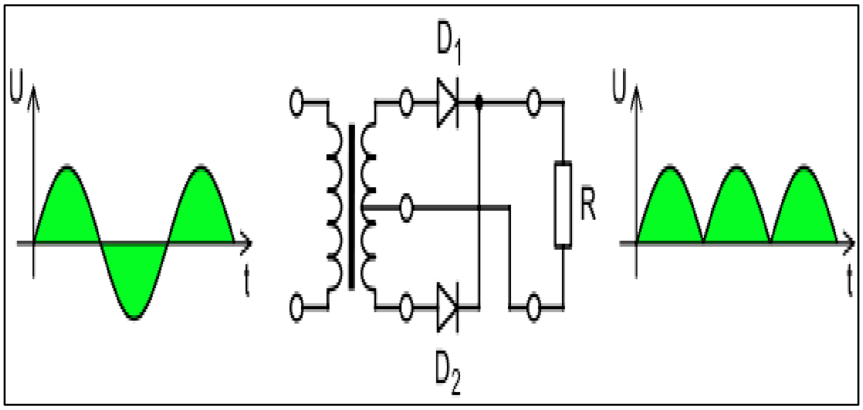


Fig. 12: Centre Tap Transformer

F. Voltage Divider

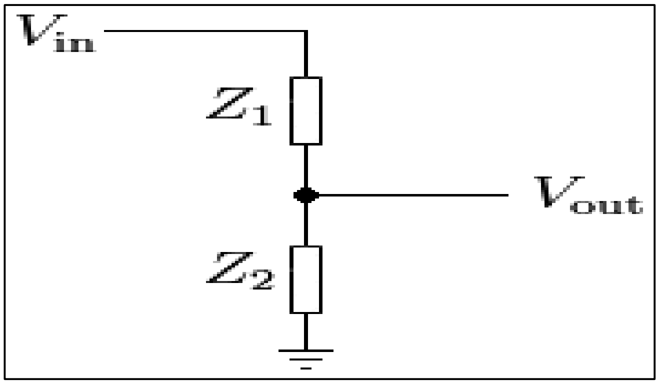


Fig. 13: Equivalent Circuit of Voltage Divider

In electronics or EET, a voltage divider (also known as a potential divider) is a linear circuit that produces an output voltage (Vout) that is a fraction of its input voltage (Vin). Voltage division refers to the partitioning of a voltage among the components of the divider.

1) Resistive Divider

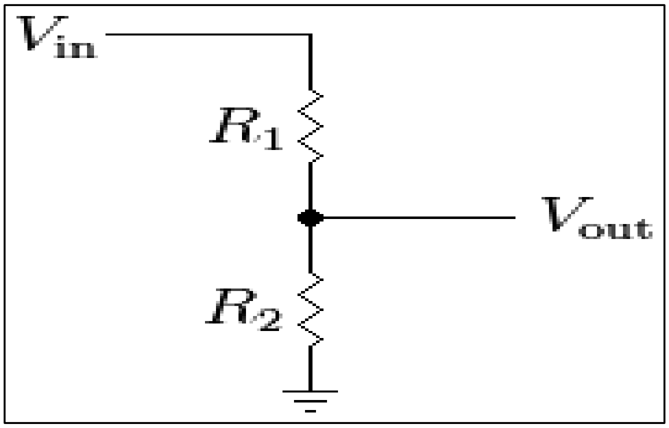


Fig. 14: Simple Resistive Voltage Divider

A resistive divider is the case where both impedances, Z_1 and Z_2, are purely resistive. Substituting $Z_1 = R_1$ and $Z_2 = R_2$ into the previous expression gives:

$$V_{out} = \frac{R_2}{R_1 + R_2} \cdot V_{in}$$

If $R_1 = R_2$ then

$$V_{out} = \frac{1}{2} \cdot V_{in}$$

If V_{out}=6V and V_{in}=9V (both commonly used voltages), then:

$$\frac{V_{out}}{V_{in}} = \frac{R_2}{R_1 + R_2} = \frac{6}{9} = \frac{2}{3}$$

and by solving using algebra, R_2 must be twice the value of R_1.

G. Diode

The effect described in the previous tutorial is achieved without any external voltage being applied to the actual PN junction resulting in the junction being in a state of equilibrium. However, if we were to make electrical connections at the ends of both the N-type and the P-type materials and then connect them to a battery source, an additional energy source now exists to overcome the barrier resulting in free charges being able to cross the depletion region from one side to the other. The behavior of the PN junction with regards to the potential barrier width produces an asymmetrical conducting two terminal device, better known as the Junction Diode. [8]

A diode is one of the simplest semiconductor devices, which has the characteristic of passing current in one direction only. However, unlike a resistor, a diode does not behave linearly with respect to the applied voltage as the diode has an exponential I-V relationship and therefore we cannot described its operation by simply using an equation such as Ohm's law.

If a suitable positive voltage (forward bias) is applied between the two ends of the PN junction, it can supply free electrons and holes with the extra energy they require to cross the junction as the width of the depletion layer around the PN junction is decreased. By applying a negative voltage (reverse bias) results in the free charges being pulled away from the junction resulting in the depletion layer width being increased. This has the effect of increasing or decreasing the effective resistance of the junction itself allowing or blocking current flow through the diode. [7]

Then the depletion layer widens with an increase in the application of a reverse voltage and narrows with an increase in the application of a forward voltage. This is due to the differences in the electrical properties on the two sides of the PN junction resulting in physical changes taking place. One of the results produces rectification as seen in the PN junction diodes static I-V (current-voltage) characteristics. [8]Rectification is shown by an asymmetrical current flow when the polarity of bias voltage is altered as shown below.

1) Junction Diode Symbol and Static I-V Characteristics

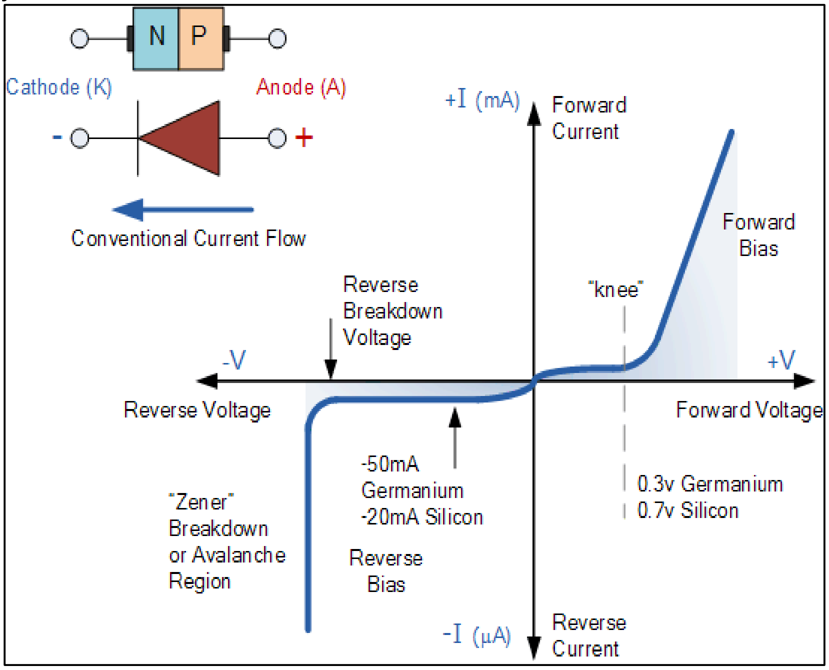


Fig. 15: Symbol and V-I Characteristics of Diode

But before we can use the PN junction as a practical device or as a rectifying device we need to firstly bias the junction, i.e. connect a voltage potential across it. On the voltage axis above, "Reverse Bias" refers to an external voltage potential which increases the potential barrier. [8]An external voltage which decreases the potential barrier is said to act in the "Forward Bias" direction. There are two operating regions and three possible "biasing" conditions for the standard Junction Diode and these are:

1) Zero Bias - No external voltage potential is applied to the PN-junction.
2) Reverse Bias - The voltage potential is connected negative, (-ve) to the P-type material and positive, (+ve) to the N-type material across the diode which has the effect of Increasing the PN-junction width.
3) Forward Bias - The voltage potential is connected positive, (+ve) to the P-type material and negative, (-ve) to the N-type material across the diode which has the effect of Decreasing the PN-junction width

H. Resistor

A resistor is a two-terminal electronic component designed to oppose an electric current by producing a voltage drop between its terminals in proportion to the current, that is, in accordance with Ohm's law:

$$V = IR$$

Resistors are used as part of electrical networks and electronic circuits. They are extremely commonplace in most electronic equipment. Practical resistors can be made of various compounds and films, as well as resistance wire (wire made of a high-resistivity alloy, such as nickel/chrome). [1]

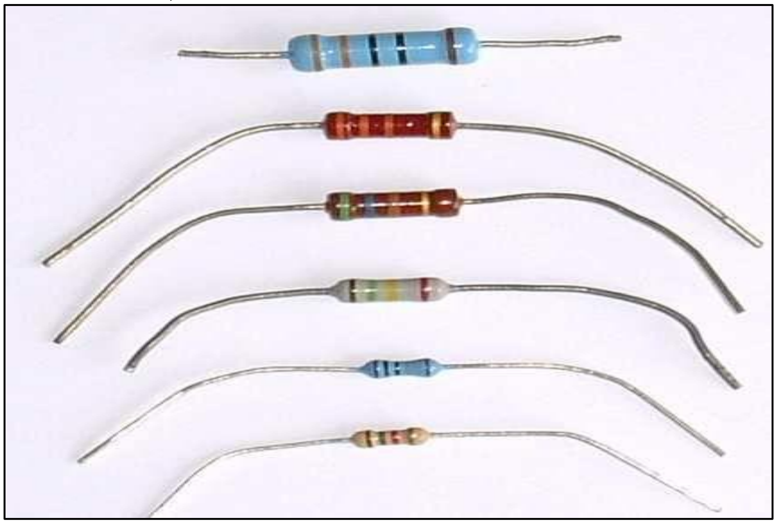


Fig. 16: Resistors

A resistor is a two-terminal passive electronic component which implements electrical resistance as a circuit element. When a voltage V is applied across the terminals of a resistor, a current I will flow through the resistor in direct proportion to that voltage. The reciprocal of the constant of proportionality is known as the resistance R, since, with a given voltage V, a larger value of R further "resists" the flow of current I as given by Ohm's law:

$$I = \frac{V}{R}$$

I. Led

LEDs are semiconductor devices. Like transistors, and other diodes, LEDs are made out of silicon. What makes an LED give off light are the small amounts of chemical impurities that are added to the silicon, such as gallium, arsenide, indium, and nitride. When current passes through the LED, it emits photons as a byproduct. Normal light bulbs produce light by heating a metal filament until its white hot. Because LEDs produce photons directly and not via heat, they are far more efficient than incandescent bulbs. Not long ago LEDs were only bright enough to be used as indicators on dashboards or electronic equipment. But recent advances have made LEDs bright enough to rival traditional lighting technologies. Modern LEDs can replace incandescent bulbs in almost any application.

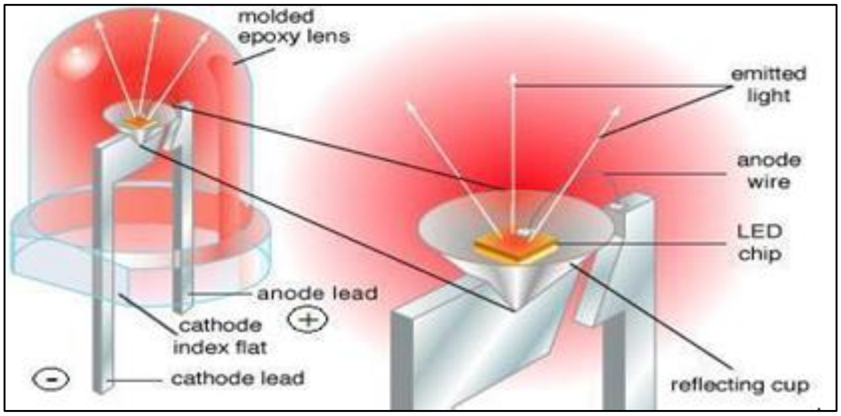


Fig. 17: LED

LEDs are based on the semiconductor diode. When the diode is forward biased (switched on), electrons are able to recombine with holes and energy is released in the form of light. This effect is called electroluminescence and the color of the light is determined by the energy gap of the semiconductor. The LED is usually small in area (less than 1 mm2) with integrated optical components to shape its radiation pattern and assist in reflection.

IV. APPLICATION

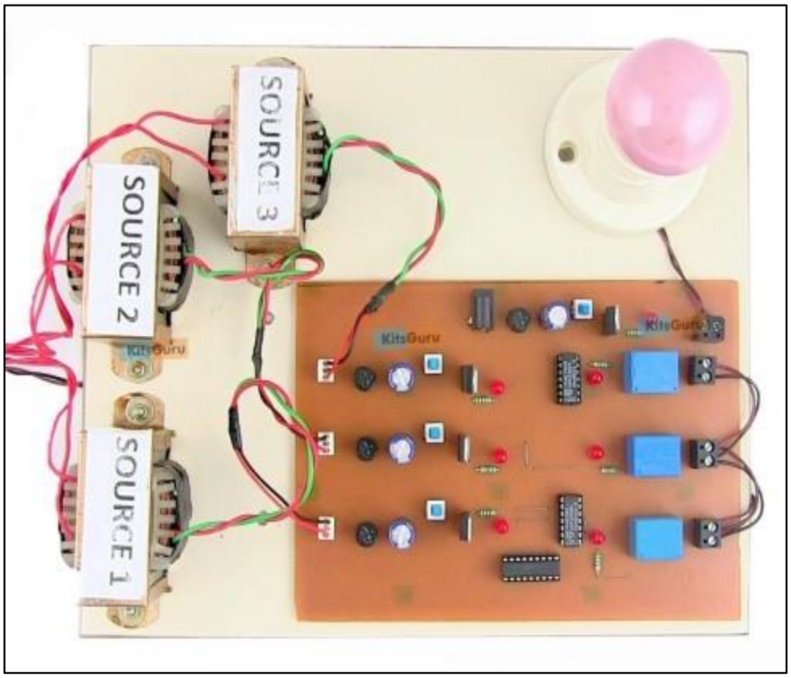
1) In railways: - In railways, the automatic phase changer is applicable to provide un-interrupted power to railway signals which provide information about the railway line whether they are busy or not.
2) In industries: - In industries the single phase machines required continuous power supply, so automatic phase changer is applicable here.
3) In hospitals use: - In hospitals for various proposes like test, operations etc. The automatic phase changer is required to provide continuous power supply.
4) In domestic purpose: - Many single phase equipment’s are used in domestic purpose so to provide continuous supply to these equipment automatic phase changer is used.
5) In bank/ATMs:-For the security of banks and ATM’s the automatic phase changer is very helpful because it provides un-interrupted power supply.

V. CONCLUSION

In order to provide un-interrupted power supply to the load. This project provide superior result. For better system performance it is important to provide continuous power at low cost. Automatic phase changer effectively and efficiently provide continuous power supply as per the requirement. An automatic phase changer continuously measure the voltage level and compare with remaining two other phase voltages. If the voltage is different from appropriate value automatic phase changer changes the phase and supply is continue without interruption. It enhance the reliability of system and improved technology from the previous one which consist three transformers. It also reduce PCB size and bulky circuit as a result in reduction in cost. It is very reliable so it can easily use in any place and cost is also less so it is applicable in number of applications.

VI. RESULT

A. Hardware Model



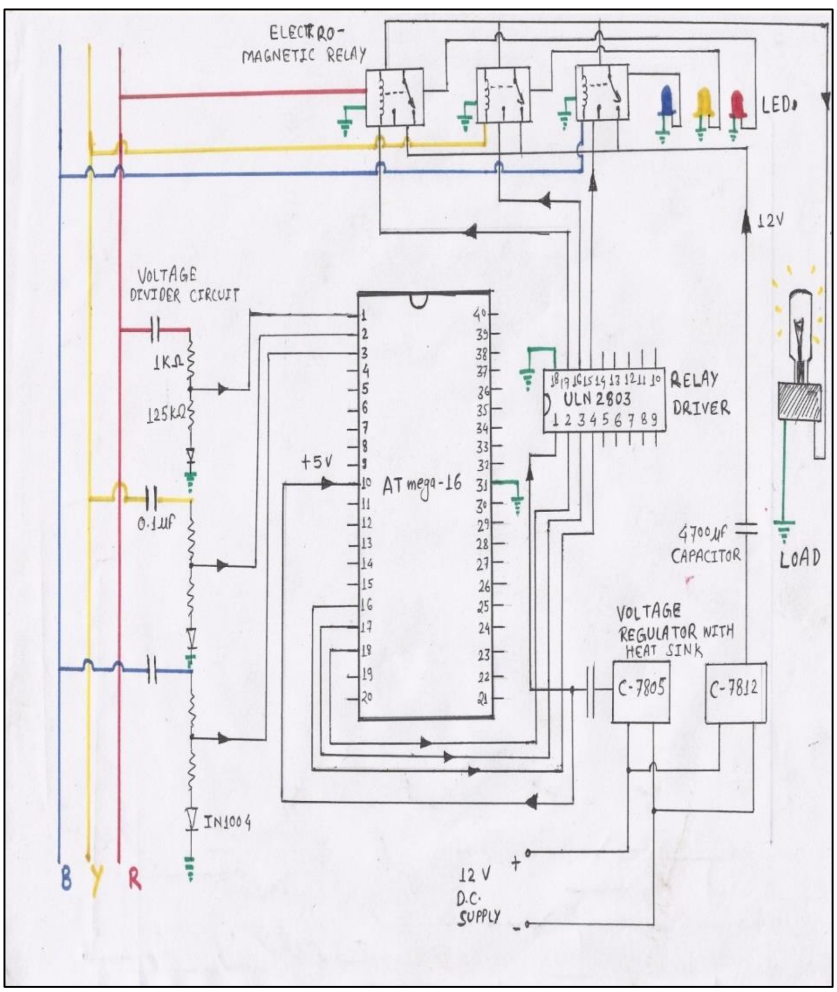


Fig. 18: Model Circuit structure

REFERENCES

[1] Sharad Chandra Rajpoot, Prashant Singh Rajpoot and Durga Sharma," Power system Stability Improvement using Fact Devices",International Journal of Science Engineering and Technology research ISSN 2319-8885 Vol.03, Issue. 11, June-2014, Pages: 2374-2379.
[2] Sharad Chandra Rajpoot, Prashant singh Rajpoot and Durga Sharma,"Summarization of Loss Minimization Using FACTS in Deregulated Power System", International Journal of Science Engineering and Technology research ISSN 2319-8885 Vol.03, Issue.05,April & May-2014,Pages:0774-0778.
[3] Sharad Chandra Rajpoot, Prashant Singh Rajpoot and Durga Sharma, "Voltage Sag Mitigation in Distribution Line using DSTATCOM" International Journal of ScienceEngineering and Technology research ISSN 2319-8885 Vol.03, Issue.11, April June-2014, Pages: 2351-2354.
[4] Prashant Singh Rajpoot, Sharad Chandra Rajpoot and Durga Sharma, "Review and utility of FACTS controller for traction system", International Journal of Science Engineering and Technology research ISSN 2319-8885 Vol.03, Issue.08, May-2014, Pages: 1343-1348.
[5] Sharad Chandra Rajpoot, Prashant Singh Rajpoot and Durga Sharma, "A typical PLC Application in Automation", International Journal of Engineering research and TechnologyISSN 2278-0181 Vol.03, Issue.6, June-2014.
[6] Iba K. (1994) 'Reactive power optimization by genetic algorithms', IEEE Trans on power systems, May, Vol.9, No.2, pp.685-692.
[7] Sharad Chandra Rajpoot, Prashant Singh Rajpoot and Durga Sharma,"21st century modern technology of reliable billing system by using smart card based energy meter",International Journal of Science Engineering and Technology research,ISSN 2319-8885 Vol.03,Issue.05,April & May-2014,Pages:0840-0844.
[8] Prashant singh Rajpoot , Sharad Chandra Rajpoot and Durga Sharma,"wireless power transfer due to strongly coupled magnetic resonance", international Journal of Science Engineering and Technology research ISSN 2319-8885 Vol.03,.05,April & May-2014,Pages:0764-0768.