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Electronic phase selector switch

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Abstract: The power failure slows down the production of industry, construction work of new plants and buildings. It can overcome by using a backup power supply such as a generator. But it is a cost effective and also time consuming, as certain time is required to switch on the generator manually. The power interruption in distribution system is about 70% for single phase faults while other two phases are in normal condition. In any commercial power supply system, if three phases are available, then automatic phase selection can be done in to critical loads in the event of power failure in any phase. There is no need of backup power supply and the phase is changed automatically within a few seconds. The aim of this paper is the real idea of an automatic phase changing switch for 220V -240V alternating current. The designs available are single phase change over switches, two phase automatic transfer switch and three phase automatic change over switch which are manually operated. The present paper informs about an automatic phase selection using electronic circuit which is designed only for, three phase A.C. input power to single phase A.C. output applications.

Keywords: Automatic, Phase selector, Power failure.

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1. Introduction: The concept of the paper is to provide uninterrupted power supply to the single phase load. The out of the 3 phases any one phase is having fault, then the supply will be automatically shifted to the next phase from the available three phase supply. It is frequently perceived that power interruption in distribution system is about 70% for single phase faults while other two phases are in normal condition. Thus in any commercial or domestic power supply system where 3 phase is available, it is advisable to have an automatic changeover system for uninterrupted power to critical loads in the event of missing phase.

1.1 Fault: In an electric power system, a fault or a fault current is any abnormal electric current. Considering the example, a short circuit is a fault in which current bypasses the normal load. An open circuit fault occurs if a circuit is interrupted by some failure. In 3 phase system, a fault may involve one or more phases and ground, or may occur only between phases. In a “ground fault”, current flows into the earth. In power systems, protective devices can detect fault conditions and operate circuit breakers and other devices to limit the loss of service due to a failure.

1.2 Three Phase System: The electrical power used in India is normally generated and distributed in the form of three phase ac supply. A three-phase system is usually more economical compared to single phase system. The same rating three phase machines are smaller, simpler in construction and have better operating characteristics than single phase machines. Voltage regulation of a three phase system is better than that of single phase System. A three phase system can be used to supply domestic as well as industrial or commercial power.

In a symmetric three-phase power supply system, three conductors each carry an alternating current of the same frequency and voltage amplitude relative to a common reference but with a phase difference of 120^0. The common reference is usually connected to ground and often to a current-carrying conductor called the neutral. Due to the phase difference, the voltage on any conductor reaches its peak at one third of a cycle after one of the other conductors and one third of a cycle before the remaining conductor. This phase delay gives constant power transfer to a balanced linear load.

In a three-phase system (Figure 1.1) the current in each conductor is equal in magnitude to the sum of the currents in the other two, but with the opposite sign. The return path for the current in any phase conductor is the other two phase conductors.

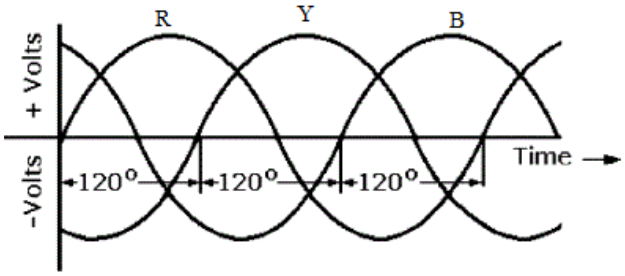

Figure (1.1): Three Phase System Waveform [8].

1.3 Need of Phase Selector: It is frequently observed that power interruption in distribution system is about 70% for single phase faults while other two phases are in normal condition. Thus in any commercial or domestic power supply system where three phase is available, it is likely to have an automatic changeover system for uninterrupted power to critical loads in the event of missing phase.

1.4 Advantages of Electronic Phase Selector Switch:

1. The time required for switching between the phases has been drastically reduced.
2. More automatic operation with the elimination of selector switch.
3. Reduced circuit size and easier implementation with the use of relay.
4. The problem of unwanted rotation of gear motor does not arise.
5. The problem of sparkling between the selector switch and phase connection does not arise.

2. Literature Survey:

In 2000 the system developed by Steven .M Hietpas "Automatic Voltage Regulator " using ac voltage – voltage convertor which load great flexibility in the voltage regulation for power distribution systems but had high complexity [1]. In 2003 March, Gua-Kiang Hung and Chih- chang Chang developed the system named as Automatic Phase Shift Method for finding Detection of Grid connected Photo Voltaic Inverter used photo-voltaic inverter but the statistical analysis were complicated to achieve in single detection [2]. The system named as "Grid Current Regulation of Three Phase Voltage Source Inverter with LC Input Filter" in 2003 May used simple series inductor as the filter interface between VSI and Grid network. But due to harmonic distortion it does not proved to be more advantageous [3]. In April 2004 the system was proposed by Mariuz Malinowkshi named as "Simple Direct Power Control of Three Phase PWM Rectifier using Space Vector Modulation (DPC-SVM). But due to variable switching frequency and violation in polarity there was a need to design such a system which would overcome all of above system drawbacks [4]. In 2012 Mbaocha Christian paper "Smart Phase Change-Over System with a AT89C52 Microcontroller" which led to the discovery of three-phase smart switching system which makes the selection process a lot stress free, efficient and cost effective. But in this only simulation results were shown [5]. Ezeofor J. C. and Okafor E. C. in 2014 published a paper "Design and Simulation of Microcontroller Based Electronic Calendar" using Multisim circuit design software. The paper says about the simulation results but not the hardware model [6]. In 2015 Adedokun J. A, Oladosu, K. A.

Adegboye, written about microcontroller based single phase power selector [7] which is cost effective and complex in nature. In this paper AND & NOT logic is used with other necessary circuit to design the model.

3. Proposed Work: In this section a brief overview of Electronic Phase Selector with block diagram, and its components description and priority selections are discussed.

3.1. Methodology of Proposed work

1. Three phase supply is stepped down to 12V by 3 single phase transformers connected to each phase.
2. 12V is passed through a bridge rectifier with IC LM7805 which converts AC voltage into DC voltage of 5 to operate relay, logic gates and transistors.
3. The three phases are connected to the 'NO' terminal of the respective relay and each relay output connection are tapped and given to the 1-phase load.
4. Under normal working condition the 'R' phase supplies the single phase load and the relays of the other phases remain normally open.
5. When fault occurs in 'R' phase, the NOT gate sends a low signal to the relay connected to the next healthy phase becomes normally closed and the supply to the single phase load remains unaffected.

3.2 Block Diagram:

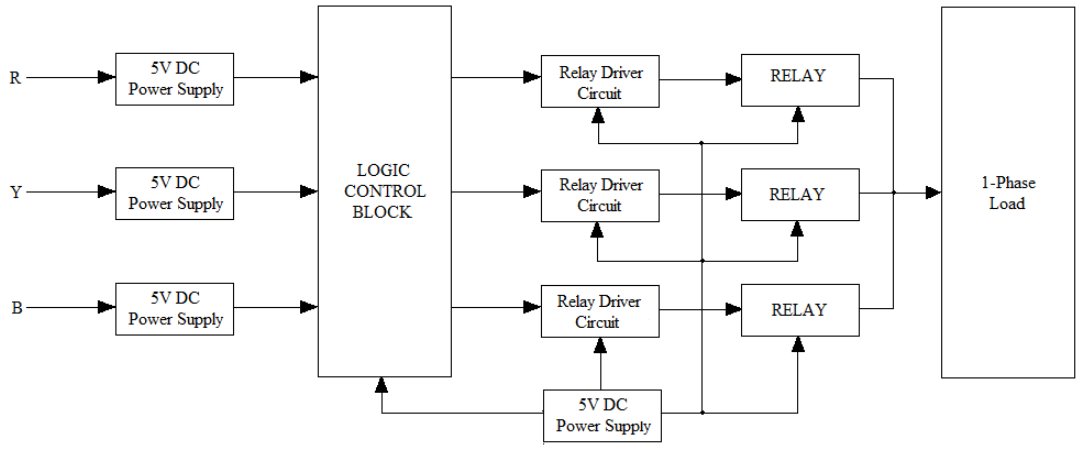

Figure (1.2): Block Diagram of Electronic Phase Selector Switch.

Circuit Diagram of Electronic Phase Selector with component description

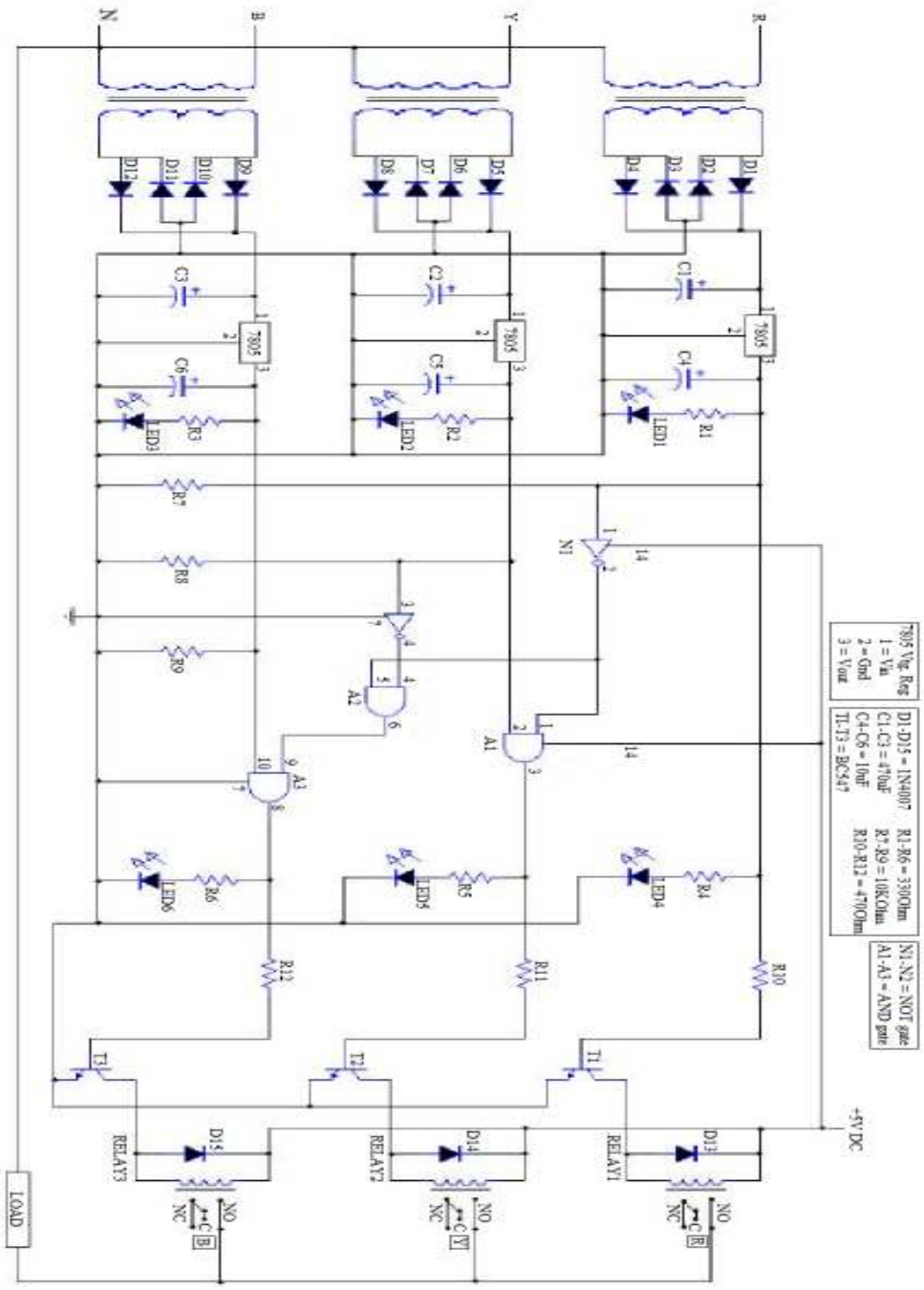

Figure (1.3): Circuit Diagram of Automatic Phase Selector.

3.3 Component Description:

Power Supply Unit: 230V AC, 50Hz supply for each phase (i.e. R, Y and B)

5V DC Power Supply: A bridge rectifier with IC LM7805 which converts AC voltage into DC voltage of 5V.

Logic Control Block: It consists of NOT and AND logic gates. It decides the phase priority for one out of three lines.

Relay Driver Circuit: It consists of resistor, transistor and diode. Resistor is used to limit the high current from the output of logic gate signal to operate the relay through transistor. The diode acts as a freewheeling diode which stops the reverse current flowing to the logic control circuit through transistor as reverse current damages the logic gate circuit.

Relay: A relay is an electrically operated switch which works at 5V DC to operate 230V AC. The DC current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and have double throw (change-over) switch contacts.

Load: Here any kind of 1-phase load can be used.

3.4 Working of logic control circuit

3.4.1 Logic Control Circuit:

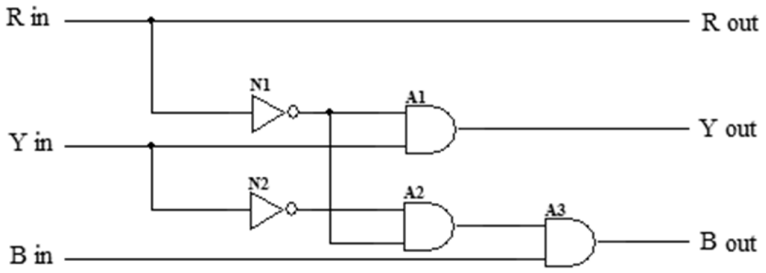

Figure (1.4): Logic Control Circuit

In Figure (1.4), R in, Y in and B in are inputs to the logic control circuit. R out, Y out and B out are output from the logic control circuit. N1-N2 are logic NOT gates and A1-A3 are logic AND gates. The logic control circuitry decides the phase priority for one out of three lines. The order of phase priority is R-phase followed by Y-phase, B-phase as shown in the truth table.

3.4.2 Truth Table:

Table (1.1): Truth Table of Electronic Phase Selector.

INPUT			OUTPUT		
R	Y	B	R	Y	B
0	0	0	0	0	0
0	0	1	0	0	1
0	1	0	0	1	0
0	1	1	0	1	0
1	0	0	1	0	0
1	0	1	1	0	0
1	1	0	1	0	0
1	1	1	1	0	0

3.4.3 Priority Selection of Active Phase

Table (1.2): Priority Selection of the Active Phase.

R	Y	B	SELECTION OF ACTIVE PHASE
0	0	1	B phase is selected
0	1	0	Y phase is selected
0	1	1	Priority phase selection case 4

1	0	0	R phase is selected
1	0	1	Priority phase selection case 3
1	1	0	Priority phase selection case 2
1	1	1	Priority phase selection case 1

3.4.4 Priority Phase Selection of Case 1

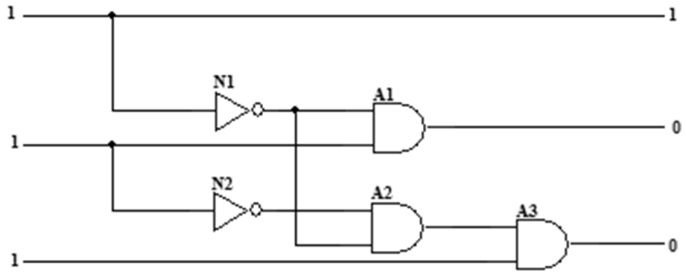

Figure (1.5): Priority Phase Selection Case 1.

When all phases are present input to all phases are HIGH, hence output of R phase is HIGH i.e. 1. Input to N1 NOT gate is HIGH hence output of N1 NOT gate is LOW i.e. 0 which is fed to A1 AND gate therefore output of A1 AND gate is LOW i.e. 0. As inputs of N1 NOT gate and N2 NOT gate are their respective outputs are LOW i.e. 0 which is given as input to A2 AND gate. Output of A2 AND gate is LOW which is fed to A3 AND gate hence output of A3 AND gate is LOW i.e. 0. Hence the active phase is **R PHASE** (Figure 1.5).

3.5.5 Priority Phase Selection of Case 2

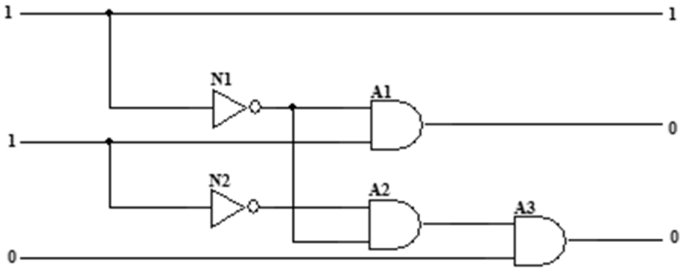

Figure (1.6): Priority Phase Selection Case 2.

When the fault occurs in B phase, the input to A3 AND gate is LOW i.e. 0, so the output from A3 AND gate is LOW i.e. 0. The other two phases are available, so the input to other phases is HIGH. The output of the N1 NOT gate is LOW i.e. 0 it is fed to A1 AND gate so the output from A1 AND gate is also LOW i.e. 0. Overall output from A1 and A3 AND gate is LOW. Hence the active phase is R PHASE (Figure 1.6).

3.5.6 Priority Phase Selection of Case 3

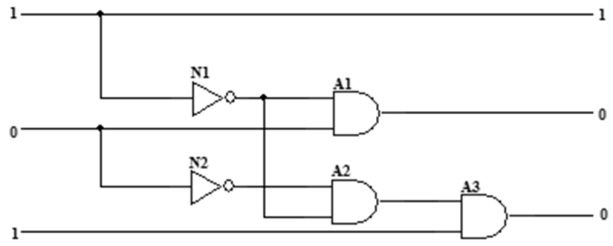

Figure (1.7): Priority Phase Selection Case 3.

When the fault occurs in Y-phase the output is LOW i.e. 0. The other two phases are available, so the input to other phases is HIGH. The output of N1 NOT gate is LOW i.e. 0. Thus we get LOW output i.e. 0 from the A1 AND gate. Output of N2 NOT gate is HIGH which is fed to the A2 AND gate. The other input to A2 gate is from N1 and thus we obtain LOW output from A2 gate which is again fed to A3 AND gate. Output from A3 AND gate is LOW. Hence the active Phase is R PHASE (Figure 1.7).

3.5.7 Priority Phase Selection of Case 4

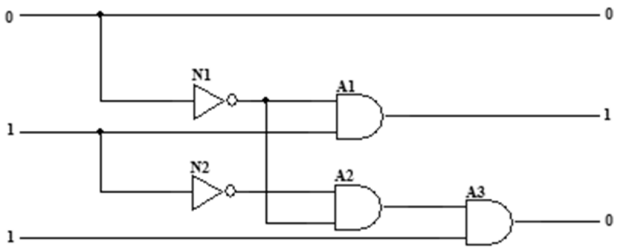

Figure (1.8): Priority Phase Selection Case 4.

When fault occurs only in R-phase, the output from it is LOW i.e. 0. Thus the output of N1 NOT gate is 1. Hence we get HIGH output from the AND gate A1. Output of N2 NOT gate is LOW which is fed to A2 AND gate. The other input of A2 gate is from N1 and thus we obtain LOW output from A2 gate which is again fed to A3 AND gate. The other input for A3 AND gate is HIGH. Thus the overall output of A3 gate is LOW. Hence the active phase is Y PHASE (Figure 1.8).

3.5.8 Relay Driver Circuit

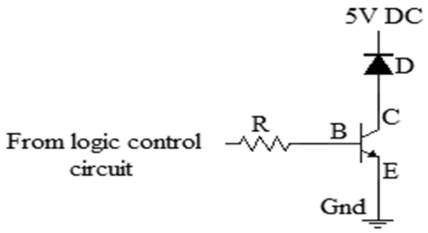

Figure (1.9): Relay Driver Circuit [9].

Relay driver circuit (Figure 1.9) consists of resistor, transistor and diode. Resistor is used to limit the high current from the output of logic gate signal to operate the relay through transistor. The diode acts as a freewheeling diode which stops the reverse current flowing to the logic control circuit through transistor as reverse current damages the logic gate circuit.

3.5.9 Relay

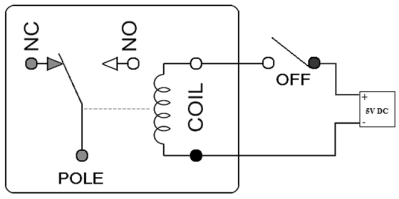

Figure (1.10): Relay [10].

A relay (Figure 1.10) is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can

be on or off so relays have two switch positions and have double throw (change-over) switch contacts.

3.5.10 Load

Here load is used as single phase load such as Hospitals, Schools, and other domestic and lighting applications.

4. Description of Working Model

The model is designed to provide uninterrupted AC mains supply of 230 Volt to a single phase load. This is achieved by automatic changeover of the load from the missing phase to the next available phase in a three phase system. In this system auto selection is achieved by using a set of relays interconnected in such a way that if one of the relay feeding to the load remains energized always. Under the phase failure condition the corresponding step down transformer secondary delivers zero voltage which is duly rectified to DC and then fed to the logic gates corresponding of NOT & AND to switch on the next relay that delivers the power to the load. Here transistor is used to drive the relay and diode connected across the relay input, acts as freewheeling diode which stops the reverse current flowing to the logic control circuit through transistor. The Figure (1.11) shows the hardware model of the Electronic Phase Selector.

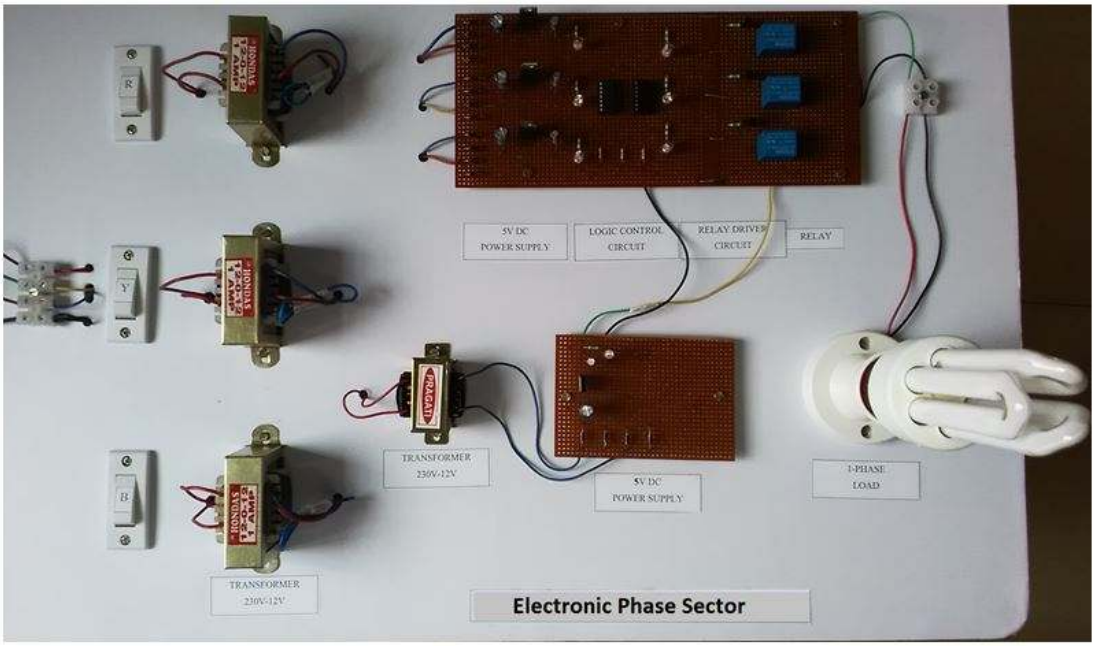

Figure (1.11): Hardware Model of the Electronic Phase Selector Switch.

4.1 Working Model

The three phase supply is stepped down to 12V by 3 single phase transformers which are connected to each phase. Then the 12V is connected to the input of 5V DC power supply to obtain 5V DC supply which is required to operate relay, logic gates and relay driver circuit. Each relay output connection are tapped and given to the 1-phase load. The Figure (1.12) and Figure (1.13) shows the working model of the Electronic Phase Selector.

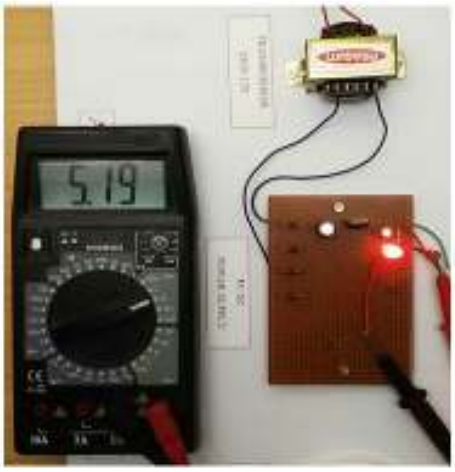

Figure (1.12): 5V DC Power Supply.

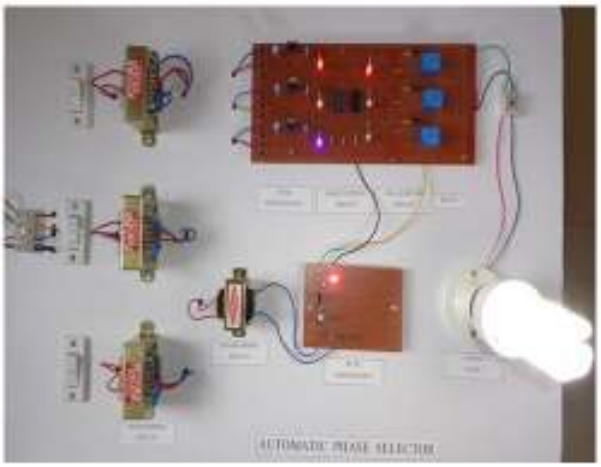

Figure (1.13): Priority phase selection Case 1.

5. Result and Performance Analysis

The Table (1.3) gives the result about the logic input and logic outputs which was observed while working on the working model. Without any interruption, always single phase load is connected. From the truth table R phase is having first priority, Y phase is having second priority and B phase is having last priority. By comparing the truth table 1.1 and 1.3 designed logic is same as result achieved by the hardware model.

Table (1.3): Truth Table of Electronic Phase Selector.

INPUT			OUTPUT		
R	**Y**	**B**	**R**	**Y**	**B**
OFF	OFF	OFF	OFF	OFF	OFF
ON	ON	ON	ON	OFF	OFF
ON	ON	OFF	ON	OFF	OFF
ON	OFF	ON	ON	OFF	OFF
ON	OFF	OFF	ON	OFF	OFF
OFF	ON	ON	OFF	ON	OFF
OFF	ON	OFF	OFF	ON	OFF
OFF	OFF	ON	OFF	OFF	ON

6. Conclusions

In this paper Electronic Phase Selector Switch model has been designed and developed as working model. The designed parameter is matched with the working model outputs. Without any interruption single phase can be supplied to the load. The system developed is cheaper in cost and easy to operate. The developed model size is compact. In this no rotating parts as it reduces the maintenances cost. Sparking between the selector switch and phase connection does not arise in this model. Electronic phase selector Switch helps in uninterrupted power supply during phase fault also.

7. Future Scope: Weight of the model can be further reduced by replacing the transformer with transformer less power supply unit. The protections for phase selector can be considered.

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