A Microcontroller based Automatic 3-Phase Selector for Load Control in Home Applications

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Abstract: **Technological advancements have been tailored to ensure improvements in the design and implementation of existing technologies. Thus, the design and construction of a 3-phase automatic selector was undertaken in this study. The 3-Phase Automatic Selector is a device that does the automatic switching of a three phase supply without human intervention. It is useful in homes to militate against faults arising from overloading on a particular phase or from outright phase-off. The proposed system consists of the load unit, which was implemented using 15AMPS sockets, 13AMPS sockets, 15AMPS switches and a 20watt bulb connected in series and parallel to simulate the load needs of a typical household. The switching unit consisted of 210V- 250V relays, the power supply unit consisted of step down transformers (220-12V), 1microfrad 50V capacitors, a rectifier circuit and 4.7k resistors. The microcontroller unit was an Arduino UNO board interfaced with a liquid crystal display. C++ was used in the software programming, with system operation described using a flow chart. The developed system checks the input and selects the highest phase value which it applies to the load through appropriate relay connections, this ensures that the microcontroller switches automatically from one phase to another when there is power outage. Test results showed that the system was able to select an optimal phase amongst the three at all times, with minimal delay for application to the load**

Keywords: **Load Control, Arduino Uno, Three Phase, Relay, Microcontroller**

I. INTRODUCTION

A 3 phase supply means there are three (3) power generating coils connected together either in Y (star) or delta configuration, where each coil is physically displaced at an angle of 120 degrees (Wong, 2016).3 phase electricity is referred to as alternating current. It is the most common delivery method worldwide because it is a cheaper and easier way to transmit power from one place to another. While this method of electrical transmission is popular in industrial, commercial and institutional power systems, most homes only use single-phase power.

A phase is applicable to alternating current where the voltage and current swing up and down sinusoidally. The changes in voltage up and down across a power generating coil in a distinct period as it rotates is called a phase. In a single phase power supply, there is one live wire that goes to the load and one return wire (neutral) that goes back to the power source (Wong, 2016).

Voltage fluctuation has a lot of harmful effects which are caused by loose and corroded connections on the phases. This can be as a result of voltage being too low due to overloading, loose connections and electric shock. Thus, voltage dips can occur when there is a reduction in the supply of voltage power and then it comes back after a particular period of time, this can also be caused by fault. The phase selector becomes useful in such a scenario because the switching to the next phase can be executed in milliseconds before the failed phase is restored.

Very short interruptions has high tendency to occur when there is power outage on a line or phase, the automatic phase selector becomes handy as it also reduces inconveniences and the risk factors arising from unauthorized personnel interference through a manual changeover. This can result in electrocution, severe injury, death etc. (Amol, 2015).

Oduobuk (2014) ,designed and constructed an automatic three- phase changer using an LM324 Quad Integrated Circuit. The system was designed and simulated using (Multisim) with results showing that, when the three phase A.C inputs: Red phase , yellow phase and blue phase from the public utility supply was fed to the system, the system compared the inputs with regard to phase imbalances, and the input with the highest voltage appears across the output. It also changes over from one phase to another immediately the circuit senses further phase imbalance.

(Ofualagba G., 2017) , Designed and simulated An Automatic Phase Selector and Changeover Switch for 3-Phase Supply. It provided a means of switching from one phase of AC mains to another in the case of failure in the existing phase; it also changed over to a generator supply if there is failure in all the three phases of the ACmains. The circuit also senses the restoration of any or all the three phases of the mains and changeover withoutany notice of power outage. The system was achieved using 1 - of - 4 analogue multiplexers(CD4052), analogue to digital converter (ADC0804), AT89C51 microcontroller and relay switches.

(Iwu, 2015), Designed and constructed an Automatic Three Phase Power System Selector which automatically switches over to the alternative phase that has current when there is power outage or extremely low current in the phase which the load is connected without the power being off. The selector links the load and the other phases and relay switches allowing the usage of the remaining phases where there is outage on the mains source without disturbing or interrupting the load. It maintains constant power supply to the load by automatically activating the phases when the need arises. This safeguards the electronics system from being damaged or burnout as a result of voltage instability, collapse, insistent outages which are paramount in under developed and developing countries.

(MR.Lalit Patil, 2016), Designed an Automatic Phase Selector Using an 89C52 Microcontroller 89C52.The system proposes that if the supply voltage is low, a proper rating fuse need to be used in three phase i.e. R, Y, and B inputs lines. Where the correct voltage is available, it automatically switches to the next phase without interruption. The circuit consisted of a relay comparator, transformer.

(Nwafor Chukwubuikem M., 2012), implemented a cost effective approach to the changeover system. The research reviewed the methods of implementing change over systems and proposed a better and cost effective approach to realizing the same system by making use of the solid state relay (SSR) which eliminates totally the noise, arching, wear and tear associated with electromechanical relays. Digital integrated circuits and microcontroller were used to reduce the component count as well as improve the speed of the system. The system also has some desirable features like liquid crystal display (LCD) which makes the system user friendly, an alarm system for indicating generator failure, automatic phase selector for selecting most appropriate phase, over-voltage and under-voltage level monitoring.

The system proposed by the researchers were limited to obvious failure modes, e.g. heating issues that are inherent in a solid state solution as proposed by Nwafor (2012), system instability issues that are inherent in the solution proposed by oduobuk (2014) due to the fact that phase imbalances are a regular occurrence in Nigeria as corroborated by iwu (2015), thus the developed system will switching too frequently that a user cannot adequately utilize the power. Thus to offer a simplistic approach to change over technology devoid of heating issue in solid state solutions or over complexities in phase imbalance management, this study was thus embarked upon.

II. METHOD

The hardware methodology adopted in this project is the top down methodology. This methodology was used in integrating the load unit, switching unit, microcontroller unit and the power supply unit in the design of the hardware (test bed) as shown in fig 1.

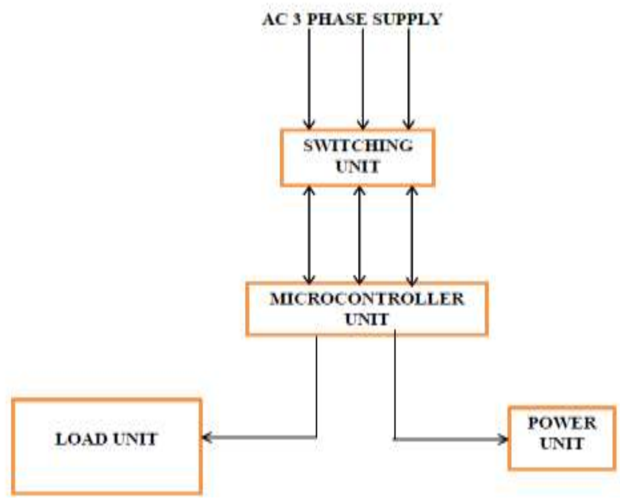

Fig 1: Overall System Architecture

Load Unit

The load unit consists of three (3) 15AMPS sockets, two (2) 13AMPS sockets, four (4) 15APMS switches, one (1) 20watt bulb. In a series circuit, the current that flows through each of the components is the same, and the voltage across the circuit is the sum of the individual voltage drops across each component. In a parallel circuit, the voltage across each of the components is the same, and the total current is the sum of the currents flowing through each component.

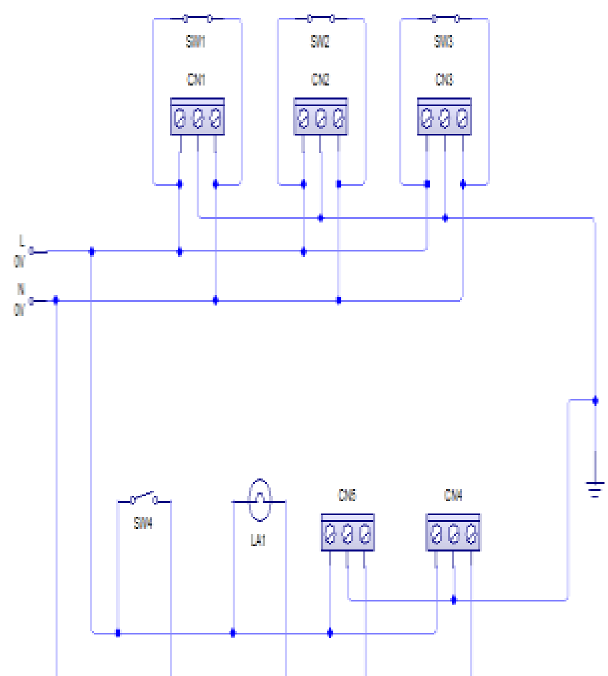

Fig 2: Circuit Representation of Load Unit

Microcontroller Unit

The Arduino UNO board as shown in fig 3 is a microcontroller board. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller. It can be powered either with a computer with a USB cable or an AC-to-DC adapter or battery. But in the case of this project, it will be powered by an AC supply. The system checks the input and selects the highest value and then load the output circuit. When there is live, the load line will be NO and the Green led comes ON but when there is no live, in the space of when the next load line comes ON, it triggers the buzzer and the Red LED comes ON instantly. The operation occurs simultaneously.

Fig 3: Arduino UNO Board

Switching Unit

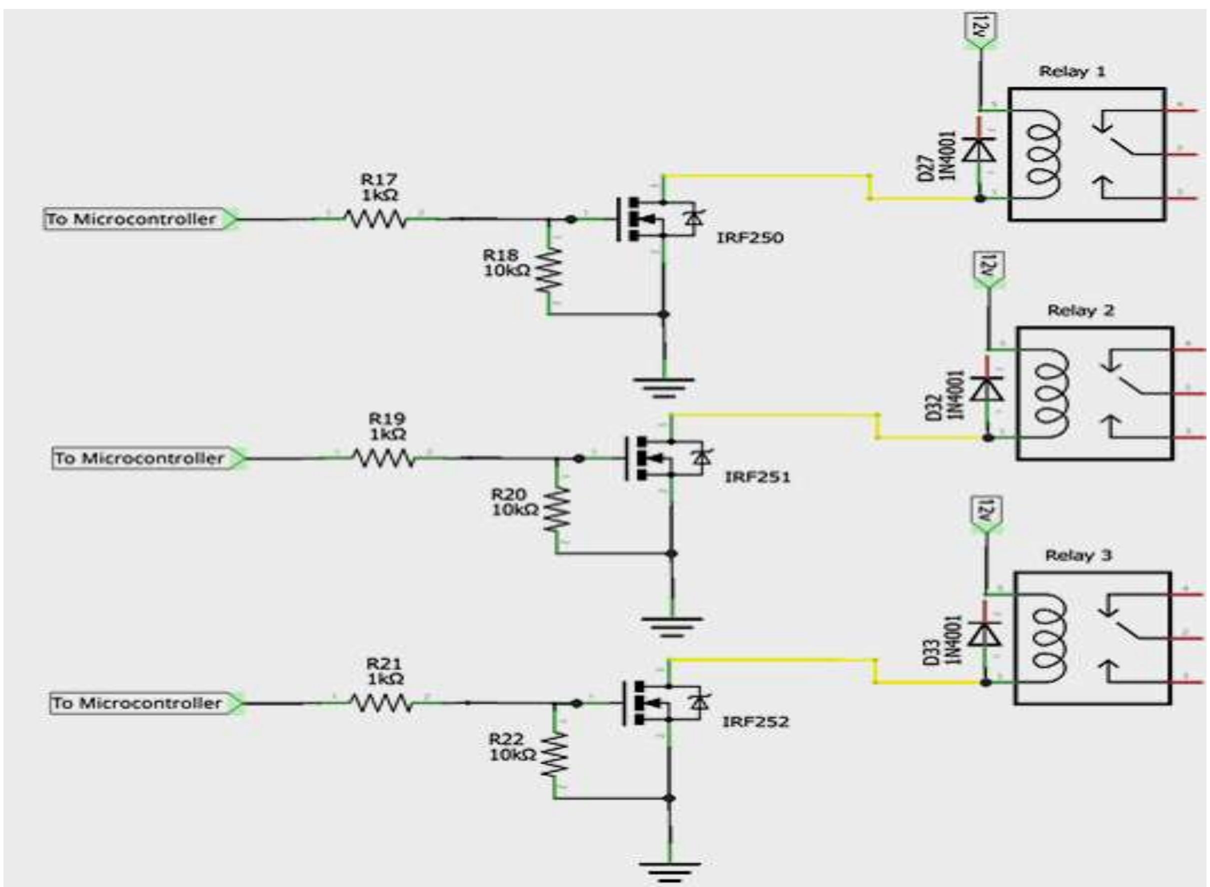

Fig 4: Switching Unit Circuit

The switching unit as shown in fig 4 was designed using three relays to control the three phases of the load supply. Interfacing the relays to the microcontroller unit (arduino UNO board) required some signal conditioning , which consisted of three (3) IRF252 FET's connected to the microcontroller port through 1kΩ and 10kΩ resistors respectively as shown in fig 4.

Power Unit

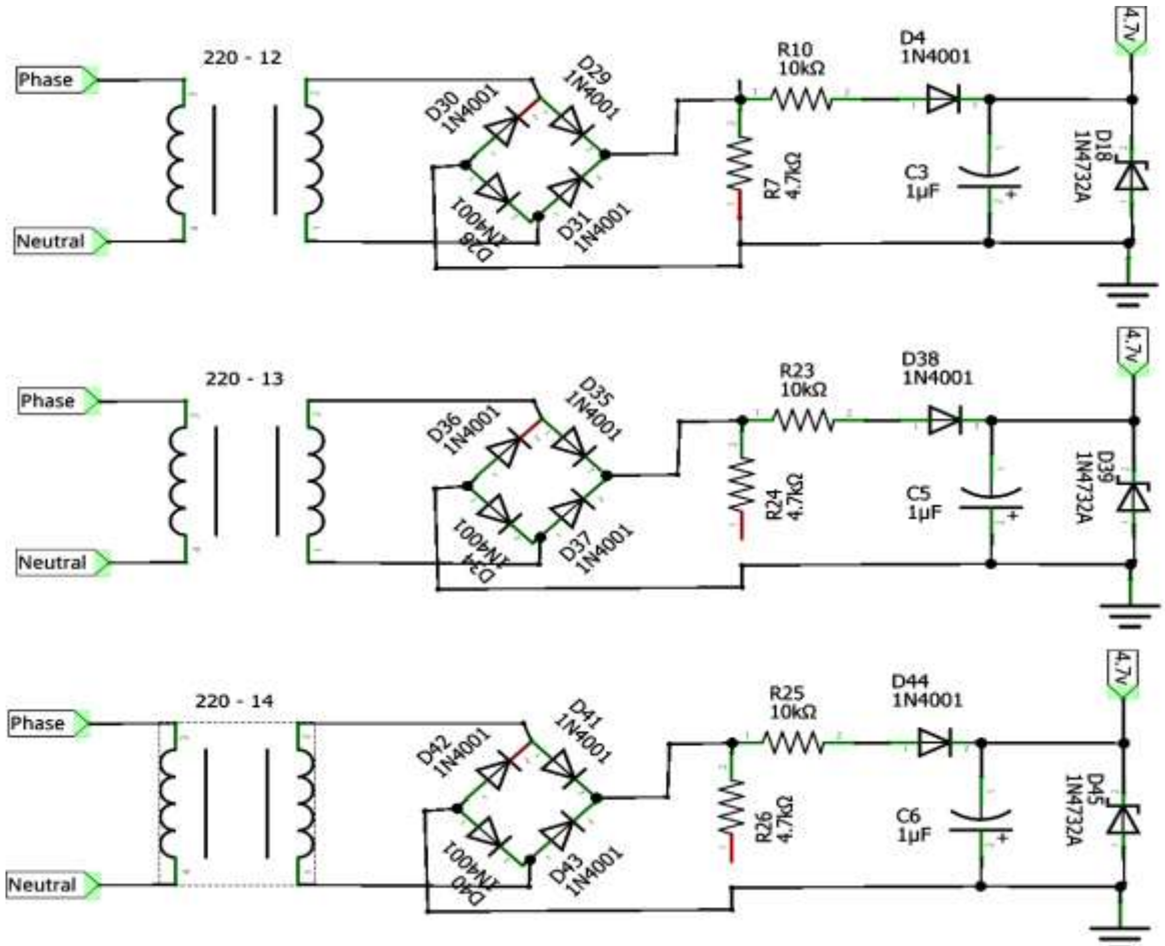

Fig 5: Power Unit

The power unit as shown in fig 5consists of the rectifier (IN4001 diodes), voltage regulators (7805 IC), capacitors and transformers that are used to power the microcontroller unit. The input voltage from all the phases is stepped down by the step down transformer, rectified by the bridge rectifier, filtered by the capacitor and the dc output is fed to microcontroller sensing unit. The same dc voltage is used to supply the relay that controls the load. The sensing stage includes zener diode, resistor and transistor.

Where the main supply is 220V/50Hz, the transformer used is a 220/12V according: to

$$\frac{Es}{Ep} = \frac{Ns}{N1} = \frac{Ip}{Is} = \frac{Vs}{Vp} = K \quad (1)$$

Where k = transformation ratio.

V_p = primary voltage of the transformer = 220V

V_s = secondary voltage of the transformer = 12V. Hence for 220V/12V transformer,

$K = \frac{12}{220} = 0.05455,$

$$V_{rms} = \frac{Vmax}{\sqrt{2}} \quad (2)$$

Where $V_{max}$is the maximum or peak voltage, hence for the secondary of the transformer.

Vrms = 12v

$V_{max} = \frac{12}{\sqrt{2}} = 16.97V$

For the Microcontroller Unit

$$V_{out} = V_{in}12\left(\frac{\text{R2}}{\text{R1+R2}}\right) \quad (3)$$

$= 12\left(\frac{4.7}{10+4.7}\right)$

$= 12\left(\frac{4.7}{14.7}\right)$

$= 12 \times 0.319727$

$= 3.8367\ Volts$

Software Methodology for Microcontroller Unit

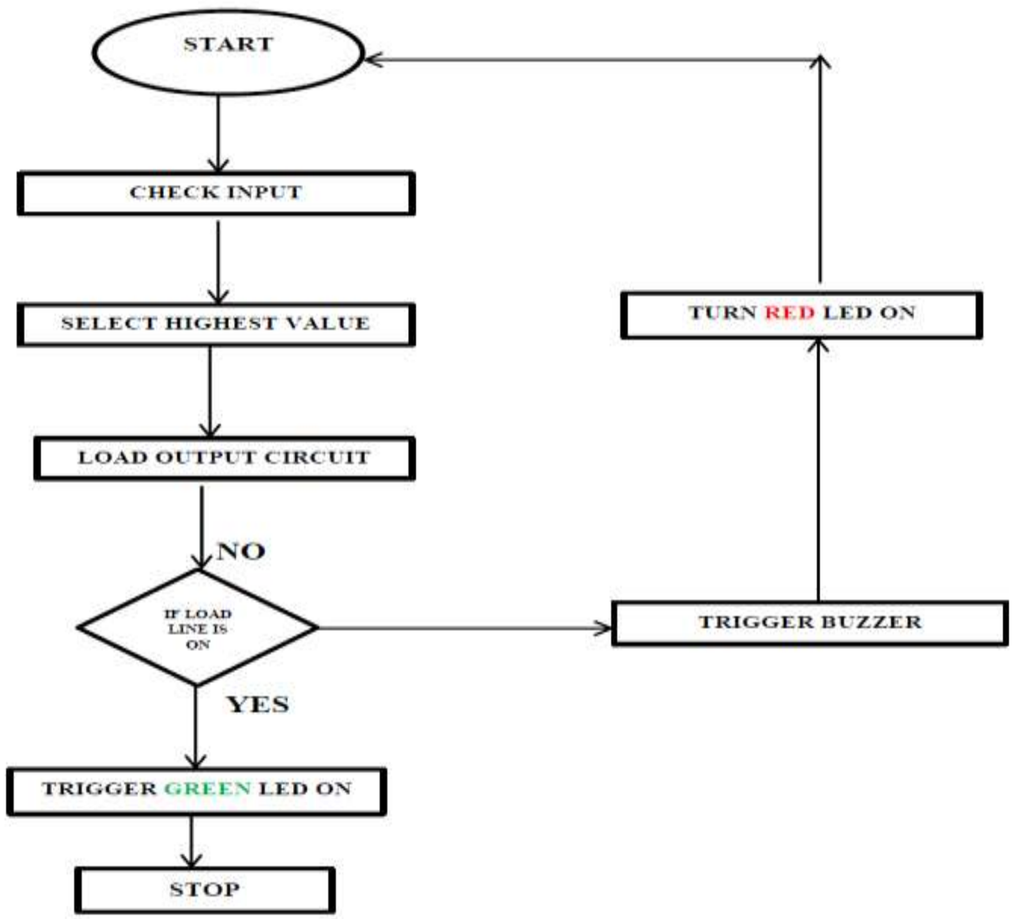

Fig 6: System Flowchart

III. RESULTS AND DISCUSSION

The various modules as described in fig 2, 3,4 and 5 are interfaced together as shown in fig 7. The overall system thus is in-line with the system architecture described in fig 1. Fig 8(a), 8(b), 8(c) and 8 (d) depict the system implementation for the load unit, microcontroller unit, switching unit and the overall system respectively.

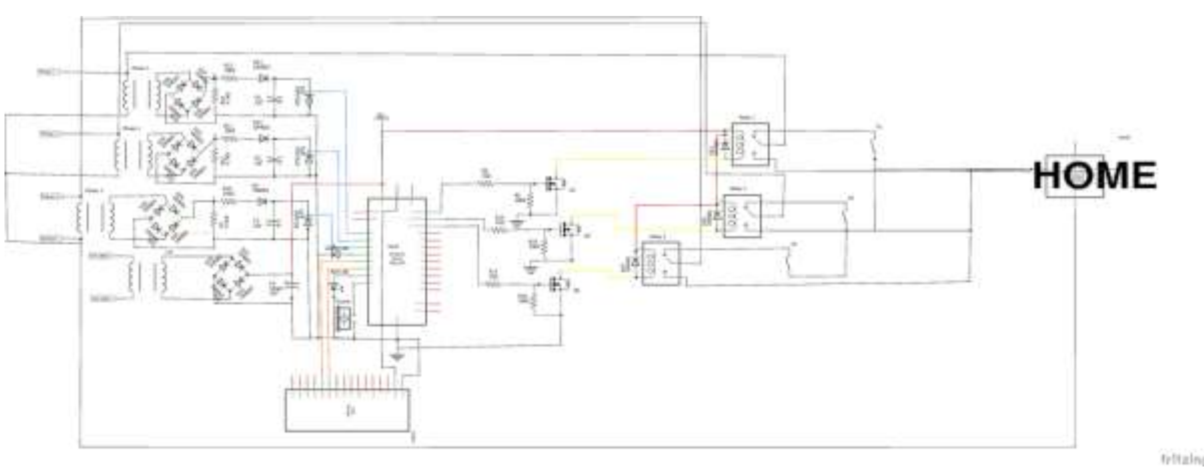

Fig 7: Overall System

Fig 8(a): Load Unit

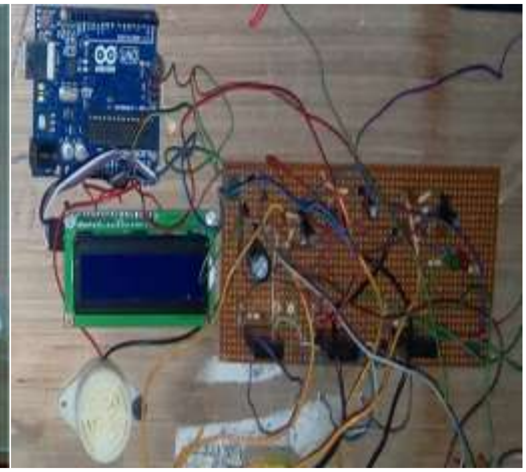

Fig 8(b): Microcontroller Unit

Fig 8(c): Switching Unit

Fig 8(d): Overall System Implementation

The microcontroller unit in the circuit was able to switch between the phases whenever there is any available phase. The microcontroller unit has to be mute when the changeovers are on manual and each phase will be selected one at a time The green led indicates when there is output and the red led indicates when there is no output It indicates few seconds before the switching to the next phase occurs It displays all the unseen operations of the microcontroller unit

Table 1: Truth Table Showing Summary of Result

Input Red Phase, R	Input Yellow Phase, Y	Input Blue Phase, B	Output Voltage
0	0	0	No supply
1	0	0	Red Phase
0	1	0	Yellow Phase
0	0	1	Blue Phase
0	1	1	Yellow or Blue Phase
1	0	1	Red or Blue Phase
1	1	0	Red or Yellow Phase
1	1	1	Red, Yellow or Blue Phase
Note: High (1); >5V Low (0); ≤ 5V			

Table 1 describes the summaries of the result during the testing of the system. It also explains the switching process of the system. However, the 0 signifies "Low" and 1 signifies "High" respectively. In other words, 1 is considered 5V and above while 0 indicate signal less than 5V. It shows that when P1 is High (1), P2, P3 are low, the output signal is "High" (1). This is because the voltage at Phase 1 is greater than the others. Hence, P1 (Red phase) will appear in the output. Secondly, when P1, P3 are low, the output P2 (Yellow Phase) will become "High". Also, when P1, P2 are all low and P3 is high, automatically P3 (Blue Phase) will appear across the output.

IV. CONCLUSION

The variation of the calculated design values and experimented result shows that the design meets the design objectives. The main aim and objectives of this project has been achieved with the significance of providing a device or equipment that is able to automatically switch itself without human intervention. Some various tests were carried out and the results obtained demonstrates that the 3 phase automatic selector is achieved and the construction process successful.

The system worked according to specification by monitoring phase outage and under voltage thereby switching to the next phase. The automatic selector functions without manual assistance; hence the sluggishness of human effort is eliminated.

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