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Research Paper

Performance Analysis of Crystalline Solar Panel

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Abstract: This paper aims at designing, constructing and testing an automatic three phase selector under standard conditions. This analysis involves identification of a real life problem, and research on innovative, economic and efficient ways of solving this problem. This is project sets out to fuse two automatic processes together namely automatic transfer switching and automatic phase selection, making the constructed device very important to homes and industries in countries where power supply is not constant.

Keywords: Three Phase Supply, Automatic Phase Selection, Automatic Transfer Switch, Electricity.

1. Introduction

A transfer switch, popularly called a changeover switch, is a device which switches power between two sources of supply. Many nations face power supply challenges such as insufficient generation, poor network maintenance and unfavorable regulatory policies. These lead to load shedding which results in frequent interruption of power supply to consumers. This interruption of power supply has had an adverse effect on the smooth running of small and medium scale businesses in these countries. Alternate sources of supply are used in order to make up for this deficit in supply from the utility, the most common one being the diesel generators. There is a need to switch from one source to another, seeing as two sources are being used. The supply from the utility to a consumer can be cut off suddenly and if the changeover process is manual, the time involved can reduce the tempo of business process. The cost associated with breakdown varies from one application to another. Some operations require that power should be restored as quickly as possible in the event of an outage. In the case of a patient undergoing an operation in a hospital, there should be little or no time spent in restoring power else the patient could lose his or her life. Furthermore, many countries distribute a three phase system of supply even when most household loads make use of one phase. By reason of the challenges faced with the power supply, all phases may not be supplied with power at the same time. There is the need for a way to select a phase with power supply in the event of a phase outage.

2. Background

2.1. Problem statement

Due to the poor condition of power supply, all three phases are often times not supplied with power simultaneously and the power supplied across the three phases may not be equal. Power may be absent in some phases and present in some. It may also be present in different voltages in some phases. This supply of over voltage or under-voltage can be dangerous to equipment. Supply of low voltage for example can result in distortion of the output waveform of an input signal. Distortion in the operation of logic devices is possible due to the sensitive nature of these devices. Supply of over voltage on the other hand could result in burn-outs, melt-downs, and fire outbreaks.

Seeing that power may not be present in all phases at the same time or that it may not be present in the same quality in all phases at the same time, there is often the need to switch from one phase to another. This can be done manually, which often is the case in most homes and small establishments, by removing the contacts from the undesired phase outlet and placing them in the desired phase outlet. This method often involves trial and error due to the fact that there are no indicators for the presence or quality of power in any of the phase and may lead to damage of electrical appliances if unfortunately a faulty phase is selected or in use.Alternate sources of power supply are being used in most homes and offices today, with the most common one being the diesel generator. In the event of power failure, the consumer has to switch from the utility supply to the supply from the generator. The entire process of manual changeover can be time consuming seeing as it depends on the proximity of the user to the generator and it can be an inconvenience to the user.

2.2. Aim

The aim of this project is to design an automatic phase selector capable of successfully switching from one phase to another and selecting the phase with the optimum voltage level so as to protect the building from the effect of undesired voltage. It is also to design an automated means of switching from one power source to another.

2.3. Objectives

The objectives of the study are to;

- Determine the presence of voltage across each phase
- Monitor the voltage level in the three (3) different phases
- Select an optimum voltage value and for the purpose of this project, we have decided to take 220 volts as our maximum voltage and 180 volts as our minimum voltage.
- Create a latching system that will prevent it from unnecessary fluctuations
- Provide an automated means of switching from one phase to another (In the case of a fault).
- Provide an automated means of switching from one source of power (power from the utility company) to an alternative source of power (a backup generator)
- Provide a form of display to show the status of all its operations.

3. Methodology & scope of work

The system will incorporate a means of the selection of available three phase power supply. This will be implemented using optocouplers and feedback circuit to the microcontroller to monitor the availability and unavailability of power supply in each phase. The system will also be able to determine the voltage in each phase and check if it falls within a specified range. For this feature we will be making use of operational amplifiers connected as a comparator in a window comparator format which will feed its output into logic gates. This single arrangement accounts for the second, third and fourth objectives earlier stated. Thirdly, the system has the ability to change over from a phase whose power supply has failed, to a phase with available power. This operation will be by the use of high current carrying A.C coil contactors whose coil will be controlled by the microcontroller via the use of transistors and relays.

Furthermore, the system has a feature such that in the event that power fails in all three phases, a standby generator will be automatically turned on and deployed provided the power switching function is activated. This will be achieved using dc relays. If the function is not activated, the system continues to check for the availability of power from the utility.The system will have a form of display to show the status of all its operations, this will be implemented using an LCD (Liquid crystal Display) in conjunction with a number of LED's (Light Emitting Diode). The system also has a programmable integrated circuit (microcontroller) to direct and co-ordinate the operation of the circuit. The microcontroller that will be used is the AT89c52 microcontroller. The whole system will be simulated using the simulation software called Lab center Proteus.

3.1. Significance of study

This project upon execution will be of great use to the consumer as it would enable him save on expenses he would have incurred due to the damage of the equipment as a result of poor quality of supply.

4. The Design

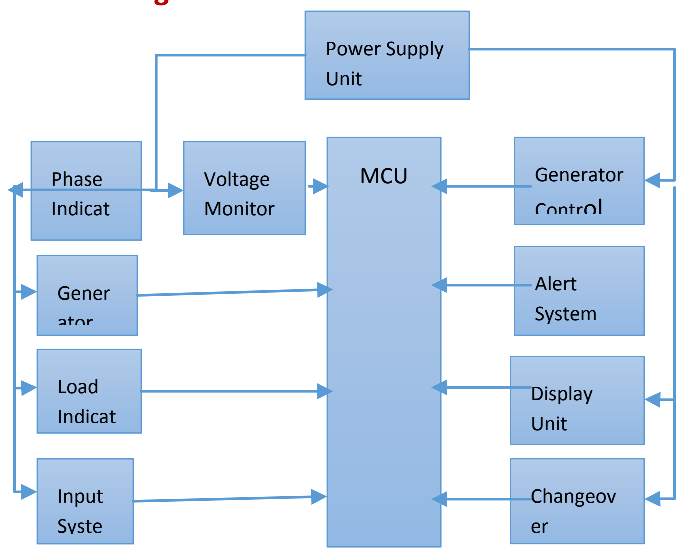

Figure – 1: Block diagram of the proposed system

The block diagram consists chiefly of a power supply unit which supplies power to the circuit components at their required voltage levels and the Microcontroller Unit (MCU) which co-ordinates the activities of the device. Other parts include the generator control for turning on and turning off the generator, the indicators (phase indicator, generator indicator and load indicator) which enable us to detect the presence or absence of power and the source of supply currently in use (Utility or generator), the voltage monitors, the alert system, the display unit, input system and changeover control. These will be discussed in the following section.

4.2. Components of block diagram

Power Supply Unit: This is a circuit comprising of diodes, capacitor a voltage regulator and power indicator. This supplies two DC voltage levels to the whole circuit from an AC source.
The Microcontroller Unit: The microcontroller unit circuit is the heart of the project. This is where the program for the control part of the project is written and burned using assembly language and a universal programmer, respectively.
Phase Indicators: It is the circuit that allows us to know whether there is power available in any phase. A 16 x 2 LCD was used in combination with an LED which turns on when there is power in any phase.
Generator Indicator: This is the circuit that indicates if the system is running on generator or not.
Generator Control: This is actually the circuit that controls the operation of the generator. The microcontroller sends a signal to the transistor which turns on the relay. This energizes the contactor coils which in turn close the contacts to turn on the generator.
Alarm: This is the alarm circuit that will indicate when there is power supply either from the utility company or from the generator. The alarm unit consists of a multivibrator integrated circuit otherwise

known as a 555 timer. For its operation, the alarm is made to sound at discrete intervals of 1second apart hence the frequency of the 555 timer is an important parameter to be decided.

Voltage monitoring Unit: This unit employs the use of 2 operational amplifiers arranged in windows comparator format in conjunction with an AND gate in order to compare the voltages at the different phases

Changeover control unit: The microcontroller unit energizes the LED which energizes the optotriac which in turn allows current to flow through the triac which also energizes the contactor contact to be able to turn on the phase to supply load. The contactor coil has a current rating of 40A so as to enable it have a high power capacity.

This value is not a standard value of resistors therefore so a value of 330Ω was chosen

For effective switching, the collector current should be about 10 times the base current.

Input System: The input system performs the dual function of resetting the entire system if the system is malfunctioning.

It also activates the automatic changeover function of the device such that when the switch is on, the device will automatically changeover from one source to the other and when the switch is off, the device will not be able to automatically changeover.

The display unit: This is a 16x2 LCD that displays information concerning the circuits operations. Such information will be sent to the display unit from the microcontroller.

4.3. The microcontroller program

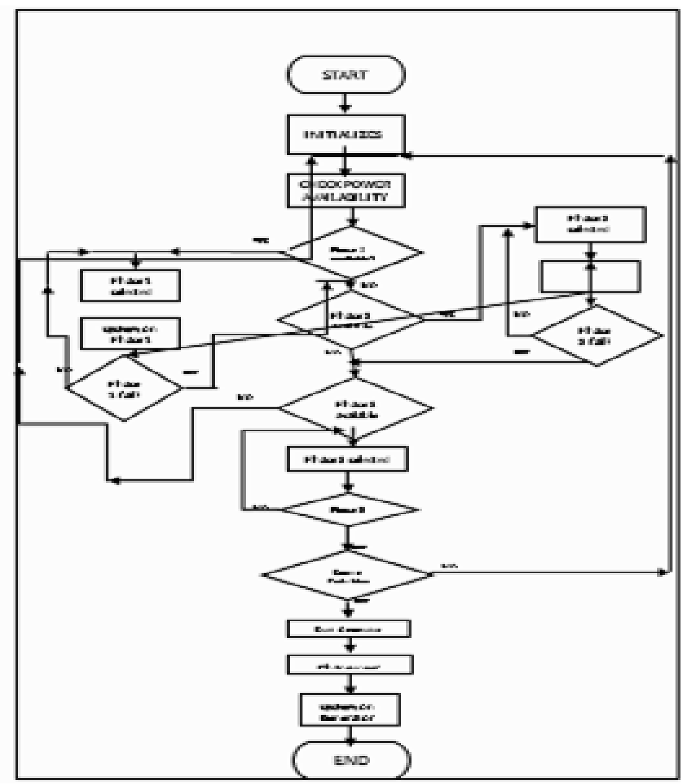

Figure -2: Micro controller unit

5. Construction

5.1. Construction procedure

The circuit diagram was gotten after a careful design and calculation has been done. The complete project was first simulated using "LABCENTER PROTEUS" before the actual components were then assembled on a bread board. The resistors, capacitor, the integrated circuit and diodes were first placed on the board, before the bigger components like the relay, contactors, were placed and soldered carefully. Finally the transformer was introduced

5.2. Tools used

The tools used for the construction of the project and the casing of the project are as listed; Soldering Iron, Screw Driver, Pliers, De-Soldering pump, Hand Saw, Multi-meter.

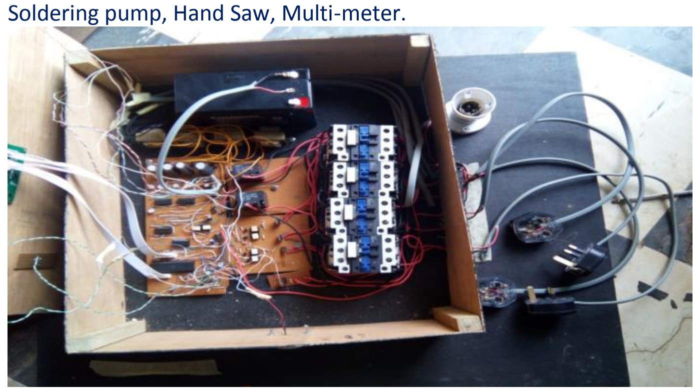

Figure – 3: Picture of the completed circuit.

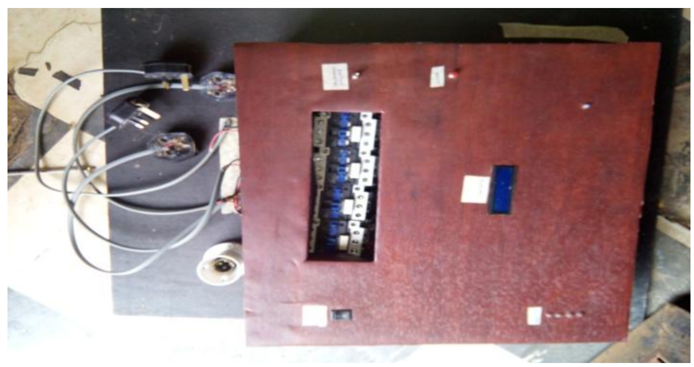

Figure – 4: Casing of the completed circuit.

6. Testing

The testing involves the simulation of the designed circuit using any electronics simulation software (in this case, "LABCENTER PROTEUS") and also the final testing of the completed circuit. For the purpose of testing, the three phases were designated as phases "A", "B" and "C" respectively. Phases "A","B" and "C" are connected to plugs which are connected to sockets to simulate the supply of power to the phases. The public supply was available during this test and a 60W bulb is used as a load. A plug is also used in place of the generator supply. The testing procedure is as follows:

6.1. To determine the presence of voltage in all phases

- Supply power to all three phases.
- Cut off power to phase A
- Cut off power to phase B
- Cut off power to phase C

6.2. To monitor the voltage level and select the optimum voltage

- Supply power to all phases at 220v
- Keep voltage at phase A constant and vary the voltages at phases B and C
- Keep voltage at phase B constant and vary the voltages at phases A and C
- Keep voltage at phase C constant and vary the voltages at phases A and B
- Keep voltage at phase C and A constant while varying the voltages at phase B
- Vary the voltages in all phases to be below 220v

6.3. Phase selector and changeover switch TEST (With the changeover function deactivated)

- Supply power to all three phases one after the other.
- Cut off power to phase A.
- Cut off power to phase B.
- Restore either phase A or phase B.
- Cut off power to all the phases with the changeover switch OFF.
- Restore power to any of the phases A, B or C.

6.4. Phase selector and changeover switch test (With the changeover function activated)

- Supply power to all three phases one after the other.
- Cut off power to phase A.
- Cut off power to phase B.
- Restore either phase A or phase B.
- Cut off power to all the phases with the changeover switch OFF.
- Restore power to any of the phases A, B or C.

7. Results

The results of the test are represented using the tables below. The load is represented by a 60W bulb.

Table-1: Testing to determine the presence of voltage in the phases.

PHASE A	PHASE B	PHASE C	LED A	LED B	LED C
0	0	0	OFF	OFF	OFF
0	0	1	OFF	OFF	ON
0	1	0	OFF	ON	OFF
0	1	1	OFF	ON	ON
1	0	0	ON	OFF	OFF
1	0	1	ON	OFF	ON
1	1	0	ON	ON	OFF
1	1	1	ON	ON	ON

The figure "0" is used to represent a condition of UNAVAILABLE SUPPLY while the figure "1" is used to represent a condition of AVAILABLE SUPPLY. In this test the quality of the supply is not taken into consideration. As can be seen from the table above, whenever there is supply to any of the phases, the LED will be lit up irrespective of the quality of supply to that phase.

Table-2: Testing to monitor the voltage level and select the optimum voltage.

Phase **A** (red)	Phase B (yellow)	Phase C (blue)	Output Q	Output phase interpretation
220	220	220	220	Red phase
220	100	50	220	Red phase
100	220	50	220	Yellow phase
100	50	220	220	Blue phase
240	100	220	220	Blue phase
50	50	50	0	No supply

From the table above, it is observed that as long as there is a presence of voltage within the range of 180 and 240v the output at the load selects that particular phase to deliver power. However as long as the output voltage is supplied by a phase within appropriate voltage value, the system does not select a phase with a higher voltage output in order to avoid fluctuations.

Table - 3: Results of testing with switching function de-activated

Phase A (V)	Phase B (V)	Phase C (V)	Switching function	Generator	Load	
220	220	220	OFF	OFF	ON	Red phase
0	220	220	OFF	OFF	ON	Yellow phase
0	0	220	OFF	OFF	ON	Blue phase
220	0	220	OFF	OFF	ON	Blue phase
220	220	0	OFF	OFF	ON	Red phase
0	0	0	OFF	OFF	OFF	No supply

Table - 4: Results of testing with switching function activated

Phase A (V)	Phase B (V)	Phase C (V)	Switching function	Generator	Load	
0	0	0	ON	ON	ON	Generator
220	220	220	ON	OFF	ON	Red phase
0	220	220	ON	OFF	ON	Yellow phase
0	0	220	ON	OFF	ON	Blue phase
220	0	220	ON	OFF	ON	Blue phase
220	220	0	ON	OFF	ON	Red phase

From the tables, we can observe that upon de-activation of the switching function, the generator did not start in the absence of power and as a result, there was no supply to the load. When the switching function was activated, there was successful changeover in the absence of power and there was supply to the load. The generator did not start so long as there is power available even though the switching function is activated. Phase change was successful whether the switching function was activated or de-activated. The system checked for the presence of power at the appropriate range in order of priority (Red phase first, followed by the Yellow phase then the Blue phase). When power is cut off from one phase, the system searches for power on the phase with the highest priority available to select. Thus if phase A (or the red phase) is available, it is selected and if power is unavailable in phase A but available in phases B and C, phase B is selected.

8. Precautions

In a project as complex and delicate as this, a lot of precautions were observed.

- Bridging of components was avoided.
- The construction and assembly was carried out in a suitable environment.
- The project was first assembled on a bread board before it was transferred to a VERO board
- Care was taken so as not to damage heat sensitive components when soldering
- The ratings of all the components were carefully selected so as not to damage sensitive components with over voltage.

9. Problems encountered

While working on this project, the following challenges were encountered

- Some of the components were damaged and as such had to be replaced.
- The project took a longer time than was normal to construct. Due to power instability
- After calculations, the values we obtained were not standard values for some electronic components so we had to settle for the available standard value.

10. Conclusion

The aim of this project was to combine the functions of an automatic changeover switch and a phase selector in one unit. We sought to design a system that can switch from one source of supply to another and select the phase having power supply within the optimum range so as to protect from under or over voltage. After the design, construction and testing of the finished work, the automatic phase selector and changeover switch performed satisfactorily, switching power sources as at when due and also selecting the appropriate phase. It also maintained its current phase of supply even when power was supplied to other phases.

11. Recommendation

This project was an interesting one to undertake. It was interesting brainstorming over how to improve upon current technology. The following are our recommendations upon completion:

- There should be a way to design the system such that the changeover cycle can be timed i.e, instead of the switching method, or rather in addition to the switching method, the system should be designed such that the user could input the time period when he wants the system to changeover from generator to the utility.
- The system could also be later improved upon to include other alternate sources of power such as inverters, solar energy systems, etc.

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