A COST EFFECTIVE APPROACH TO IMPLEMENTING CHANGE OVER SYSTEM

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ABSTRACT

This paper reviewed the methods of implementing change over system and proposed a better and cost effective approach to realizing the same. Some of the approaches which have been employed to implement change over system include manual change over switch box, automatic change over system with electromechanical relays and change over system with automatic transfer switch. Each of the methods has some drawbacks that make it undesirable. Among these drawbacks are time wastage, possibility of fire outbreak, generation of noise, frequent failures, product damage, high component count to mention but a few. These contribute to the high cost of these methods. The approach proposed in this paper makes use of 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.

Keywords: *electromechanical relays, Automatic phase selector, solid state relay, voltage level monitoring.*

INTRODUCTION

Power instability in developing countries has necessitated the need for automation between public power supply and alternative generators to backup the utility power supply, and as the rate of power instability becomes predominantly high the need for automation also becomes high. And since most industrial and commercial processes require uninterrupted power supply, if the process of power supply changeover is manual, it will not only waste time by slowing the process, but could also cause device, process or product damage. There could also be error during the manual changeover as a result of human factor, and this in some cases can lead to massive loss of revenue. Therefore the major aim of this work is to exploit the ubiquitous microcontroller facilities in bringing about automation of changeover process. One of the most critical needs of an embedded system such as this is to decrease power consumption and space [7] and this is achieved in this work. It has been observed over the years that power instability has caused companies to lose millions of dollar each time there is power failure, as a result of the time lag between power failures and when power is restored. This can be seen clearly in companies like telecommunications, breweries, cold rooms to mention but a few.

This system was designed to proffer solution to the shortcomings of the already existing manual changeover by performing power swap from public power to generator automatically and vise-versa. It has the ability to eliminate the stress of manually switching on the generator when there is public power failure.

REVIEW OF EXISTING WORK

To ensure the continuity of power supply, many commercial/industrial facilities depend on both utility service and on-site generation (generator set). And because of the growing complexity of electrical systems it becomes imperative to give attention to power supply reliability and stability. Over the years many approaches have been implored in configuring a changeover system. Some of them are discussed below.

Manual Changeover Switch Box

Manual changeover switch box separates the source between a generator and public supply [4]. Whenever there is power failure, changeover is done manually by human and the same happens when the public power is restored and this is usually accompanied with loud noise and electrical sparks.

Limitations of Manual Changeover Switch Box

Below are some of the limitations of manual changeover switch box.

(i) Time wasting whenever there is power failure
(ii) It is strenuous to operate
(iii) It is causes device, process or product damage
(iv) It can cause fire outbreak
(v) It makes a lot of noise.
(vi) Maintenance is more frequent as the change over action causes wears and tears.

Automatic Changeover System with Electromechanical Relays (EMRs)

A relay is an electromagnetic device that is activated by varying its input in order to get a desired output. Relays are of two types, the normally closed and normally open [6].

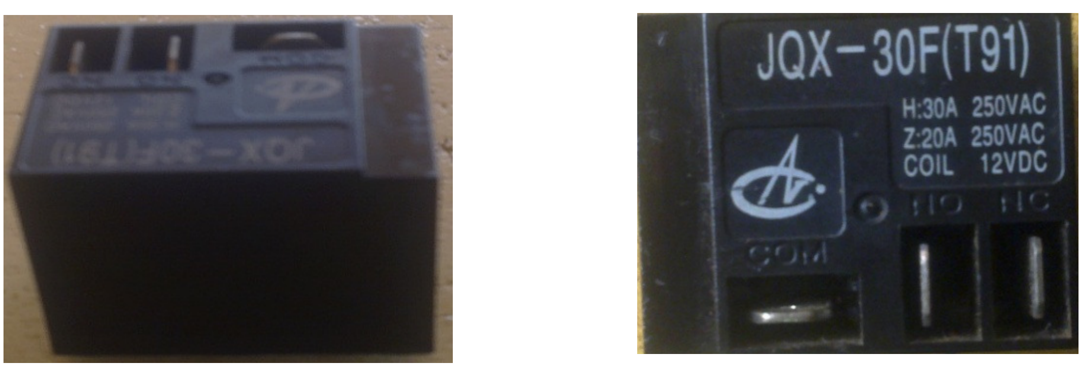

Figure 1. Diagram of electromechanical relays.

Recently, electromechanical relays (EMRs) have been used with other component to implement automatic changeover. Such components can be logic gates, transistors, opto-coupler, microcontroller etc. Most of these components make use of 5v since they are Transistor Transistor Logic (TTL) based. Such control system must be properly isolated from the relay as shown in figure 2 to avoid the flow back of ac signal into the control electronics.

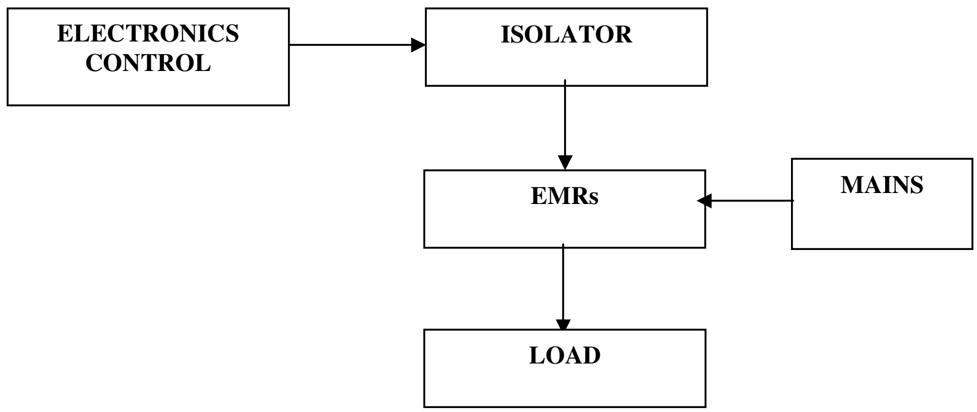

Figure 2. Block diagram of automatic changeover system with electromechanical relay.

This type of changeover system is better than the manual changeover with switch box because it is automatic and faster, but has its limitations which are listed below:

- Noise associated with switching of relays.
- Wear and tear.
- Arching which can cause fire outbreak.
- High Component count making the system more prone to failures.

Changeover with Automatic Transfer Switch

This type of changeover system has an automatic transfer switch [3], which monitors the alternating current (AC) voltage coming from the utility company line for power failure conditions. Upon detection of power failure for predetermined period of time, the standby generator is activated (started), after which the load is transferred from utility to the standby generator. Then, on return of the utility feed, the load is switched back after some time and the generator is stopped. The limitations of this approach are more or less the same thing with automatic changeover system with electromechanical relays.

DESCRIPTION OF THE NEW SYSTEM

In view of the limitations of the above previous works, this paper proposes and implements a change over systems that drastically reduced the shortcomings. The noise, arching, wear and tear associated with EMRs are eliminated totally by the introduction of solid state relay. Digital components were also used to make the work more reliable unlike the previously existing ones that make use of circuit breakers. Also an AT89C52 microcontroller was also incorporated to help improve the speed of automation. The system is controlled by a software program embedded in the microcontroller. This work is handy and portable compared to the bulky works done previously. It also have some important 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. Economically, this project is of low cost due to the use of ICs in place of discrete components.

Description of Solid State Relays

With emergence of semiconductor technology the production of solid state relays were made possible which in many applications out perform their predecessors. A typical solid state relay consists of a light emitting diode (LED) optically coupled to a photovoltaic device such as a Field Effect Transistor (FET). Light from the LED creates a voltage across the photovoltaic array and activates the output FET. FET is the preferred switching element in a solid state relay because it presents comparatively less electric resistant when it is in a conductive state than a triac in the same state and therefore generates less heat[9]. As a result of this, FET requires smaller heat dissipating fins and can reduce the overall size of the solid state relay. The internal circuitry of a typical solid state relay is shown figure 3 while figure 4 is a solid state relay from FOTEK:

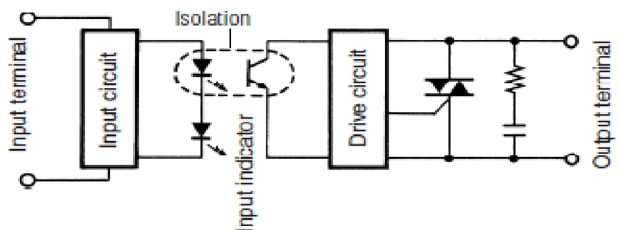

Fig. 3 The internal circuitry of a typical solid state relay

Fig. 4 Solid state relay from FOTEK

Advantages of Solid State Relay over Electromechanical Relay

Solid state relay has the following properties which gave it an edge over the EMR:

(1) It has no moving coil part.
(2) It has long operating life.
(3) Bounce-free operation.
(4) It has immunity to electromagnetic interference.
(5) It has high switching speed

(6) It can be controlled by a low signal (3v).
(7) Multi function integration
(8) No arching or sparking.
(9) No acoustical noise.
(10) High reliability.
(11) Resistance to shock and vibration.
(12) Wide input voltage range.
(13) High input-output isolation [11].

Because of the low signal control feature, solid state relays can be driven directly by the microcontroller without the use of interface drivers. This can save space, time and money, reduce component count as well as improve product life, performance and reliability.

IMPLEMENTATION OF MICROCONTROLLER_BASE AUTOMATIC CHANGEOVER WITH SOLID STATE RELAY

Figure 5 shows the block diagram of the system. The implementation of this system was achieved by using the AT89C52 as the host controller. The microcontroller does the control through the software program embedded in it. The phase, over voltage and under voltage monitoring was achieved using the operational amplifier LM3914 interfaced to microcontroller. LM3914 is a single IC that has ten separate op-amps embedded in it [10].

Below is the summary of the operations of the entire system:

- The microcontroller monitors the mains supply through the phase selector, over/under voltage and mains failure units, and switches the appropriate phase to the load through the solid relay arrangement.

- In the case of total power failure, the system, sustained by back up battery, switches on a single phase generator, whose output is also connected to the load through the solid relay arrangement. The switching of the single phase generator is controlled by the generator control unit.

- In case of starting failure after three attempts, the system sounds an alarm and automatically goes to manual mode (where the user will have to start the generator manually after putting it in order).

- The system connects the load back to utility power and automatically turns off the generator as soon as utility power is restored.

- The liquid crystal display (LCD) displays all the activities of the system, making it user friendly.

Flowchart and Schematic diagram of the System

Figure 6 is a flowchart which represents the operation of the system. With the knowledge of this flow chart, a software program can be written to drive or control the action of the microcontroller. Figure 7 is the expanded schematic diagram of the system drawn in proteus environment. The bank of resistors and op-amps shown in the diagram can be replaced with a single LM3914 IC mentioned previously.

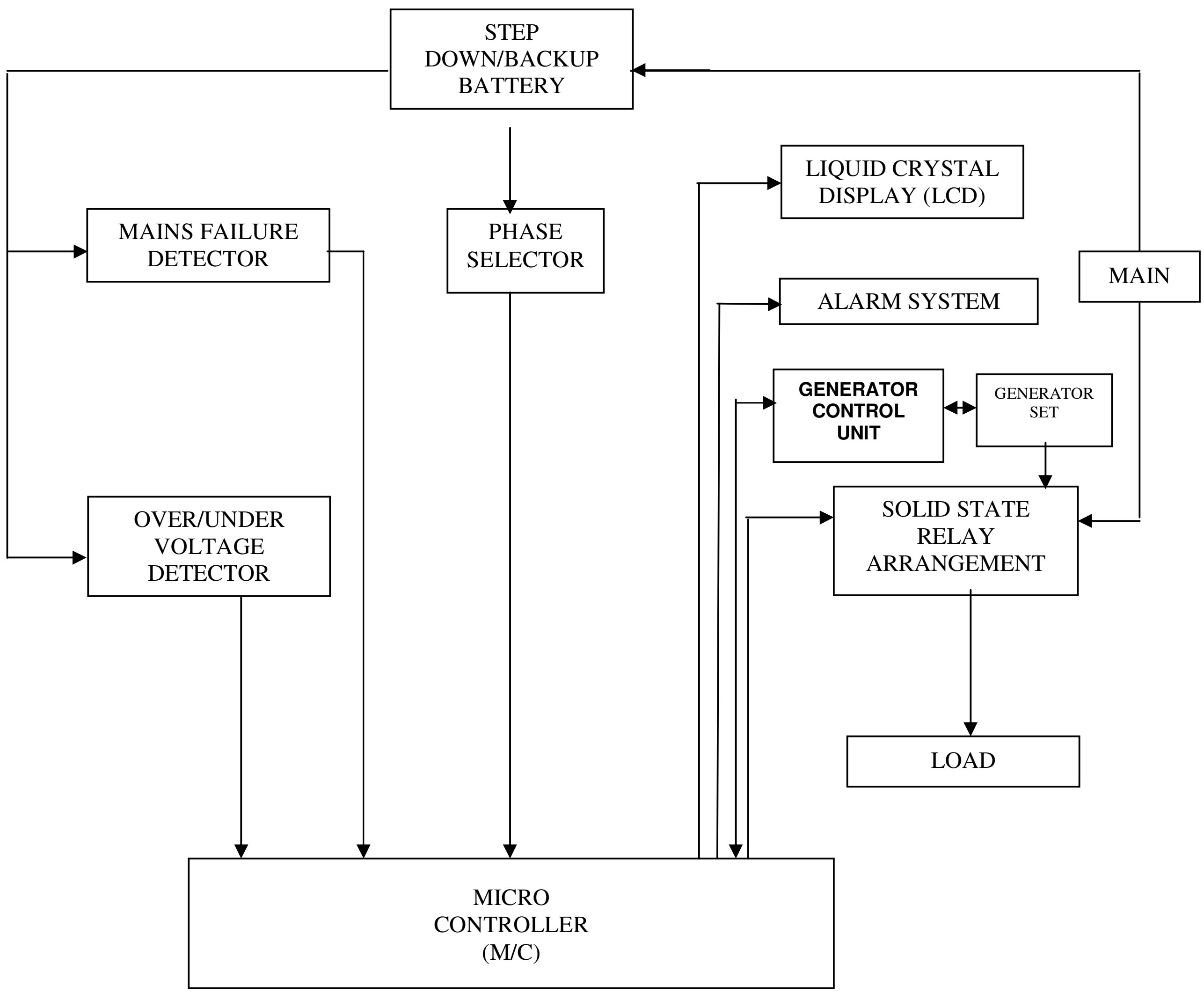

Figure. 5 Block diagram of microcontroller based automatic change over with solid state relays

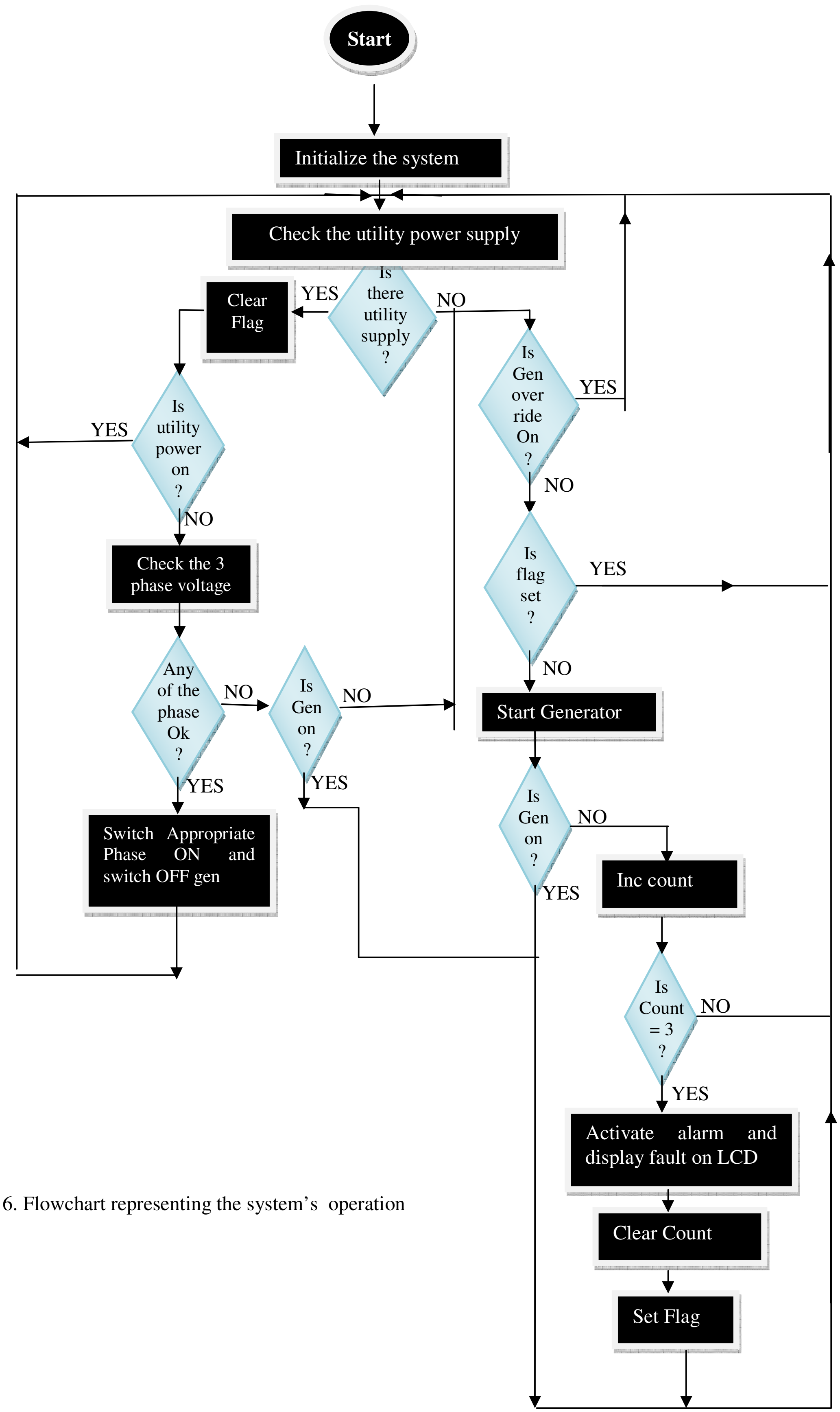

Figure: 6. Flowchart representing the system's operation

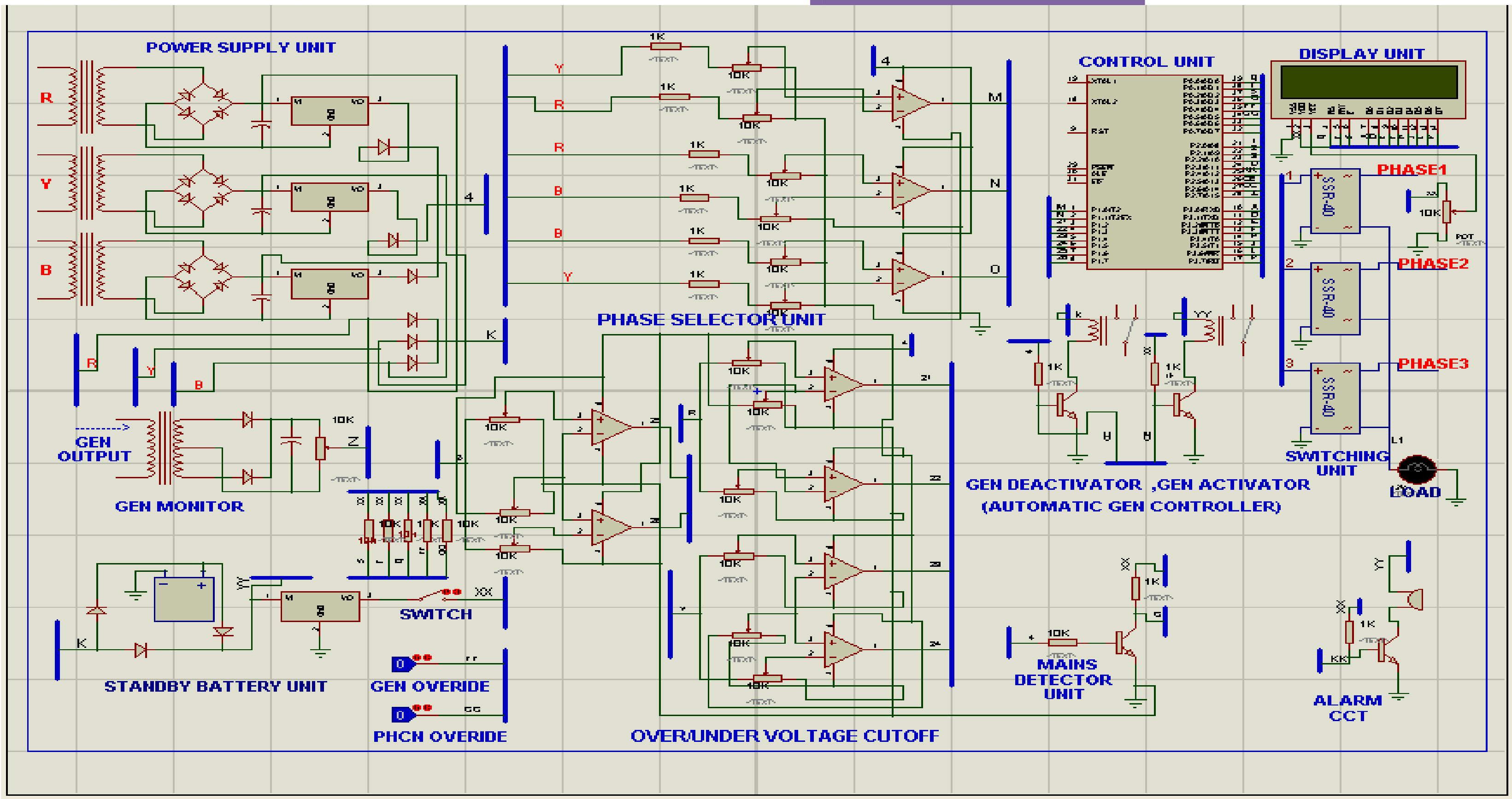

Fig 7: Expanded circuit diagram of microcontroller based automatic change over with solid state relays

TESTING AND RESULTS

Table 1. Summary of tests and results

Testing	Expected Result	Result Obtained
1. Activate the generator override and off the utility power supply	The system should not attempt starting the generator despite the fact that there is no utility supply	The system did not attempt starting the generator.
2. The power supply still off and generator override deactivated	The system should attempt starting the generator.	The system did attempt starting the generator.
3. The power supply still off and generator override deactivated and generator disengaged.	The system should attempt starting the generator three (3) times and then sounds an alarm and display fault on LCD.	The system immediately did start the generator three (3) times and alarm was sounded and the fault was displayed on LCD.
4. The power supply still off and generator override deactivated and generator engaged.	The system should start the generator.	The system actually started the generator immediately.
5. Switch on the utility power supply and activate the utility power override.	The system should not switch on any of the three (3) phases available from the utility supply.	The system did not switch on any of the available three (3) phases available from the utility supply.
6. Switch on the utility power supply and deactivate the utility power override and reduce the mains to 170V using variable transformer.	The system should not switch on any phase but puts on gen if gen is not on.	The system did not switch on any of the available three (3) phases from the utility supply, but switch on the generator immediately when it was not on previously.
7. Switch on the utility power supply and deactivate the utility power override and return the mains to 220V using variable transformer	The system should switch on any of the phase and switch off the gen.	The system switched on one of the phase and puts off the generator almost immediately.

DISCUSSION

From the discussion so far it can be seen that the use of solid state relay in the implementation of microcontroller based automatic changeover has a number of advantages over the other devices used in changeover system implementation. It eliminates all the noise, arching, wear and tear associated with EMRs and manual changeover switch box. The microcontroller with its ability to execute millions of instruction within seconds has also helped to improve the speed of the automation besides miniaturizing the entire system.

AREAS OF APPLICATION

This system can be applied in areas where continuous power supply is needed such as homes, banks, industries, hospitals and so on.

CONCLUSION

This paper has been able to show that solid state relay is a better replacement for electromechanical relays in microcontroller based automatic changeover system. This paper also will definitely be of great help to researchers and students in the matters concerning a better and reliable switching device for automatic changeover system.

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