Design And Implementation Of A Microcontroller Based Power Change-Over Switching System With Generator Shutdown

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***Abstract*— An automatic power changeover system designed and implemented basically disconnects load from its power source and transfers it to a standby power source, in the advent of a power failure. This transfer is done at a very high switching speed such that minimal change occasioned by the transfer process goes unnoticed. It also incorporates a generator shutdown terminal that switches off the generator after the Mains power supply has been restored. This process is controlled by a microcontroller that keeps sensing to detect the availability of power supply on the Main supply line. The system is also fitted with an AC voltmeter that correctly reads the analogue voltage supplied by the power source and displays it on a seven segment display module.**

Keywords*— *Microcontroller; Relay; Switching; Power supply; Decoder

I. INTRODUCTION

Alternative sources of power supply have been recommended due to the epileptic power supply that is short of meeting industrial and domestic demands. This has led to a downward trend in the economy because a robust power supply infrastructure drives the industrial initiative of any viable clime. Automating the power supply process is imperative owing to the value chain it creates [1]. In the event of power failure there is need to transfer control from the main power supply to an alternative source. Most homes make use of power generators to supply electrical energy that would power their homes whenever the supply from the electricity company is cut off. A power changeover switch enables this transfer [2].

Power Change-over switches can be operated manually in order words whenever there is power failure, an individual can shift a handheld lever that would open contact on the main power supply line and close contact on the power generator line. This process consumes time and puts such an operator at risk of electrical hazards. According to [3] manual switching process has led to several deaths and damage to electrical appliances Automating this process has been a key point of many researchers today. This paper seeks to outline an optimal way of automating this process with measurement goal in view.

Electrical loads are outlined as thus [4]

Essential loads: These loads are critical and governed by high switching time.

Critical loads: These loads are the elevators in upscale shopping malls and lightings in medical facilities, markets and banks.

Sensitive loads: These loads require minute power supply examples are computers which requires uninterruptible power supply to protect critical data

The Power Change-Over Switch is a device that detects when the electrical energy from the mains power supply is cut off and subsequently switches on the power generator. Basically it is aimed at switching on a more convenient power supply to the load. Since it switches on power to the load, precautions has to be taken while choosing the type of Change-over Switch, selecting the appropriate size and the control of electrical arcs.

Power Change-over switches incorporates relay contacts that opens or closes in relation to availability and absence of power, a switching mechanism that transfers control from the Mains power supply to the power generator and a system that monitors the conditions that would lead to optimal transfer[5].

A good switch should be the one whose contact is made in such a way as to limit the arc formation by having no contact-bounce and by having contacts made of good conductive, corrosion resistance and wear resistance materials. A good change over switch must have adequate insulation and must be so constructed and located as not to constitute a potential hazard [6].

A good change over switch should also have tight contact points so as to limit or eliminate the possibility of partial contact at the contact point. The partial contact leads to over heating of the components and may lead to fire outbreak in the entire room.

This paper is aimed at designing and implementing a workable automatic change over switch with a phase failure detecting circuit also known as "Automatic Mains Failure" which switches on the head from power the Mains power supply to a generator when power fails and from generator to the Mains power supply when power comes back.

The automatic power change-over unit is operated in single phase system. The automatic change over switch has the following advantages;

a) It minimizes damages to lives/equipment since it has its own monitoring system and its switching requires no human contact with the switch, thus eliminating human error.

b) It reduces its change over timing to the minimum due to its fast response to power outage.

c) It maintains high quality of service through its fast and prompt response.

Moreover, the size and captivity of the unit will depend upon the load for which it will be used. The unit is also portable, easy, convenient and safe to install.

II. Mode of Operation

The unit has the generator power mode as its default mode of supply. Power from the generator keeps powering the load until power from Mains power supply is restored. When the microcontroller detects it, it will automatically be powered on and two transistors are triggered in the process. The transistors are connected to the live and neutral terminals of the Mains power supply. This action unloads the power generator and the load is connected to the Mains power supply terminals. An alarm system that indicates the restoration of power supply from the Mains incorporates buzzer that is triggered by the microcontroller via a transistor. After the alarm goes off, the microcontroller starts counting up to 12s after which it will turn on the transistor controlling third relay to shut down the power generator.

The microcontroller starts reading analogue voltage from the Analogue to Digital Converter section via its analogue to voltage channels, after which it displays the data on the digital section. It repeats this routine every few milliseconds to check if the voltage level has changed, if it changes it reads the new value and displays it but if it has not changed it retains the old data in its internal registers. A block diagram of the system is shown in Fig. 1.

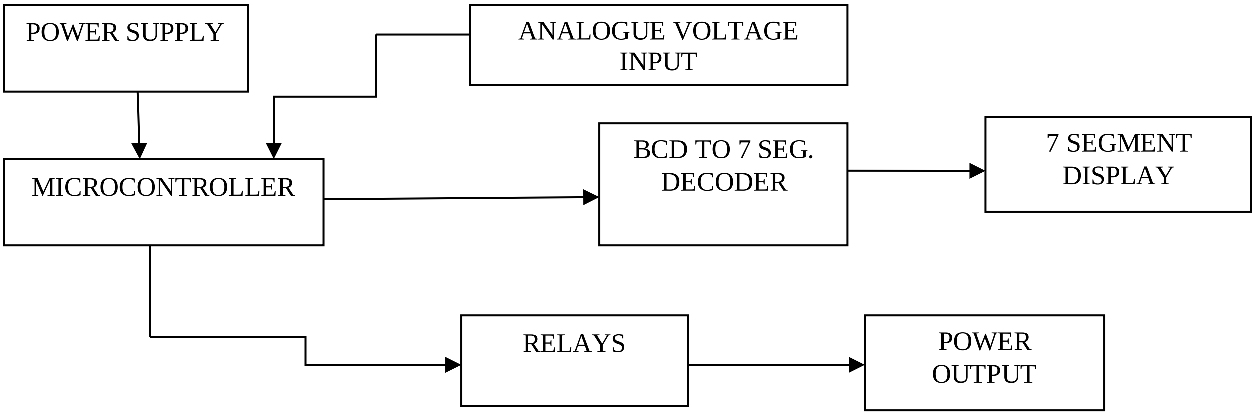

Figure 1: Block diagram of the Automatic Power change-over system

III. Implementation

The Automatic Power changeover-unit was designed for residential buildings, a high amperage relay was deployed for the switching purpose. A PIC microcontroller was used since high speed switching was very imperative, and this PIC was driven with an oscillator of 10MHZ speed, for higher speed switching. A 6 x 6 inches white plastic adaptable box was used to package the unit as shown Fig. 3, since if not properly insulated there will be a high risk of current leakage. Hence, to ensure high insulation of the unit from surrounding objects the above was done to maximize safety.

Figure 2: Plastic package showing display

IV. Hardware Components

The hardware components that are required for the implementation of the Automatic Power change-over system are enumerated

A. PIC16F873A

This the microcontroller used in the design, it has three ports port A , B and C. It has five ADC channels for analogue to digital conversion. It has so many other SFR's (special function registers) . Portb.6 and portb.7 was used in triggering the relays connected to the live and neutral terminal of the power supply, portb.5 was used to trigger the generator shut down relay, portb.0 was used to switch the buzzer, porta.0 was used as the analogue channel, and portc was used for the electronic display.

B. 74LS47

This is a BCD to seven segment decoder, it was used to convert the analogue voltage from its binary format to a seven segment format for display on the screen .

C. Crystal Oscillator

This is a piezo crystal that is used to set the speed of program execution of the microcontroller. it is usually rated in mega hertz, in the design an 8 Mhz crystal was used .

D. C1815

This is an NPN transistor used to drive the various relays and to switch the buzzer. It is all connected in a sink configuration so as to achieve voltage amplification.

E. Relay

This is the electromechanical switch used to transfer control between the power sources that is the Mains power supply and the power generator. The SPDT relay has five terminals.

F. Seven Segment Display

A common anode seven segment display was used because the decoder 74LS47 is only used to drive common anode displays.

G. Bridge Rectifier

This was used in ADC section to rectify the voltage that is going to be measure by the microcontroller, before feeding it to the other components making up the adc section or ac voltage handling.

H. Preset:

Here a 10k ohm preset was used in the ADC section to help in adjusting the measured voltage during the time of callibration.

I. IN4007

This anti spiking diode was connected in an opposite directio to the relay power pins, so as to always short out the back emf that may flow back to the transistor and hence cause damage.

J. PCB

A printed circuit board(PCB) of the unit was prepared so as to enable mass production, PAD2PAD software was used to design the pcb before it was pinted on the board and later etched,drilled and ready to use.

V. Power Requirements

The Automatic Power changeover-unit was designed for residential buildings, a high amperage relay was deployed for the switching purpose. A PIC microcontroller was used since high speed switching was very imperative, and this PIC was driven with an oscillator of 10MHZ speed, for higher speed switching. A 6 x 6 inches white plastic adaptable box was used to

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package the unit, since if not properly insulated there will be a high risk of current leakage. Hence, to ensure high insulation of the unit from surrounding objects the above was done to maximize safety. The power rating of the unit was calculated as follows:

Voltage level of Mains supply : 240v

Ampere rating of the relays used is 40A.

Therefore power = I X V = 9600 WATTS

Therefore the relay contacts and hence the entire unit can support electrical loads that do not exceed the calculated power rating for safe operation. A schematic diagram of the system is shown in Fig. 2 and the PCB configuration is shown in Fig. 3.

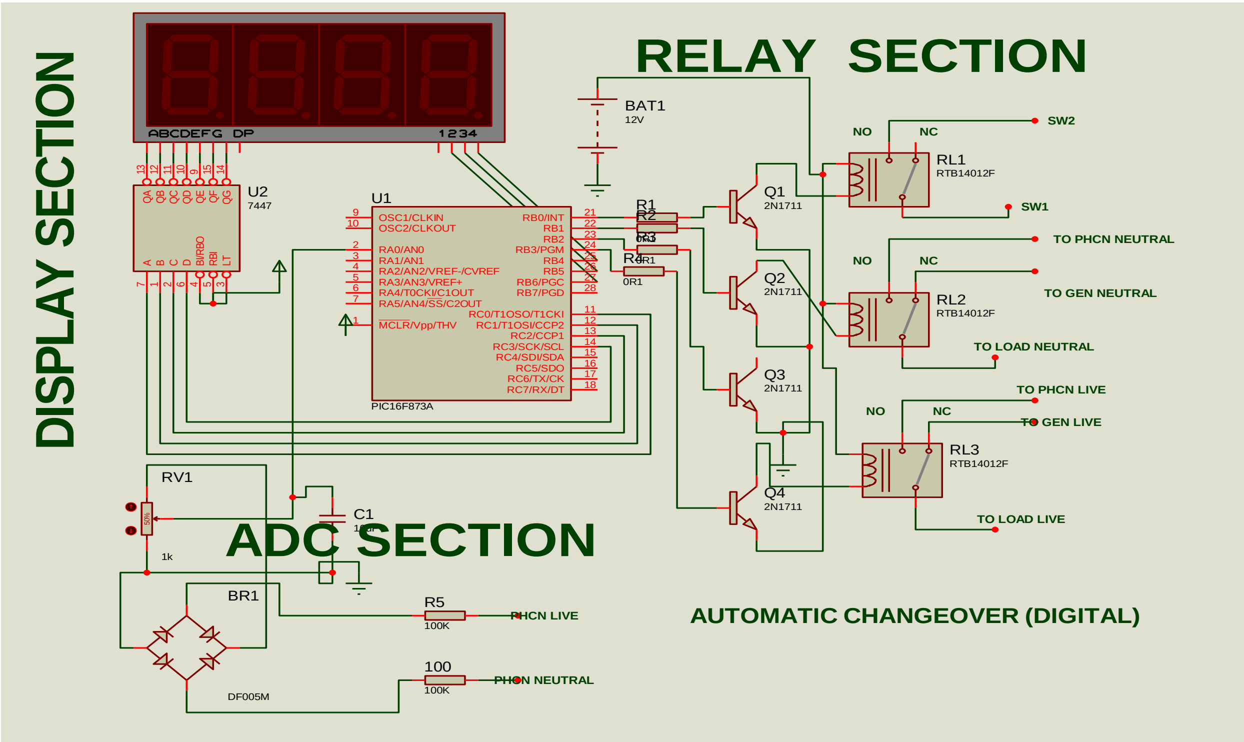

Fig. 3: Schematic diagram of the Automatic Power Change-over switch

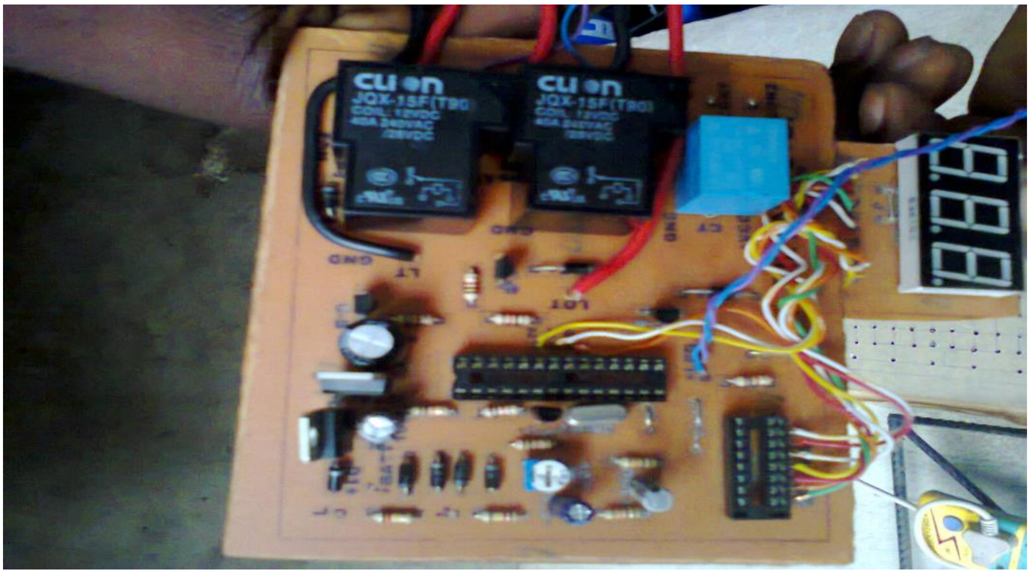

Figure 4: PCB configuration of the system

VI. Programming of the Microcontroller

The language used is BASIC language and the compiler used is Mkrobasic compiler for PICs, version 7.0.0.2. The program is written BASIC and registered as file program.bas, is converted into an assembler code (program.asm) so obtained assembler code is further translated into executive HEX code which is written to the microcontroller memory by a programmer. A programmer is therefore an electronic device used to transfer HEX files from a PC to the microcontroller memory. Beginners All purpose Symbolic Code (BASIC) has long time been known to the PC user to be the easiest, faster and most widespread one. MIKROBASIC enables quicker and relatively easier program writing for PIC microcontrollers in comparison with microchip's assembly language MPASM. For achieving programming, MIKROBASIC contains its own inbuilt commands intended for solving problems often encountered while programming. The programmer used here is K150 PIC PROGRAMMER. It has a USB interface for connecting to the pc. After the program was written it was compiled by the compiler. After compilation the compiler generated the .HEX file which is the only file format that a microcontroller can accept and execute. This .HEX file was now embedded into the microcontroller with the above mentioned programmer.

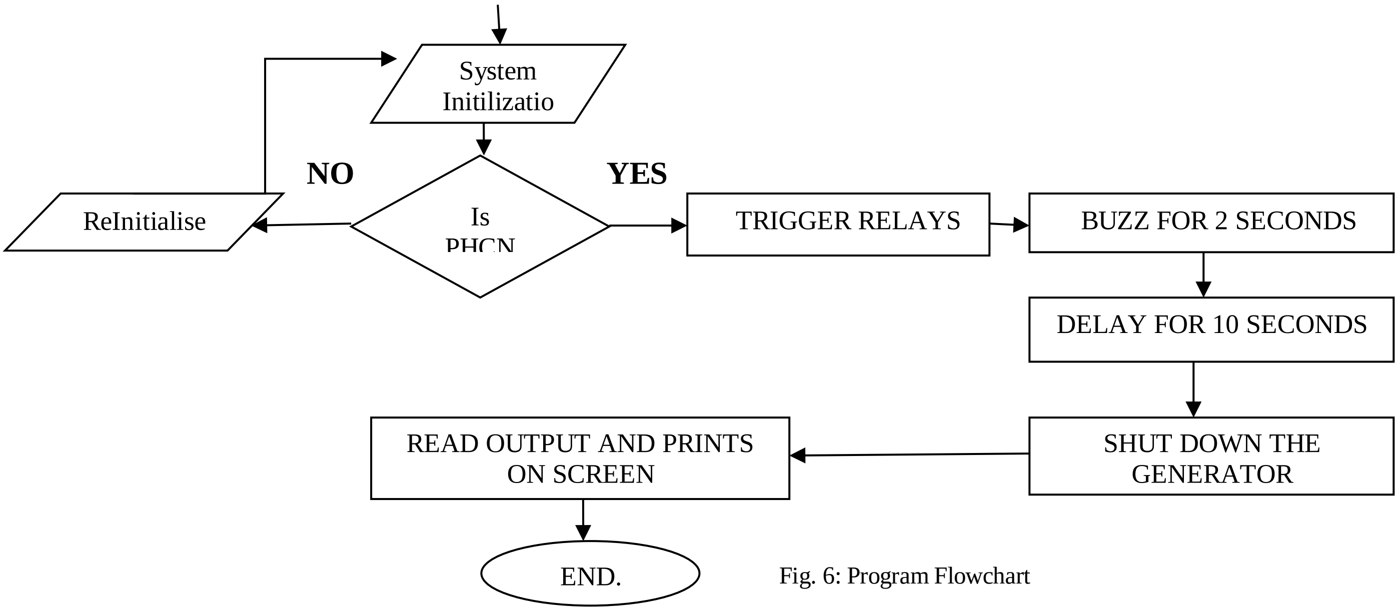

Fig. 6: Program Flowchart

VII. Programming of the Microcontroller

When the public power supply system was restored the microcontroller detected it turned the various relays responsible for changing the power source and buzzed for some time. After which the generator was shut down. The change in the power source was very fast that it was not noticed and hence there was no flickering in the supply neither did the various appliances detect any change. High switching speed are recommended for automatic changeover design so as to maximize efficiency and reliability.

Table 1: System Result

PARAMETER	PERFORMANCE
Switching Speed	< 0.25 seconds
Load Capacity	< 9600 Watts
Voltmeter Reading	< 999 Volts
Buzzer Alert	>70 Decibels
Input Voltage = 240V	Output Voltage = 240V

Conclusion

Automatic change over switch with generator shut down facility has been designed to help reduce the stress and loss of time associated with the manual changing and shutting down of power generators in the advent of failure in power supply. It is worthy to note that this project is subject to scrutiny and further development. We recommend that for future development an overload protection system be included. We also recommend this project to the entire field where electricity is highly needed and even to the small and medium entrepreneurs that the automatic change over switch with generator shut down facility will help them. To the government, we recommend they encourage the mass production of this project.

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