Design and Implementation of Microcontroller Based Programmable Power Changeover

Obasi, Chijioke Chukwuemeka[1*] Olufemi Babajide Odeyinde[1] John Junior Agidani[2] Victor Onyedikachi Ibiam[1] Ubadike, Chiedu Osichinaka[3]

1. Electrical Electronics Engineering Department, Air Force Institute of Technology, Nigeria
2. Aircraft Maintenance Department, Air Force Institute of Technology, Nigeria
3. Research and Development Centre, Air Force Institute of Technology, Nigeria

Abstract

Power failure is a key issue in many developing countries of the world. To sustain development, the need for alternative power supply becomes necessary. Changing between the main supply line and the alternative supply poses yet another problem. Many attempts have been made to develop automatic power changeover but without due consideration of the fact that there could be times when we need to regulate the behavior of the automatic change over. This paper therefore presents the design and construction of microcontroller based programmable automatic power change over. The paper discusses the design, construction and operation of a program controlled power change over system that allows users to select the mode they would prefer to have their change over operate. Three modes were achieved, including auto mode, timed mode and manual mode, which were selected from push buttons. LCD interface was used for the output display. 8051 microcontroller was used to implement the control program while modular methodology was adopted.

Keywords: Microcontroller; power; change over; Programming; Automatic; Relay; Kick start; LCD.

1. Introduction

The role of electric power in everyday need of individuals and nations cannot be overemphasized, especially in this era of the proliferation of consumer electronics and electrical appliances for both home and industrial use. The need is quite obviously on an ever increasing demand.

The global economy depends largely on constant supply of electricity for growth, so nations with poor or epileptic supply of electricity may not develop in this 21st century.

While the era of fluctuation of supply of electricity is long forgotten in many industrialized nations of the world, many developing countries still suffer setbacks arising from incessant power failures. The provision of alternative power source (generators) has no doubt brought succour but not without an attendant challenge associated with manual operation of the changeover (Agbetuyi, Adewale, Ogunluyi, Ogunleye, 2011).

2. Related Works

The related research works are not limited to:

a. Design and Implementation of a 3-Phase Automatic Power Change-over Switch (Roy, Newton & Solomon, 2014). The paper deals with the design and development of 3-phase automatic changeover. The authors designed a system that could detect phase failure and automatically select and switch to a phase that has supply.

b. Design and Simulation of Microcontroller Based Electronic Calendar Using Multisim Circuit Design Software, (Ezeofor & Okafor, 2014). They were able to simulate the use of microcontroller in the development of electronic calendar.

c. Construction of Microcontroller Based Digital Voltmeter (Jony & Rahman, 2014). In their study, the authors developed a digital voltmeter using PIC microcontroller that could measure and display up to 220 V on a 7-segment.

The work according to Agbetuyi *et al.* (2011) however attempted to solve the problem with the manual changeover between the public supply and the secondary supply with an automatic changeover.

Automatic power changeover, according to Roy, Newton and Solomon (2014), is meant to identify fluctuation on the public supply line, start the generator and switch the load to the generator's output. It is also meant to identify when power is restored on the public supply line again, switch to it and turn off the generator.

Yet again, some problems are being envisaged with the performance of the automatic power changeover. Users of the automatic power changeover may want to regulate the use of the generator based on some conditions, such as how long the generator should stay on and what time of the day the generator should be used or not used. In places where power outage lasts for a long time (days or weeks), this becomes necessary in order to limit the utilizations of the generator's utilities like fuel and reduce maintenance cost.

Hence the concept of the design and implementation of microcontroller based programmable power changeover is presented in this paper. This aims to use the power of microcontroller in the design of control logic that will perform the duties of detecting power failure, switch between lines and also provide the programmability functionality by deploying the input/output and storage feature of the microcontroller.

3. Methodology

Modular division methodology was adopted in the design and construction of the system. The following modules were implemented:

Figure 1 shows the block diagram of the system. The control logic unit consists of the microcontroller and the control program running in its memory. The mode select switches block represents the switches used for selecting the mode of operation of the system. The changeover actuator block represents the relay that does the switching over between the generator line and the mains line. The main supply monitor block represents the circuit that monitors the presence or absence of power on the main supply line. The feedback block performs the function of monitoring the output to ensure that proper switch over was done. The LCD is a display unit that shows the activities of the user during operation. The kick start actuator switches kick start of the generator to turn it on.

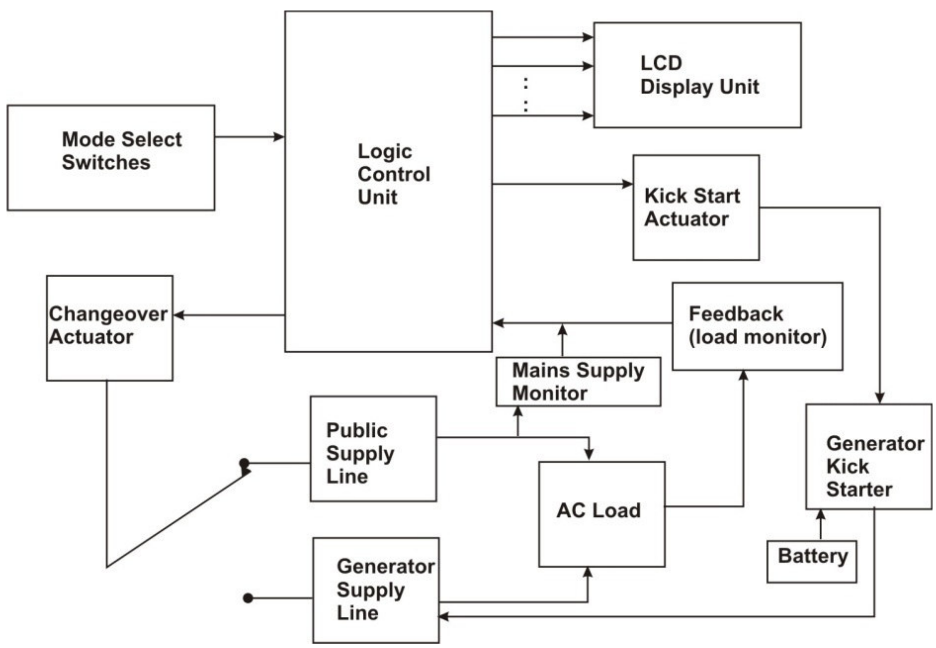

Figure 1 System Block Diagram

a. Microcontroller Unit
b. Mode Select Switched
c. Changeover and Kick start Relay circuits
d. Feedback (voltage sensor circuits)
e. Control Logic

3.1 Implementation of the Microcontroller system

AT89S52 microcontroller was used in this implementation. Before using this chip for any function, some necessary circuitry must be installed. These include the reset circuit and the clock circuit. Fig. 2 shows the microcontroller pin configuration and reset and clock circuits. The reset pin (Pin 9) is connected to Vcc through C1 capacitor. This implements a power up reset of the microcontroller. Pin 31 is connected to Vcc to enable the chip execute program instructions from the internal ROM. Pins 18 and 19 connect 11 MHz crystal through two 30pf capacitors in parallel to provide clocking trigger. The value of the crystal determines the operations cycle of controller (that is time spent in computation of 1 instruction) and is given by 4T [4], where T is the period. Therefore, for 11MHz crystal,

$$T = 1/f = 1/11 = 0.09 \text{ us.} \qquad (1)$$

So 1 machine cycle = 4*0.09 = 0.36 us.

The IO pins were also used to interface other component parts, while the hexadecimal form of the control program codes were stored on the Programmable Erasable ROM (Ezeofor. & Okafor, 2014).

3.2 Implementation of the Mode Select Switch

Figure 3 shows the mode select circuit implementation. The circuit has four push button switches for selecting the various modes and functions. The outputs of the switches were connected to the port P1 of the microcontroller. The pull up resistors enables the pins to toggle their values each time they were pressed. Program delay routine was used to control bouncing effects on the switches.

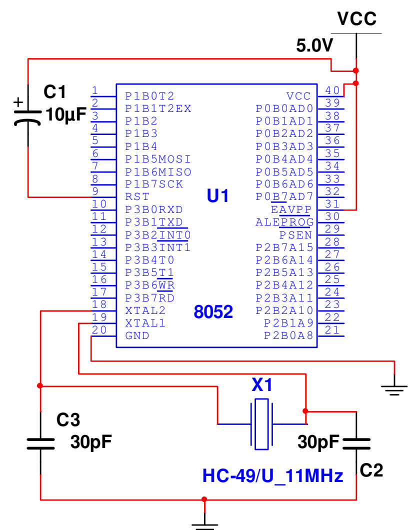

Figure 2 AT89S52 Circuit Implementation

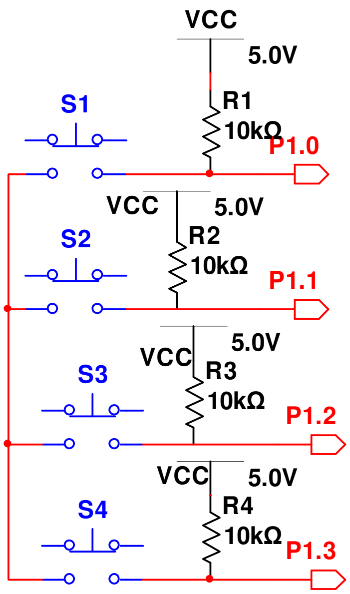

Figure 3 Circuit Implementation of Mode Select Switches

3.3 Implementation of Feedback or Voltage monitor circuit

The feedback circuit is used to monitor the voltage output at the public supply line and the load. The signal is used by the microcontroller to determine the presence of sufficient voltage at those stages. The circuit is as shown in figure 4 below.

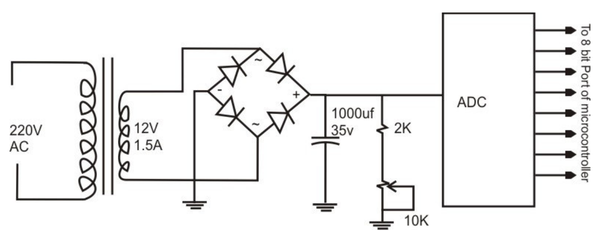

Figure 4 Voltage Detector

The circuit includes a step down transformer that steps voltage down to 12 V from 220 V. The voltage is further conditioned to produce DC voltage within the range of 0 to 5 V. This output varies in response to the fluctuation at the transformer input. 0 V at the output means complete power outage. If the input voltage drops below 180 V, the system detects that as fluctuation and would need to change over to alternative source. The ADC converts these analog processes to digital values that the microcontroller would be able to process.

3.3 Implementation of Changeover Switch

The changeover consists of a relay coupled to the collector of transistor in common emitter mode. This configuration switches between the generator and public supply lines, making use if the normally open and normally closed terminals of the relay. The base of the transistor is connected to the microcontroller through a biasing resistor, Rb. A diode is connected across the 12 v line and the collector in reversed biased mode to prevent back EMF that might be generated from the relay coil. The circuit is shown in fig. 5 below. VCE = 0 v when the transistor is saturated. VBE = 0.6v (silicon), Vin = 5 v (voltage from microcontroller), hfe = 100, RC being the relay resistance is 400 Ω, load voltage is 12 v Rb is given by

$$I_C = \frac{V_{Load} - V_{CE}}{R_C} \qquad (2)$$

$$hfe = \frac{I_C}{I_B}$$

$$\therefore hfe = \frac{V_{Load} - V_{CE}}{R_C I_B} \quad (3)$$

$$I_B = \frac{V_{in} - V_{BE}}{R_C}$$

$$R_b = \frac{hfe * R_C (V_{in} - V_{BE})}{V_{load} - V_{CE}} \quad (4)$$

Hence, R_B = 100 * 400 (5-0.6)/12-0 = 14666.67 Ω

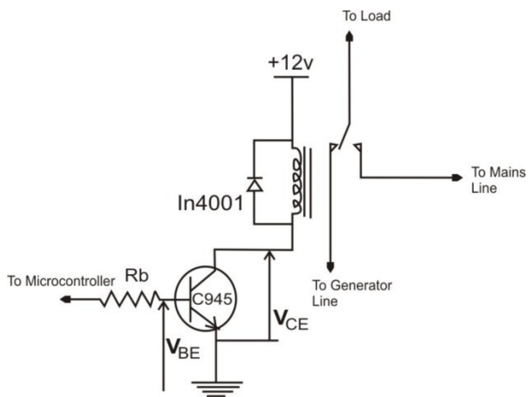

Figure 5 Changeover switch configuration

The kick starter uses the same circuit to switch the generator ON or OFF

3.4 Implementation of Control Logic

The control logic was implemented in the control program, written in Bascom basic. Major components of the control program were the voltage measurement, changeover control and the kick start control.

3.4.1 Voltage measurement

The following algorithm was used to measure and calibrate voltage measurement:

1. Make CS=0 and send a low to high pulse to WR pin to start the conversion.
2. Now keep checking the INTR pin. INTR will be 1 if conversion is not finished and INTR will be 0 if conversion is finished.
3. If conversion is not finished (INTR=1) poll until it is finished.
4. If conversion is finished (INTR=0), go to the next step.
5. Make CS=0 and send a high to low pulse to RD pin to read the data from the ADC.
6. Compute voltage value and display on LCD
7. Go to step 1.
2. Kick Starter

3.4.2 The kick starter follows this algorithm:

1. Read the output voltage sensor on the mains
2. If voltage <= 0 then send logic 1 to kick start port
3. If kick starter is on read the voltage sensor on the generator output line
4. If the voltage is present in the output of the generator stop kick starter

3.4.3 Changeover Control Algorithm

1. Read the status flag of mode selected by user

2. If the status flag is auto, turn on the changeover switch
3. If status flag is timed, measure selected time before switching over
4. If flag is manual, wait until user turns on changeover switch

4. Results and Discussions

Each module of the system was implemented, tested and integrated before testing the entire system. The system was tested with a 60 watts bulb as the load. First, the microcontroller was wired up and tested for continuity. The second module was the voltage sensor circuit, which was implemented and the output voltage measured and controlled until the required range of DC voltage was obtained. This output was interfaced with the ADC0804 for digital signal processing. The 8 bit output pins of the ADC were further interfaced with the IO port of the 8051 microcontroller. The changeover switch circuit was implemented and tested by passing biasing voltage to the base of the transistor to ensure that the relay was switching fine. This was tested Ok and interfaced to the port of the microcontroller. The last stage of the implementation was the programming. During this time, control logics were developed via program codes by implementing the algorithms. Each segment of the code was tested and any bug found during testing was debugged. The routine of testing and debugging continued until the system perfumed as expected. The final test was done by connecting the system to a generator with start switch and a 240 V AC line as mains. Result showed that when a user selects Auto Mode, and the mains turned off, the system started the generator and automatically changed over to the generator line. When a user selected Timed mode, and the mains turned off.

5. Conclusion

The design and implementation of programmable power changeover has been implemented in this paper. The technology will upon the automation of the existing change over system, add some intelligence to automatic power changeover by allowing user to choose the mode they want their automatic systems to operate on. The present system has improved the existing automatic and manual power change over.

References

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