Design and Implementation of a Microcontroller Based Auto-Switch Power Controller

Abideen A. Akanni, Abdulahi A. Badrudeen*, Ojo A. Oluwaseun and Kudirat O. Jimoh

[1]Department of Computer Engineering, Federal Polytechnic Ede, Nigeria
*aabadrudeen@graduate.utm.my

Abstract—*A number of cases have been reported where buildings were burnt down as a result of overheating of electrical household appliance(s) such as electric heater, electric cooker, which eventually led to explosion. Apart from that, the wastage of electrical energy and the damages associated with the manual switching of the household electrical appliances is a great concern which calls for immediate intervention. The above assertion prompts us to embark on developing an automation system. This paper therefore discusses a Microcontroller-Based Auto-Switch Power Controller (MBASPC) with an in-built timer as a better alternative that supercedes the manual switching of the household electrical appliances. It is configured to operate in single mode and dual mode. When in single mode, the OFF time duration is only required after which the device cuts off power supply from the connected appliance. When in dual mode, the ON/OFF time duration and connection modes are set while the device switches after each time duration elapses. Both the switching time and the mode can be reset and changed at any time by using the press buttons. The time duration and connection modes are displayed on the Liquid Crystal Display (LCD) while a 12V, 20A relay is used to switch the connected appliance(s). P1C16F377A Microcontroller is used to carry out the task and it is programmed in C language using Mickro C. The designed MBASPC capacity is 4KVA, specifically to power low load household electrical appliances. The device was tested and performed as expected.*

Keyword— Electrical energy, Household electrical appliances, Microcontroller, Time duration, Liquid Crystal Display

1 INTRODUCTION

Electrical energy is rated as one of the greatest leading factors that drives any economy to substantial growth and development (Gbadebo and Chinedu, 2009). (Theophilus, Christoper *et al* 2016) opined that one importance of power supply is the fact that it has become equally indispensable as food supply. Energy is a necessity for both industrial and economic survival. In Loko's word (2009), electricity is the driving engine of any economy of the word. Aladejare (2013) posited that apart from serving as a pillar of wealth creation in Nigeria, electricity is also the nucleus of operations and subsequently the engine of growth for all sectors of the economy.

Today, electricity plays crucial role in the growth and development of any nation in the world and its continuous availability guarantees the country's growth. This makes it a very important factor in developing the economy and the standard of living of a country (Adeel, Mian et al., 2016)

It is quite unfortunate that in most developing countries especially Nigeria, users of electricity are faced with the challenges of optimising electricity usage consequent upon human factors. Some household appliances are sometimes left connected to power supply for a longer period of time than necessary thereby wasting resources. A number of cases have been reported where buildings were burnt down as a result of overheating of electrical household appliance such as electric heater, electric cooker, boiler, which eventually led to explosion (Emmanuel, Samuel *et al*, 2016). In the same vein, some sensitive electronics devices like Laptop, smart phone and other valuable electronics devices are sometimes left overcharged resulting in early damage of the device(s).

In the light of aforementioned, it is highly important to control the misuse of electrical energy at homes as well as in industries. Hence, the need for automation system. Automation is the technology through which a process or device is controlled with little or without human intervention (Groover, 2014) and Rifkin(1995)..This brought about the design and implementation of a Microcontroller-Based Auto-Switch Power Controller (MBASPC) as a better alternative device that supercedes the manual switching of the household electrical appliance(s). MBASPC prevents the wastage of electrical energy by ensuring the appliance consumes electrical energy only when required thereby minimizing the cost of electrical power consumption, protecting the appliance(s) and directly or indirectly preventing the electrical fire hazard.

2. METHODOLOGY

The design involved hardware module and software module. The hardware module comprises sub-modules such as the power supply unit, microcontroller unit, display unit and switch unit. All these units work together to form a single device. The software module consists of the programming language MickroC used in the design as shown in figure 1.

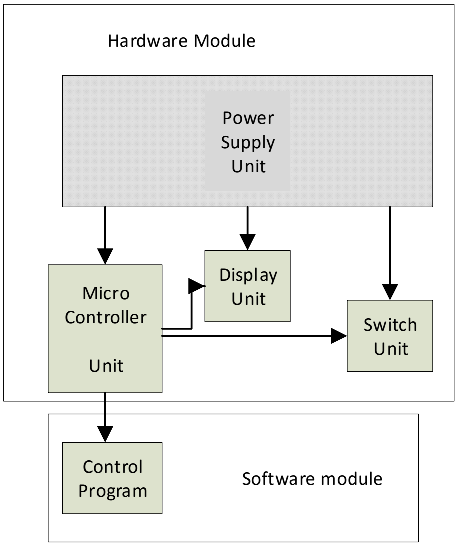


Fig.1: Block diagram of the designed project.

2.1 Hardware Module

2.1.1 Power Supply Unit

The microcontroller unit and the display unit are powered by a +5V d.c fixed regulated power supply using 7805 while the switch unit is powered by +12V d.c fixed regulated power supply using 7812. The power supply unit consists of: 220V/12V a.c step down transformer, Full wave bridge rectifier, +5V d.c regulator (7805), +12V d.c regulator (7812) and 2200µF Electrolytic capacitor

The 220V a.c mains power supply is stepped down to 12V and the bridge rectifier rectifies the a.c to d.c. Rectification is necessary for the purpose of converting a.c voltage to d.c voltage in order to supply power to the other units.

The capacitor is responsible for filtering any ripple coming out of the rectifying stage before it gets to the input of the regulator. There are two regulators in the circuit for regulating and maintaining a stable d.c output. The regulators used are the 7805 integrated circuit which provides +5V regulated d.c for the microcontroller unit and the display unit, and the 7812 integrated circuit which provides +12V regulated d.c for energizing the relay.

2.1.2 Microcontroller Unit

This unit consists of the buttons for the configuration of the device, and the PIC16F877A microcontroller which contains a set of instructions required in controlling the device. In modern day technology, electronic circuits involving microcontrollers are first simulated using computer software, before eventual implementation. A typical simulator application is The Proteus used for this project

The microcontroller has all the support chips incorporated inside its single chip and operates on a set of instructions (or the user program) stored in its memory. The microcontroller fetches the instructions from its program memory one by one, decodes these instructions, and then carries out the required operations.

2.1.3 Display Unit

This unit comprises 2x16 Liquid Crystal Display (LCD) which displays the countdown time and connection mode set by the microcontroller for the device. Liquid-crystal display (LCD) is a flat panel display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly. This module is monochrome and provides a 14-pin connector to the microcontroller

2.1.4 Switch Unit

This unit consists of the relay that is used to control the ON/OFF switch of the device. A 12V, 20A relay is used to achieve this. Relays are remote control electrical switches that are controlled by another switch, such as a horn switch or a microcontroller as in a power train control module. Relay allows a small current flow circuit to control a higher current circuit. Relay can process high power required to directly control an electric motor or other loads. Solid-state relays control power circuits with no moving parts, relays with calibrated operating characteristics have multiple operating coils that are used to protect electrical circuits from overload. In modern electric power systems these functions are performed by digital instruments still called protective relays

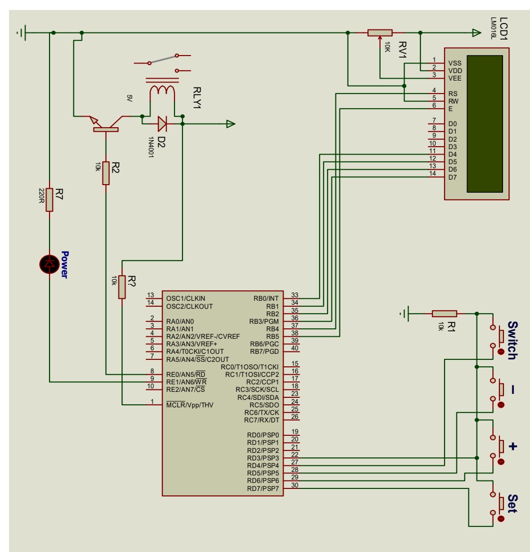


Fig. 2: Circuit diagram of the MBASPC

2.2 Software Module

The Microcontroller is nothing without the programming language. To accomplish any task on a microcontroller, there must be a set of explicit instructions. A collection of such instructions is called a program. The software module involves the programming language MikroC Pro-for-PIC, simulator (Proteus), and the integration of the microcontroller and program file (Hex File) using programmer. The choice of MickroC, for this project, is born out of the fact that, it is a portable language that requires minimal modification when transferring from one processor to another and also convenient for programming microelectronics.

2.3 Principle of Operations:

The buttons connected to the microcontroller perform various functions. The ON/OFF button is used to switch on and off the MBASPC. The select button is used to move the cursor to hour or minute before the time is been set. The enter button is used to send the selected time to the integrated circuit (IC) and start button commences the countdown. MBASPC has an in-built timer which does the countdown. Lastly, reset button is used to reset/restart the MBASPC device. The MBASPC has two terminals, one terminal is connected to the mains power supply while the device to be controlled is connected to the other end of the MBASPC. It is configured to operate in single mode and dual mode. When in single mode, the OFF time duration is only required after which the device cuts off power supply from the connected appliance.

When in dual mode, the ON/OFF time durations and the connection modes are set while the device switches after each time duration elapses. The switching time can be reset at any time using the press buttons while the mode can be changed anytime using the press buttons. The time duration and connection modes are displayed on the Liquid Crystal Display while a 12V, 20A relay is used to switch the connected appliance. PIC16F877A Microcontroller is used to carry out the task and it is programmed in C language using MikroC-Pro-for-PIC

2.4 Soldering of the Components on the Circuit Board

The tools used in soldering are a soldering iron, soldering flux and solder. The soldering iron bit is cleansed before and after use. The soldering iron tip is rubbed on a damp sponge after each solder.

During soldering, the surfaces were cleansed using soldering flux and the amount of heat was properly controlled, too much heat usually results in damage of components while insufficient heat results in dry joint which prevents the conduction of electricity.

3 SYSTEM TESTING AND RESULTS

The designed system was tested in order to ascertain its functionality. The instruments used include but not limited to digital multimeter, continuity tester etc. The various forms of tests that were carried out on the designed system are discussed in the next subsection

3.1 Out of Circuit Test

This refers to the test carried out on all the components used in the designed system before they are mounted on the board in order to ascertain their working condition. LEDs and resistors on the display module were tested using multimeter. The power supply unit voltage and current were measured with multimeter to verify the stabilization of the unit. Table 1 shows the output of the voltage and current

Table 1: Voltage and Current Output

Parameters	Voltage(Volts)	Current(Amps)
Input Voltage to the Transformer	220.00AC	
Output Voltage to the Transformer	9.00AC	
Output Voltage/current after Rectification	9.34DC	1.00
Output Voltage/current after Regulation	5.00DC	0.50

3.2 In–circuit Test

This test was carried out in order to confirm whether there is short circuit, open circuit, or no continuity in the circuit by using digital multimeter.

Short circuit test: When short circuit occurs, a very high current flows through the circuit which may tend to burn the component as a result of excessive heat that will be generated. When digital multimeter was used, nothing of such occurred.

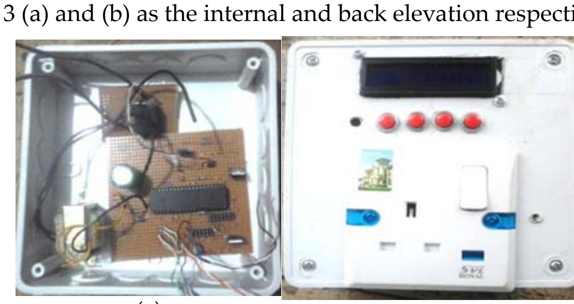
a. Open circuit test: No current flows in any open circuit. The implication is that there is a fracture or opening in the circuit. We did not experience it when tested with multimeter.
b. Continuity test:. The test was carried out on the various cables to confirm if there is any broken wire, by switching to ohm range the continuity tester. The instrument also certified the continuity test.

3.3 Testing the implemented device

It is very important to test the designed project to ascertain its functionality. The pin 11 and pin 12 of the microcontroller were fed with the required voltage 0V and 5V respectively while the circuit was observed to see how it worked. It is necessary that a supply voltage of 5V is maintained, otherwise, the voltage regulator is checked. Also, the microcontroller unit was tested using the control program, the display unit and the power supply unit were not left out in testing. The control program and the hardware soldering were checked, corrected until the system worked as expected.

4 PACKAGING

The device is housed in a plastic casing for proper compacting. The images of the device are shown in Figures 3 (a) and (b) as the internal and back elevation respectively.



(a)

Figure 3: Internal Packaging of the circuit board (a) and the front view of the implemented device (b)

5 MBASPC and the existing Power Controller Systems

MBASPC is an improvement on Auto-Switch in TV set and some modern electric kettles which are configured to operate in single mode in which the off time duration is only required after which the Auto-Switch Power controller cuts off power supply. However, MBASPC is also configured to operate in dual mode in which the ON/OFF time duration is required whereby the MBASPC switches after each time duration elapses. Another aspect that can be compared with the MBASPC is the fixed delay in stabilizer to a predetermined time. The delay in MBASPC is not fixed. It is programmed in such a way that the delay can be reset or changed from time to time by the user. Apart from stabilizer, phase control circuit for power control in microwave oven involved repetitively triggering of the Triac at some fixed point. Power controller in the aforementioned systems cannot be compared with the MBASPC device in all ramifications.

6 CONCLUSION

Microcontroller-Based Auto-Switch Power Controller with an in-built countdown timer has been designed and constructed to control low load household electrical appliance(s) in such a way that it prevents the wastage of electrical energy by ensuring the appliance(s) consumes electrical energy only when required thereby minimizing the cost of electrical power consumption, protecting the appliance(s) and directly or indirectly preventing the electrical fire hazard. It is capable of controlling more than one household electrical appliance provided the total power of the appliance(s) is not more than 4.4kw which is the maximum power of the device. It has been tested and worked as expected.

7 RECOMMENDATION

MBASPC has same off time duration for all connected household electrical appliances. Future work can focus on a design that can have different off time durations for a set of connected appliances.High value components capable of enabling the designed system control very high loads should also be incorporated in order to make the system more functional in its modus operandi.

REFERENCES

[1] Adeel A., Mian R (2016). Design and Implementation of Cost Effective Automatic Transfer Switch, International Journal of Engineering Research and General Science. Vol.4, issue 5, September-October, 2016.

[2] Theophilus I, Christopher K. et al. (2016). Electricity Consumption and Industrial Production in Nigeria, Journal of Policy and Development Studies, vol. 10, No2, May 2016.

[3] Gbadebo O. & Chinedu O (2009). Does energy consumption contribute to economic Performance? Empirical evidence from Nigeria, Journal of Economics and International Finance Vol. 1 (2), pp. 044-058, July2009.

[4] Aladejare S. (2013). Energy use and Economic Performance in Nigeria: An Empirical Study from Petroleum, Electricity and Dry Natural gas. International Journal of Physical and Social Sciences.http://www.ijmra.us, vol.3, issue 12.

[5] Groover Mikel (2014). Fundamentals of Modern Manufacturing Materials processes and Systems.

[6] Emmanuel K.A., Samuel K. et al (2016) Trend of Fire outbreaks in Ghana and Ways to prevent these incidents. Occupational Safety and Health Research Institute Published by Elsevier. An open access article under the CC BY-NC-ND license (http://Creative commons.org./license/sby-nc-nd|4.0|)

[7] Rifkin, Jeremy (1995) The End of Work: The Decline of the Global Labor Force and the Down of the Post Market Era. Putman Publishing Group pp 66 - 75.

[8] Bernstein, G. H. (2009). "Microcontroller Applications", Microsoft® Encarta® 2009

[9] Choudhary, H. (2014). Microcontroller Programer/Burner. Online article at http://www.engineersgarage.com/tutorials/ microcontroller-programmer- burner.

[10] Grindling G. and Weiss B. (2007). Introduction to Microcontrollers

[11] Paul, H. (2000). The Art of Electronics. London: Syndicate of the University of Cambridge.

Sudhakar K. S., A. A. Anil, K. C. Ashok and S. S. Bhaskar, (2013) Automatic Street Light Control System, International Journal of Emerging Technology and nj7Advanced Engineering.