IMPLEMENTATION OF AN INTELLIGENT ENERGY SAVING SYSTEM

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ABSTRACT

With the current increase in the tariff of electricity in Nigeria, there is need to efficiently regulate power consumption so as to reduce its overbearing cost effect. This paper has presented a robust intelligent energy saving system that will efficiently regulate power consumption for domestic use. In its implementation, a microcontroller and series of sensors (e.g PIR, LDR and temperature sensors) have been used to realize the set objective. The design work was initially simulated on an electronic simulator software 'PROTEUS' before being assembled on electronic breadboard and later transferred onto a PCB. When put into test, it was found to perform satisfactorily within the limit of our experimental design.

Keywords: passive infrared sensor (PIR), light dependent resistor (LDR), Smart System, Microcontroller, Energy Saving, Printed Circuit Board (PCB).

INTRODUCTION

Due to the menace of oil and gas pipeline vandalism in recent times, Nigeria as a country experienced a massive drop in generated power by 1000Mw bringing the current generated power in the country to about 2,500Mw as against the peak demand of 12,800Mw. This development, in addition to the ever increasing tariff of electricity consumption has necessitated the need for an intelligent energy saving system that will efficiently regulate power consumption in Nigerian homes. The conventional way of switching OFF lights for a period of time in order to save cost, comes with some sort of discomfort. This intelligent device can make smart decision based on data gathered or obtained from the environment. It will check the intensity of illumination within the designated area coupled with human presence, and then, decides whether to turn light ON or OFF. Many research works in the literature (Arun et al. 2013 and Hsu et al. 2010) had presented different models aimed at addressing similar challenges. In his work, (Arun et al 2013), a light controlled system (LCS) was presented which can minimize the energy consumed for lighting in a room. In furtherance to this, our paper has taken into account other electrical and electronics home appliances where energy can as well be saved. These appliances include electric fan system, air conditioning system, and water heater among others. Using appropriate sensor networks, the environmental conditions where these appliances are used will be continuously monitored and the data sent to a microcontroller unit which in turn uses these data as a basis for either switching ON or OFF the appliances. The overall effect is that energy is efficiently utilized and saved while the intended purpose for which these appliances are used in the first place is not compromised.

System Design & Implementation

The intelligent energy saving system was built around a portable, low current consumption PIC 16F877A microcontroller chip which acts like the brain of the system. The choice of the microcontroller used was informed by the sufficiency of its output ports without having to use a decoder or multiplexer, the internally built analog to digital converter (ADC) and the flexibility with regards to programming and reprogramming. The overall circuit performs sensitive job of detecting infrared light emitted by man, ambient light and the room temperature. These data are then used by the microcontroller to make decision on the right time to switch ON/OFF the home appliances with the help of the driver software. The driver software is a program written in assembly language. A typical block diagram of the energy saving system is as shown in Figure 1.0

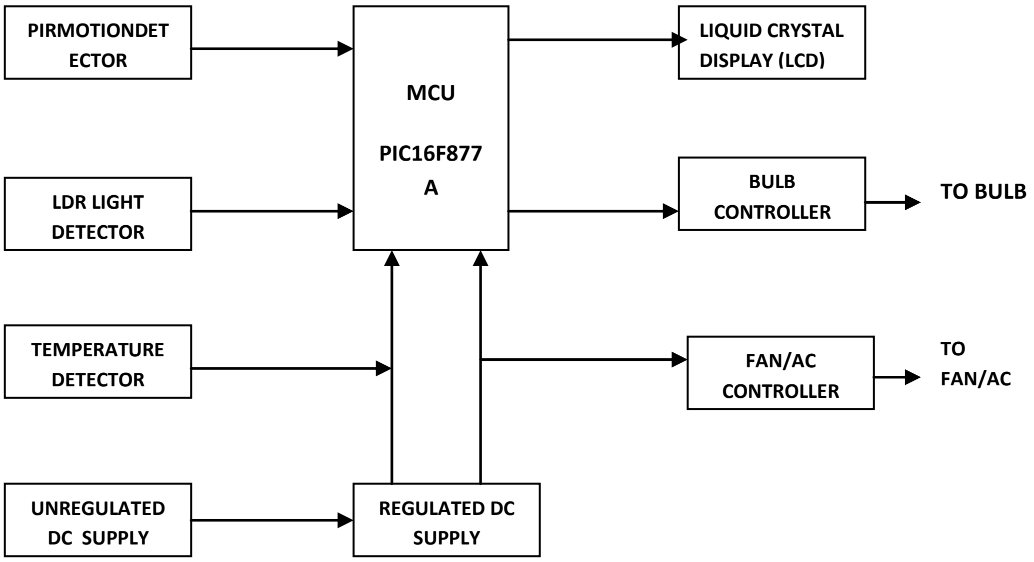

Figure 1.0 Block diagram of intelligent energy saving system.

As seen in Figure 1.0, the power stage consists of two sub-stages: the regulated and unregulated DC supply. Mains voltage is fed into the unregulated power stage which is realized by a 220 Va.c – 18 Va.c step-down transformer, diode as a rectifier and a filtering capacitor.The unregulated power stage is designed to produce about 12.7 Vd.c output. This voltage is used directly as 12V relay energizing voltage and also as supply input to the 5 V regulated supply stage. The 5 V regulated D.C supply is achieved with LM7805 voltage regulator IC. Since most digital logic circuit processors and microcontrollers need a +5 V power supply, this stage provides the supply for the solid state electronic components.
The 555-28027 PIR has been used as a motion sensor to detect the infrared energy emitted by every living thing.When an intruder walks into the detector's field of vision, the detector experiences a sharp increase in heat energy. Hence, with the help of the PIR sensor, the system will be able to determine the presence of someone and thus the need for the lighting system, air conditioner and electric fan to come ON.

To add to the functionality of the system, the LDR has been used to continuously monitor the level of illumination of the environment. The resistance of the LDR used has an inverse relationship with the intensity of the ambient light as depicted in Figure 2.0. The illumination level of the environment being monitored results in variation in the voltage drop across the LDR. This voltage is monitored by the microcontroller unit (MCU) and compared to a threshold value stored in the program.

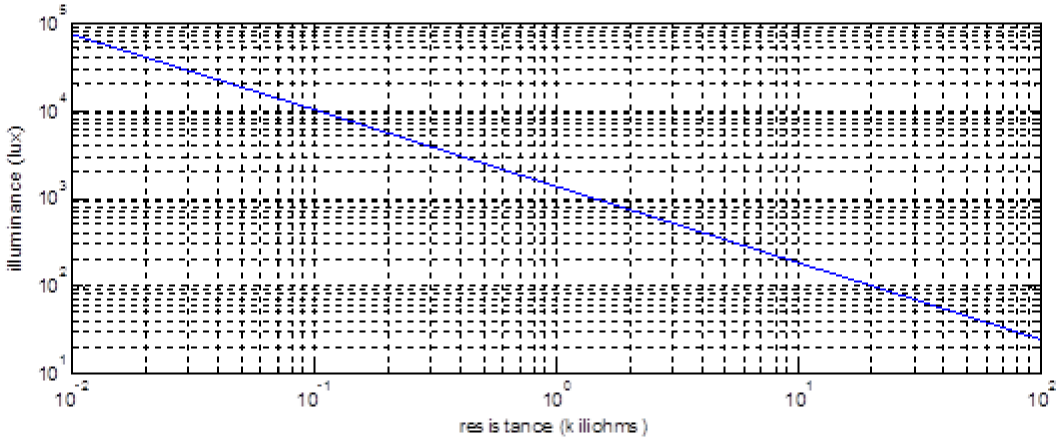

Figure 2.0. Resistance versus illuminance curve of an LDR

The Figure above shows that as illuminance increases, the resistance of the LDR decreases linearly and vice versa. This affects the current being supplied by the output pin of the LDR. In order to monitor the temperature of the environment, an LM 35 IC whose output pin supplies a voltage corresponding to the ambient temperature has been used. The output voltage versus the temperature characteristics produced a linear graph as in Figure 3.0.

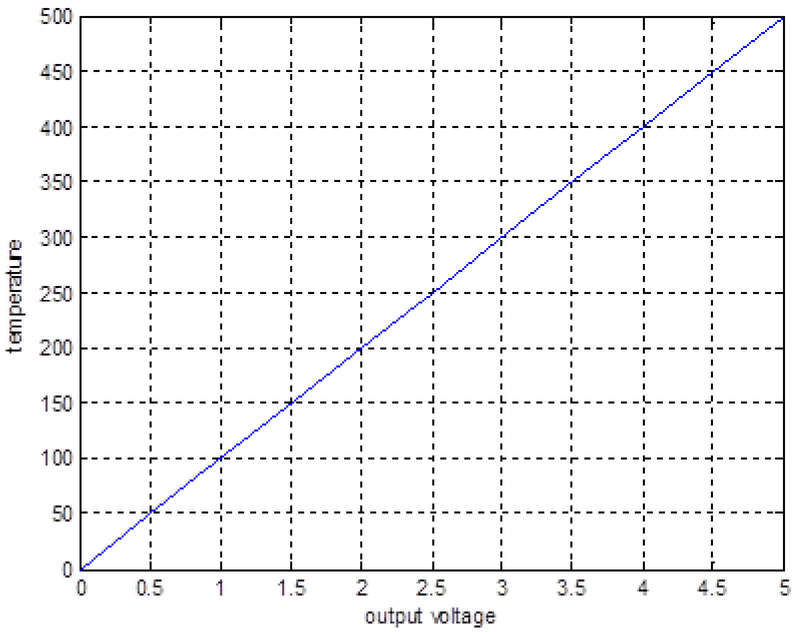

Figure. 3.0 Output voltage versus temperature.

The graph shows that as the temperature of the environment increases, the output voltage of the temperature sensor also increases with an equal factor. This output voltage is measured by the MCU and compared to a threshold value stored in the code.

Conventionally, electronic circuits are operated on DC supplies. So, to control an AC powered devices, isolators like opto-coupler or a relay must be used. In this design work, a relay, a 220µF capacitor and an NPN transistor connected as a switch were used to form a controller circuit by means of which the MCU can switch ON/OFF mains supply from or into the lighting system. In the controller circuit, the 220µF capacitor and 10kΩ resistor were used together with the transistor across the energizing coil to give time delay to the relay. The

ISSN 2056-5860

voltage behaviour in the RC circuit is shown in Figure 4.0. To switch ON/OFF the bulb, the measured voltage will be compared to a pre-stored threshold value. If the measured voltage is higher than the threshold (room is bright) then the MCU output pin remains low. But if the measured voltage is lower than the threshold (room is dark) then the MCU will send a high (approximately +5v) voltage to switch ON the bulb through a relay circuit. If after this, the room becomes brighter, then the MCU will de-energize the relay, thereby switching OFF the lighting system. The FAN/A.C controller is designed in a similar manner to switch ON/OFF the FAN and air conditioning system.

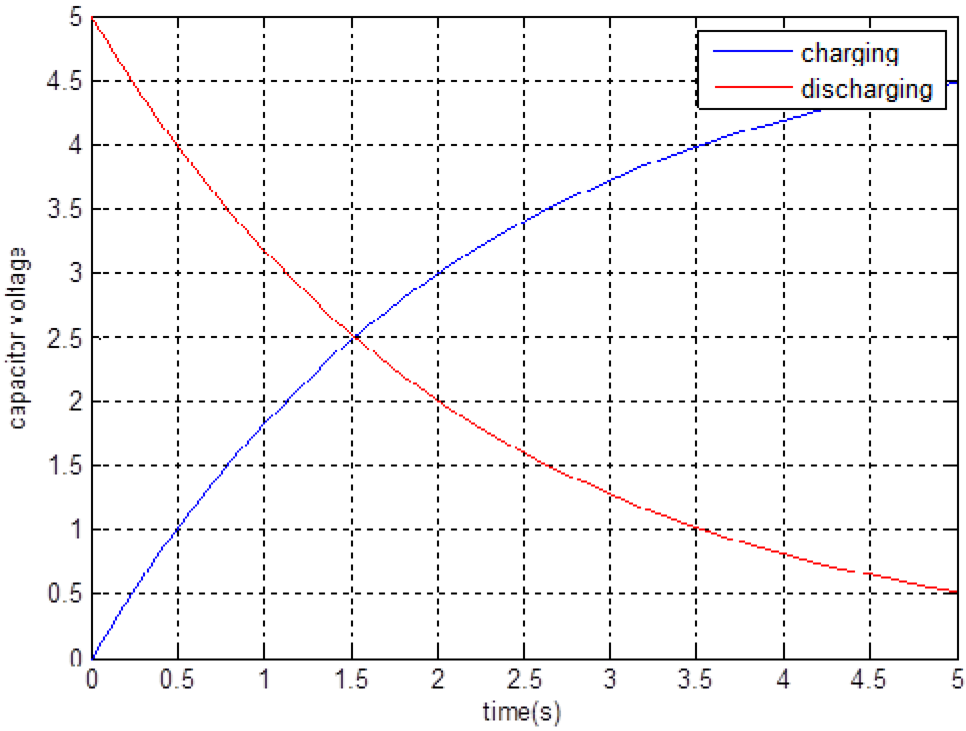

Figure 4.0.Voltage in the capacitor during charging and discharging.

As seen in Figure 4.0, the voltage behaviour is an exponential growth and exponential decay during charging and discharging times. The time constant is however 2.2, while the peak voltage is 4.5Vd.c.

TESTING AND RESULT

Having concluded the design work of the circuitry, the first stage of testing was done by setting up of the circuit on a simulator (proteus). Because of some limitations of the simulator, the infra-red switching circuit (i.e PIR motion detector) circuit was represented with a switch.

The hex code was loaded to the microcontroller and the simulator is displayed. The design was put to test in a 3 bedroom flat apartment to monitor and control 4 electric fans with 2 A.C systems, ten 60W bulbs including fluorescent tubes, television sets and water heater. Before installing our device, the overall energy consumed for the period of 24hrs with normal day to day activities was monitored and recorded. After full installation of our device the energy consumed for the same period with normal day to day activities was also monitored and recorded. Result from our findings shows that 31.2% of the overall energy was saved during the period in which the system was put to test.

ISSN 2056-5860

CONCLUSION

In this work, a complete working model of an intelligent energy saving system has been implemented using a PIC microcontroller. The active intelligent energy-saving system is to help the common man in Nigeria to save cost as opposed to the exorbitant price of electricity consumption being charged by the distribution companies. From the implementation, an average of 31% of the overall energy consumption would be saved which translates to a good cost benefit. Application of this system is not limited to domestic use only. It could be extended to industrial application with little modifications to the software coding. For better optimisation and simplicity of design (in industrial application), a wireless interfacing between the sensors and the microcontroller is recommended. This will ensure flexibility in terms of node's deployment.

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