DESIGN, CONSTRUCTION AND CHARACTERIZATION OF COMPUTERIZED CONTROL DEVICE FOR ELECTRICAL APPLIANCES

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Abstract
In this study, a computerized control of electrical appliances such as lighting and other home and office appliances was designed, constructed and characterized. A circuit (switch controller) that controls the "on" and "off" state of lightings and home appliances was first designed and then a computer program capable of sending and receiving signals back and forth the circuit was written using Microsoft visual basic 6.0. The switch controller circuit is implemented with ADC0804 analogue to digital converter which incorporates, by design, LM35 precision centigrade temperature sensor for monitoring temperature-controlled appliances like heater, air conditioner etc. And also light sensor- Light Dependent Resistor (LDR)-to monitor the on/status of the lights is incorporated as feedback mechanism. The ADC0804 is capable of harnessing information from these sensors and communicating same through the parallel port (printer's port) to the personal computer (PC) which in turn issues command to the switch controller circuit to either switch on or off the appliance. The switching is achieved by means of transistor switch (C3331), which drives directly 5V, 4700Ω relays to make or break contact with 220VAC power line to the appliances. There are altogether four sockets for four appliances. The system was tested and confirmed to perform according to design specifications.

Introduction

The industry commonly uses automatic machines and automated systems for discrete item production and batch process. These automatic machines and processes were developed to mass-produce products and control very complex operations. They replaced much human decision, intervention on and observation. Machines were originally mechanically controlled, later were electromechanically controlled, and today are often controlled by programmable devices.

The switching and control of the lightings and general appliances in a present-day multi-purpose building could be tedious. For example in some establishments, after closing hours some electrical appliances are left on when they are not supposed to be and so constitute energy wastage and potential electrical hazards. The only access to these equipments might be through the main switchboard or the room. The option of switching through the terminal board might sometimes not be easy and convenient, especially when the electrical wiring of the building is not well sectionalized. The second option, which might entail getting access to the room(s) concerned, raises questions on security.

The need for an effective means of controlling remotely located devices and equipments and monitoring their status is addressed in this study.

DESIGN AND CONSTRUCTION

The use of personal computer as control device for an appliance involves three distinct phases. A block diagram of these phases is shown in Fig. 1.0 below (Anasiudu et al, 2003).

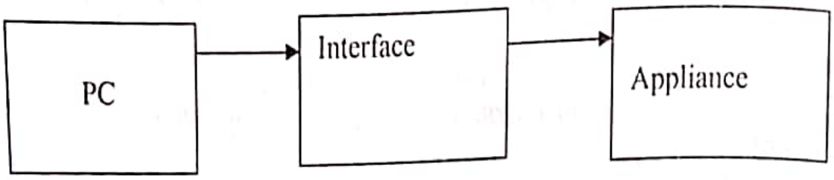


Fig.1: simple block diagram of a PC controlled house appliances.

The personal computer receives information and manipulates signal in numerical form in contrast to analogue (or continuous) signals.
For the effective operation of this computerized house task executor control system, the following considerations and specifications are made:
1. The system should be able to control up to four appliances connected to it at the same time without any conflict.
2. The system should have a feedback to indicate any fault on the process of control.
3. For the temperature controlled devices connected to it, the system should make a provision for putting the desired temperature, which should be used to control the connected device. A timing provision is made to fully affect the control of connected devices based on time logging.
The interface to the PC, which is the main thrust of this work, is such a communication line so configured to produce harmonious operation between it and other equipment. This could be another computer, a computer peripheral device, a fax machine or a telephone etc. In this particular system the interface is a system that comprises basically of three modules; switch controller, switch and the power supply modules.

Design of Switch Controller Module

The switch controller module comprises the ADC0804 unit, the feedback unit and the temperature sensor unit.

ADC0804 Unit

As shown in the typical circuit in Fig. 2, ADC0804 can be interfaced with any microcontroller. One needs a minimum of 11 pins to interface ADC0804, eight for data pins and 3 for control pins. As shown in the typical circuit in Fig. 2 the chip select (CS) pin can be made low if one is not using the microcontroller port for any other peripheral (Norasmadi, 2005).
For operation in the free-running mode an initializing pulse should be used, following power-up, to ensure circuit operation. In this application, the CS input is grounded and the WR input is tied to the INTR output (see Fig.5). This WR and INTR node should be momentarily forced to logic low following a power-up cycle to guarantee operation (Tocci, 1998).

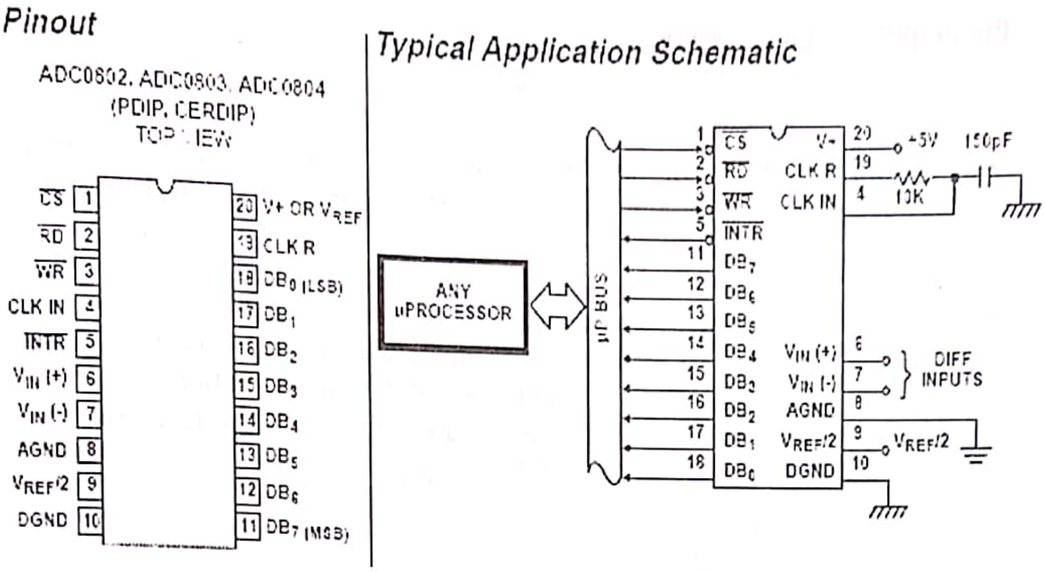


Fig. 2: ADC0804 Pin out and Typical Connections

The feedback unit

The feedback to know whether a bulb actually lights up or not when computer commands for the lighting of the bulb is achieved using comparator circuit. The comparator circuit involves LM358, 200K pot resistor, 1M resistor and an LDR (Light Dependent Resistor). The comparator circuit is powered with 5V dc. The LDR is used to sense the amount of light in the environment where the bulb is. The operation of an LDR is that its resistance decreases with increase in light intensity and increases with decrease in light intensity. The resistance of the LDR at ordinary light intensity is about 3M, and when it is brought near a lighted bulb at about 3cm distance, the resistance is 1.4M(Horowitz and Hill, 1995). It is connected with the 1M resistor to form a voltage divider as shown in Fig.3 below.

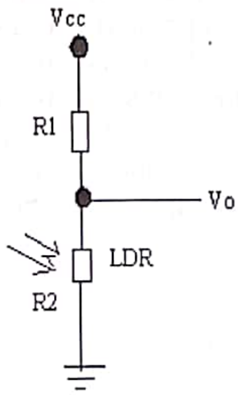


Fig.3: v… rk

Therefore, the output voltage V… and is given by

$$V_o = \left(\frac{R_2}{R_1 + R_2}\right)V_{cc} \quad 1$$

Where

R_2 is the LDR resistance

R_1 is 1M ohm

V_{cc} is the supplied voltage.

Now if the supply voltage $V_{cc} = 5V$ and the resistance of the LDR = $R_2 = 1.4M$, the output voltage V_o will be

$$V_o = \left(\frac{1.4M}{1M + 1.4M}\right) 5V = 2.9V$$

2.9V is supplied at pin2 of the LM358 when the LDR is brought near a lighted bulb, at about 3cm distance (see Fig.5).

The pot resistor connected to pin3 of the LM358 is set to 3.5V. At this point, the voltage at the non-inverting input (pin3) of the comparator is greater than the voltage at the inverting input (pin2). The output of the comparator, pin1 will be positive with respect to the ground.

However, if the bulb goes off, the LDR will read the resistance of the environment and this resistance is about 3 M ohms on bright day.

Now the output voltage V_o will be

$$V_o = \left(\frac{3M}{1M + 3M}\right) 5V$$
$$= 3.75V$$

Now the voltage at the inverting input is 3.75V, which is greater than the voltage at the non-inverting input, which is 3.5V. The output pin1 of LM358 will be negative with respect to ground. With negative voltage at pin1 of LM358 which is connected to pin15 of the parallel port of computer will give a logic LOW to the computer which the computer will use to know that the bulb did not light as commanded based on the software program, and will indicate that the bulb does not light.

LM35 temperature sensor unit

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1/4°C at room temperature and ±3/4°C over a full -55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 μA from its supply, it has very low self-heating, less than 0.1°C in still air. The temperature to voltage converted output is fed to the ADC0804 for digital conversion as shown in Fig.4 below.

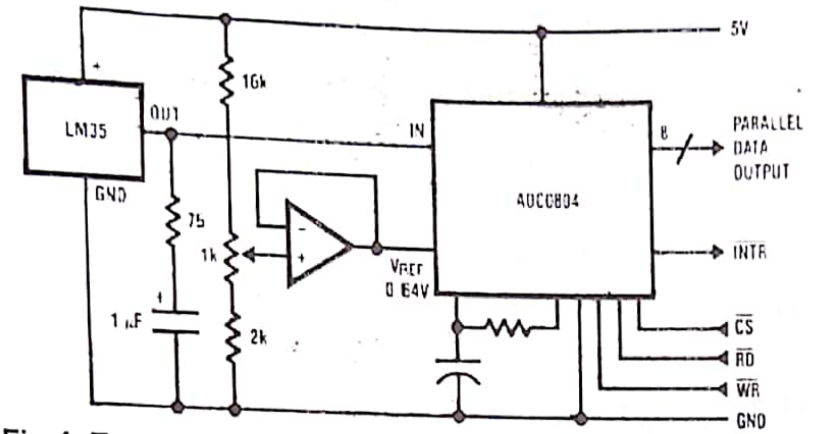


Fig.4: Temperature Analogue to Digital Converter

The Switch Unit

The switching is achieved by means of transistor switch (C3331), which drives directly 5V, 4700 Ω relays to make or break contact with 220VAC power line to the appliances. There are altogether four sockets for four appliances.

Design of Power Supply Module

This project was built using integrated circuits (ICs) based on transistor-transistor logic (TTL) and complementary metal oxide semiconductor (CMOS) technologies. While the later has a wider supply voltage range of +3 to +15

volts, the former (TTL) has a supply voltage of 5V±5% (Ezenwora, 2007). Bearing this in mind a supply voltage of +5 volts was chosen since it is compatible with both technologies. The power supply elements (components) include:

(a) Transformer, (b) Filter capacitor (c) Rectifier diodes and (d) Five (5) volts voltage regulator IC.

(a) The transformer: For a +5 volts regulator it is good to use an unregulated input of about +12 volts at the minimum of the ripple, which itself might be a volt or two (Ezenwora,2007). From the secondary voltage rating one can be sure of the d.c. output from the bridge, since the peak voltage (at the top of the ripple) is approximately 1.4 times the r.m.s secondary voltage, less two diode drops. This is to be absolutely certain that the input to regulator will never drop below the minimum necessary for regulation, typically 2 to 3volts above the regulated output voltage; else one may encounter 100Hz in the regulated output.

(b) Filter capacitor is chosen large enough to provide acceptable low ripple voltage, with voltage rating sufficient to handle the worst case combination of no load and high line voltage (240-260r.m.s). For the +5 volts, 1 amp regulated supply, contending with a ± 10% worst case line voltage variation, it is ideal to keep ripple to less than 2 volts peak (pp) (Ezenwora, 2007).

$$\frac{dV}{dt} = \frac{I}{C} \qquad 2$$

$PP\ ripple \approx \frac{IT}{C}$

3

$$T = period = \frac{1}{f}$$

$$f = frequency = 50Hz$$

$$C = capacitor\ value$$

$$I = current = 1amp$$

for bridge rectifier $= 2f$ (for positive and negative half cycles)

$$= 2x50Hz = 100Hz$$

Therefore, $T = \frac{1}{100} = 0.01s$

For 2volts pp,

$$2 = T\frac{dV}{dt} = \frac{IT}{C}$$

$$2 = 0.01x\frac{1.0}{C}$$

$$C = \frac{0.01x1.0}{2}$$

$$C = 5000\mu F$$

In choosing capacitor value, 20 % tolerance is always allowed. An oversize capacitor not only wastes space but also increases transformer heating by reducing the conduction angle. Also the current consumption of all the active components are in the order of micro amps, therefore $3300\mu F$, 25V is a minimum size choice (Ezenwora, 2007).

(c) Diode rectifier: Typical of rectifier is the popular IN 4001- 4007 series, rated at 1 amp, with reverse breakdown voltage ranging from 50 to 1000 volts. Full wave rectification is better in this respect, since a greater portion of the transformer waveform is used (Ezenwora, 2007).

(d) 7805 IC regulator: This is chosen because it can provide up to 1amp load current and has on-chip circuit to prevent damage in the event of overheating or excessive load current (Ezenwora,2007).

The complete circuit diagram of the system is shown in Fig.5 below.

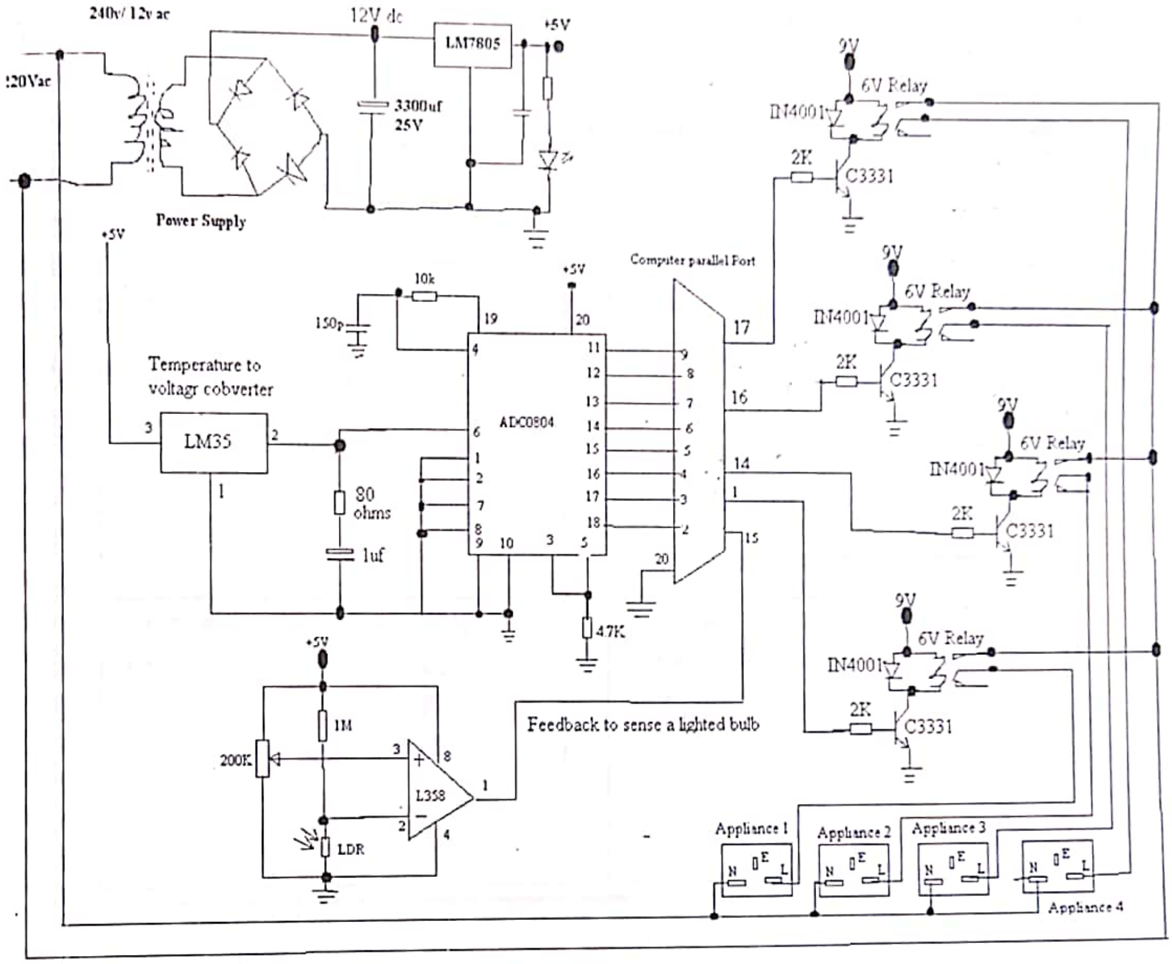


Fig.5: Circuit diagram of computerized control of electrical appliances

Communication port

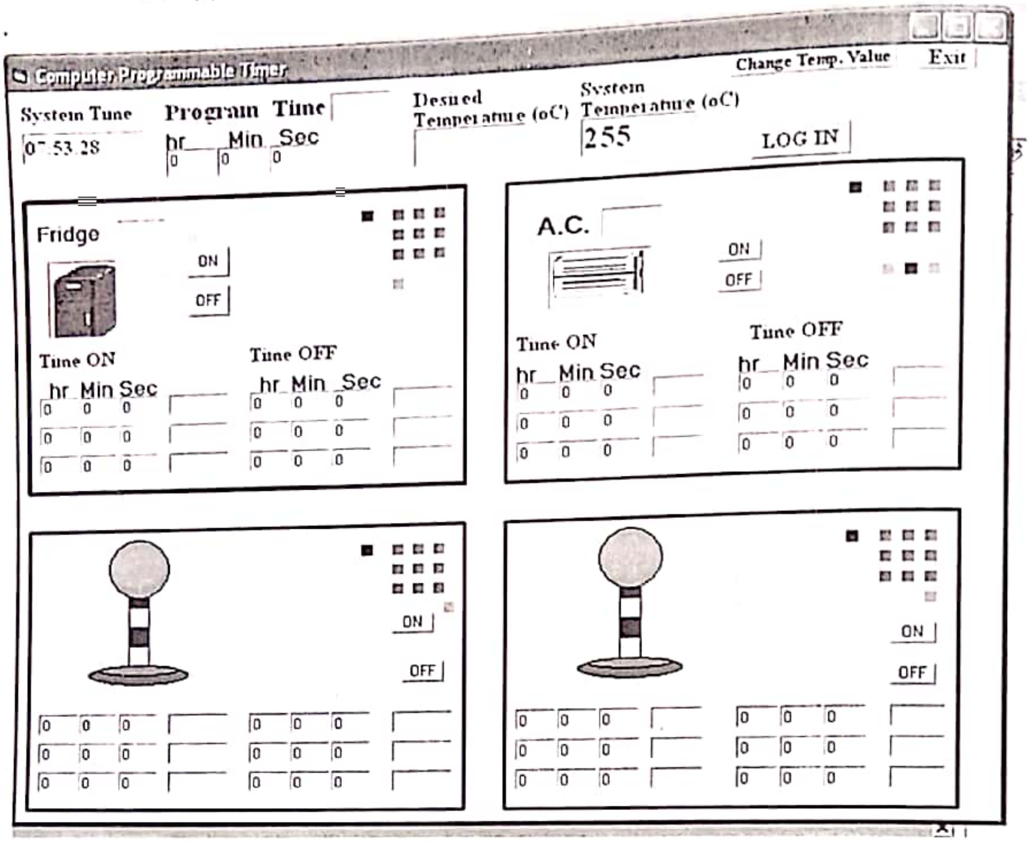
A port provides a connection between an external devices and a computer system board. By plugging a device into a port using an appropriate connector, a path is established for moving data back and forth (Anasiudu et al, 2003).

Parallel ports

The parallel port was originally created for communicating with the printer and thus is called a 'printer port'. It is the most commonly used port for interfacing home projects. This port will allow the input of up to 9-bits or the output of 12-bits at any one given time, thus requiring minimal external circuit to implement many simpler tasks. The port is composed of 4 control links, 5 status lines and 8 data lines. It is found commonly at the back of PC as D-type 25 pin female connector (Axelson, 1996).

Apart from the hardware components of the system that perform the critical functions of data input and output, there are sets of instructions (software) that define what should be done and how to do it, developed using Microsoft visual basic 6.0 (Byron, 2002; Charles, 1997).

The System Operation.
The system is comprised of hardware and software applications. It has four socket slots at the back in which four different devices could be plugged for control. When the control program is run, the user-friendly graphic interface will be displayed as shown below



The System Time

Fig.6: The graphic user interface of the system.

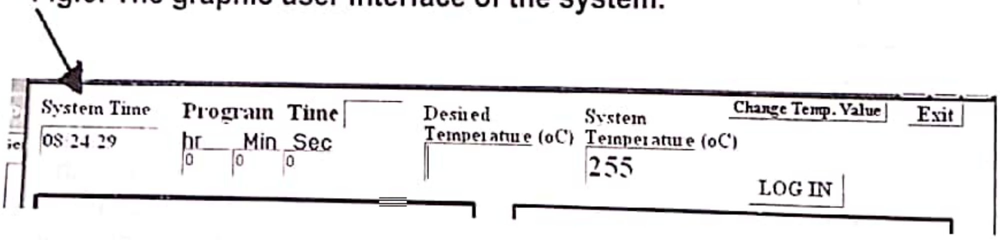


Fig. 7: The system time.

At the left hand of the upper part of the graphic user interface is the System Time.
The System Time displays the current time based on the system time in the computer used.

The Program Time

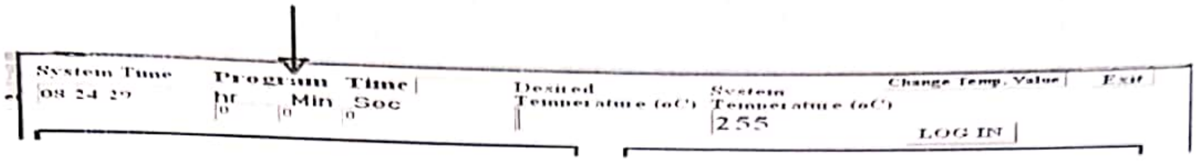


Fig.8: The program time.

Next to the System Time is the Program Time. The user has to use the system time to set the Program Time. The project uses the Program Time for the timing control of the connected devices.

The Desired Temperature (°C)

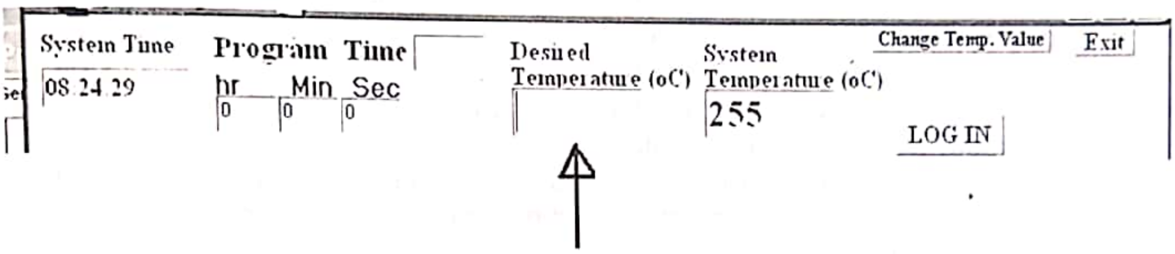


Fig.9: The desired temperature.

Next to Program Time is the Desired Temperature (°C) box. Here the user keys in the desired temperature he would like to operate if he is using any temperature controlled device like electric stove, fridge, air conditioner etc.

The Log In button

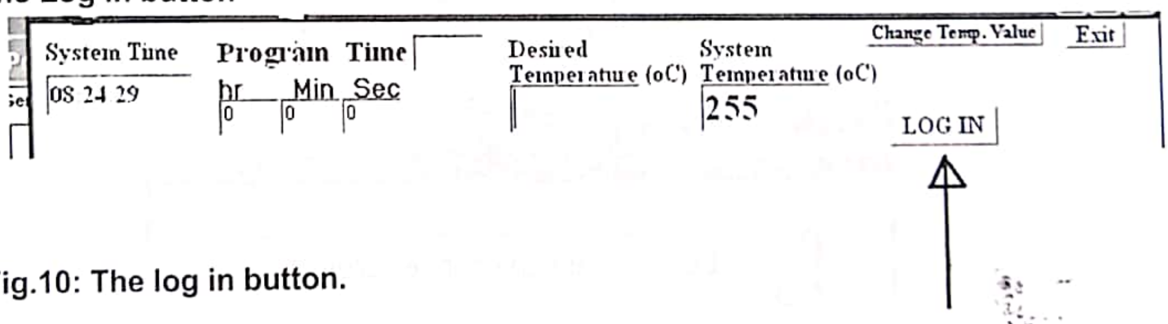


Fig.10: The log in button.

Having filled the Program Time and the Desired Temperature, the user can then click Log In to start. If the user fails to fill the Program Time and the Desired Temperature and click Log In, the computer will pop up a message box requesting that he must fill the Program Time and the Desired Temperature before it can start.

The System Temperature box

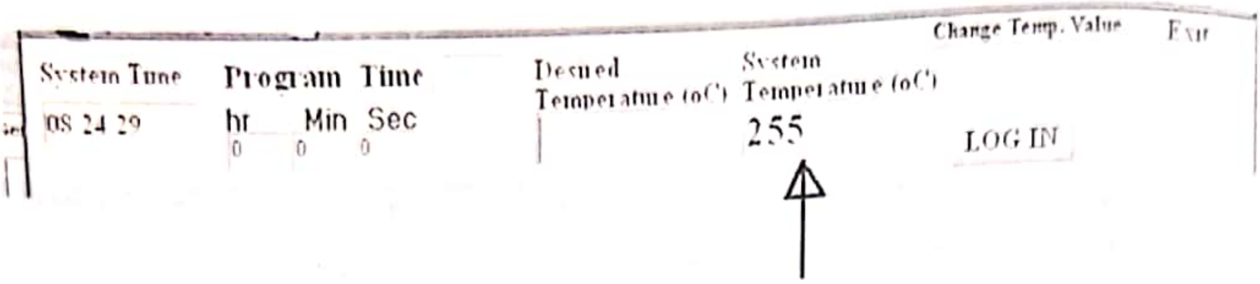


Fig.11: The system temperature box.

Having logged in, computer will display the temperature of the system being monitored. For example, if the user plugs an air conditioner and tends to monitor the temperature of the room, then the System Temperature Box will display the temperature of the room. For control, computer will not allow the temperature of the room to go above or below the desired temperature of the user. When the room temperature tends to go above the desired temperature, the computer will switch on the A/C to cool the room, and when the temperature of the room tends to go below the desired temperature, it will switch off the A/C, allowing the room to gain heat. So it does to maintain the temperature of the room at the desire temperature required by the user.

The Change Temperature Button

The Change Temperature button is used to change the temperature of the desired body during operation. If the user does not like the temperature he is operating at and he wants to change the temperature, he then clicks at the Change Temperature button and it will ask the user whether he wants to change the temperature by pop pins up a message box as shown below .

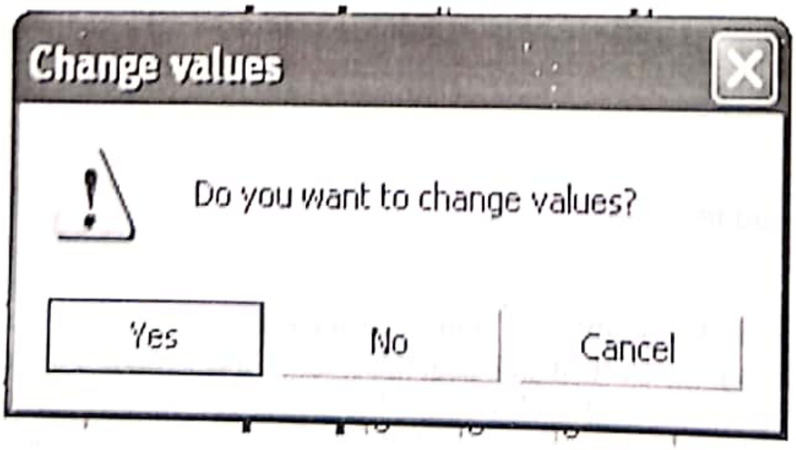


Fig.12: Message box for changing the Desired Temperature

By clicking at Yes button the system will wipe off the old values of the desired temperature and then allows the user to put the desired new temperature.

The Timing Boxes

In the boxes for Time On and Time Off for each appliance, the user should then put the time he would like the appliance to be switched ON or OFF. When it is time for the computer to switch on the appliance, it will automatically switch on the appliance and once the time elapses, it will switch it off. The menu is shown in Fig. 13 below.

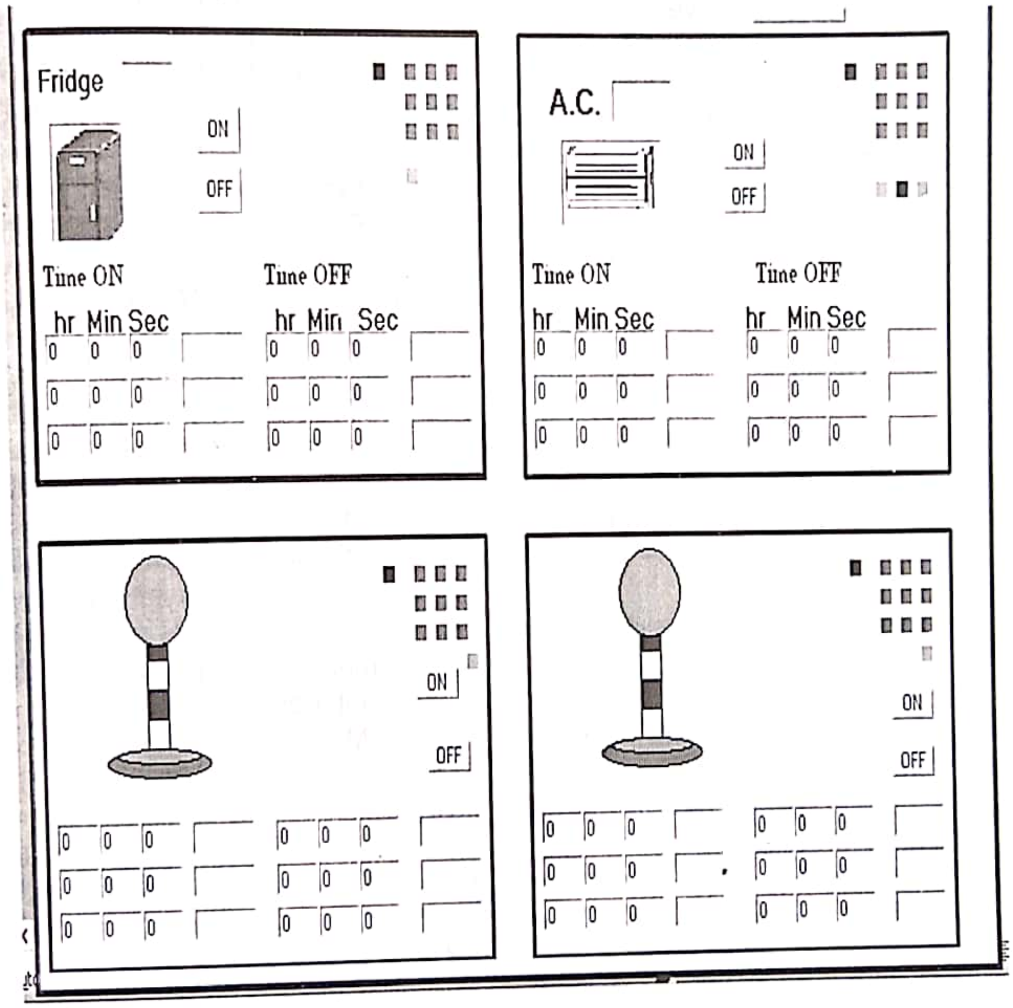


Fig. 13: The timing boxes

Conclusion

Computerized control of electrical appliances using available components is successfully designed, constructed and tested. Microprocessor-based control and automation can actually be applied to any field of human endeavor as demonstrated in this work. The application is versatile with tremendous and amazing success. The technology is simplified and can easily be reproduced for commercial purposes.

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