IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

Volume 10, Issue 8, August 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.282

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 8, August 2021 ||

DOI:10.15662/IJAREEIE.2021.1008004 |

Design and Implementation of a Factory Load-Centre Monitoring and Security System

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ABSTRACT: A Factory Load-Centre houses the motor control centre, the input/output modules, Servers, Variable Frequency Drives, Gas analysers, and other critical and sensitive equipment used for running the plant. The Factory Load-Centre Monitoring, and Security System is a system that is intended to secure the room, maintain a conducive environment for the equipment and safeguard the huge investment of the owner and make the plant available for production at all times to maximize profit. Equipment like VFDs have semiconductors, inverters, diode supply unit (DSU) and insulated gate bipolar transistors (IGBT) which generate a lot of heat and thereby increase the room temperature. For safeguarding these expensive equipment and maintaining the right environment for optimal performance, a system has been designed with the help of the PIC18F4550 Microcontroller, Keypad, Electronic Solenoid Lock, Temperature Sensor, Humidity Sensor, Smoke detector, Limit switches, Light Dependent Resistor, LCD, GSM module, relays, and an alarm system. The system checks the room condition constantly to make sure that the environment is conducive and secured. This is achieved by taking the various input signals from the sensors to the microcontroller which compares the input conditions with the acceptable conditions, and generates the required outputs such as switching on the relays to drive the respective loads so as to normalise any abnormal condition and to alert authorised persons of the occurrence of a breach. The code for the system was written and debugged in MikroC environment while the hardware was simulated in Proteus environment. The system was able to maintain the room temperature between 18°C to 24°C and humidity below 60 %. The audible alert came on when the smoke/gas concentration was above 200 ppm and when the door was kept open for more than 10 seconds. Door access was granted only with the entry of the correct password. The light was switched on below 200 Lux and switched off above 500 Lux. The various readings obtained were displayed on the LCD and an SMS is sent to a registered mobile number as designed. The responses of the constructed system agree with the design specifications.

KEYWORDS: Microcontroller, Factory Load-Centre, Monitoring, Conducive Environment, Security.

I. INTRODUCTION

Advances in technology and certain requirements of industrial processes have necessitated and increased the development, implementation and use of embedded systems in our everyday life. This has also led to the creation of certain critical locations in the factory like the Load-Centre where it is important that the environment be continually monitored and maintained within a certain range or never beyond certain critical limits. The Microcontroller-Based Factory Load-Centre Security, Room Condition Monitoring, and Control System is a system that uses electronics and sensors to free the worker from the stress of continuous check on the load-centre for any security breach, and room condition monitoring, and control of the load-centre environment. Extremely high temperature or humidity of the load-centre can cause damage and also reduce the efficiency and life span of equipment found in the load- centre. Therefore, the fast response of the system will prevent serious damage and also alert concerned persons via short message service (SMS). After receiving a logic high signal due to any of high room temperature, high humidity, smoke or the door being kept open for more than ten seconds, the microcontroller goes into alerting mode during which it turns on the buzzer to warn the operator and displays this alert state on the Liquid Crystal Display (LCD). In this condition, the microcontroller also gives a logic high signal to turn on the Air-conditioning systems for room environment control. For lighting, the system does not go into alerting mode but only switches the light on when it senses darkness and turns it off during the day to save energy. The main advantage of this load-center monitoring and alerting system is that it

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serves as a security as well as a protective and safety device. Another advantage of the project is the low cost of implementation and minimal maintenance required after the installation.

II. LITERATURE REVIEW

Many systems that implement only parts of the design being considered have been found in the following literature. Aderibigbe*et al*. (2018), in their study,presented a model gas leakage detector and evacuation system which monitors only gas leakage. Theophilus and Bhudi (2012) designed and implemented a microcontroller-based room temperature monitoring system, which monitors only temperature.Mohanad (2012) implemented an electronic embedded lock security system that provides a great benefit over traditional locks, which uses only a manual key. Omar *et al*. (2014) reviewed existing fire-detector types along with the development of a low cost, portable, and reliable microcontroller based automated fire alarm system for remotely alerting any fire incidents in household or industrial premises. SargunaPriya *et al*. (2014) designed the monitoring and control system of industrial parameters using CAN bus communication. Jadhavsunny *et al.* (2014)designed a Remote Monitoring and Control System that is able to acquire, save, analyse, and process real time data used for controlling a particular machine to change related environmental factors and monitoring from a long distance. Pushkarand Amey(2016)designed a system in which an embedded system monitors and controls the microclimatic parameters of a Greenhouse on a regular basis round the clock for cultivation of crops or specific plant species which could maximize their production over the whole crop growth season, and to eliminate the difficulties involved in the system by reducing human intervention to the best possible extent usingsensors. The major difference of this system is that it designed for agricultural use. Nagendra (2017) built an Arduino-based embedded device for monitoring environmental variables: humidity and temperature. The device was built using the microcontroller Arduino and sensors, which could sense the temperature and amount of moisture inside a building and provide information in a serial monitor and a liquid crystal display.Karthikumar*et al.* (2017) designed a wireless control and monitoring system for various industrial machines based on Zigbee communication protocol for safe and economic data communication in industrial fields where the wired communication is more expensive or impossible due to physical conditions.The system monitors only machine parameters. Oke *et al.* (2017) designed an application of temperature sensor to free the stress of continuous check on the environment for any change in temperature. An alert sub-system and a Global System for Mobile Communication (GSM) module were incorporated into the design to make it more effective. Awodeyi*et al.* (2018)presented a Microcontroller based Automated Intelligent Street lighting System using light dependent resistors and infrared sensors for power conservation, intelligence and fault detection. Adamu*et al. (*2018) designed an Automatic room Heater Control System,which is a temperature monitoring system, to set a desired temperature which is then compared to the room temperature measured by a temperature sensor. Widyaningrum and Pramudita (2018), in their research, developed an automatic lamp and fan in a smart home usingArduino Mega 2560 microcontroller. This system monitors the brightness and the temperature of a room.

The scope of the current research goes beyond any of those that have been considered in the review asnone of them has fully addressed the intended scope of this research which encompasses security, safety, power saving, continuous monitoring and control of environmental condition of a critical room like the load-centre.

III. MATERIALS AND METHOD

The materials required to design and build a prototype of the System includes a Microcontroller, Temperature sensor, Humidity sensor, Smoke detector, Light Dependent Resistor, Limit switch and Keypad. Other components used include Liquid Crystal Display (LCD), Buzzer/Siren, Solenoid Electronic Lock, GSM module, and Relays. The system also requires Oscillators, Resistors, Capacitors, Transistors, Dehumidifier, Fan, Heater and Power supply. The environmental parameter threshold values obtained from the operating manuals of the equipment in the Load-Centre include: operating temperature rangebetween 18°C to 25 °C and humidity below 60%.

3.1Block Diagram

The block diagram of the design is shown in Figure 1.The block diagram shows the main functionality of the System. Four sensors are used to monitor different analog signals including temperature, humidity, light intensity, and smoke/gas. Six relays are used to control six respective loads namely the buzzer, heater, fan, dehumidifier, lighting circuit and solenoid electronic lock. Also shown in the diagram are digital inputs and outputs from keypad, limit switch, relays, GSM and LCD. The complete schematic diagram is shown in figure 10.

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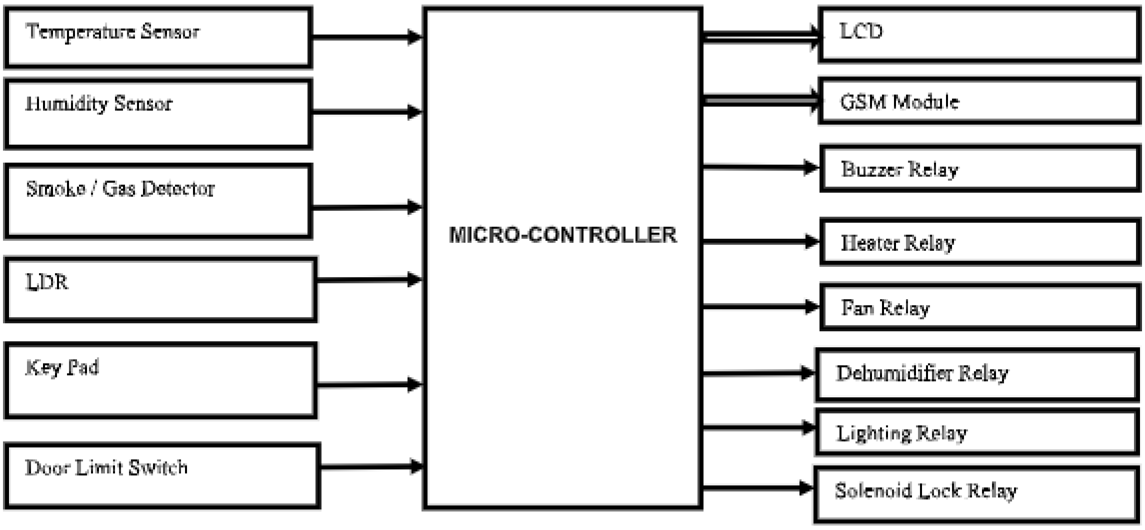

Figure 1: Block diagram of the Load-Centre Monitoring and Security System

3.2 Flowchart

The Flowchart shows the sequence and steps followed in the program designed to control the operation of the System. The main flowchart is shown in figure 2 while the flowcharts for the various subroutines are shown in Figures 3 - 8.

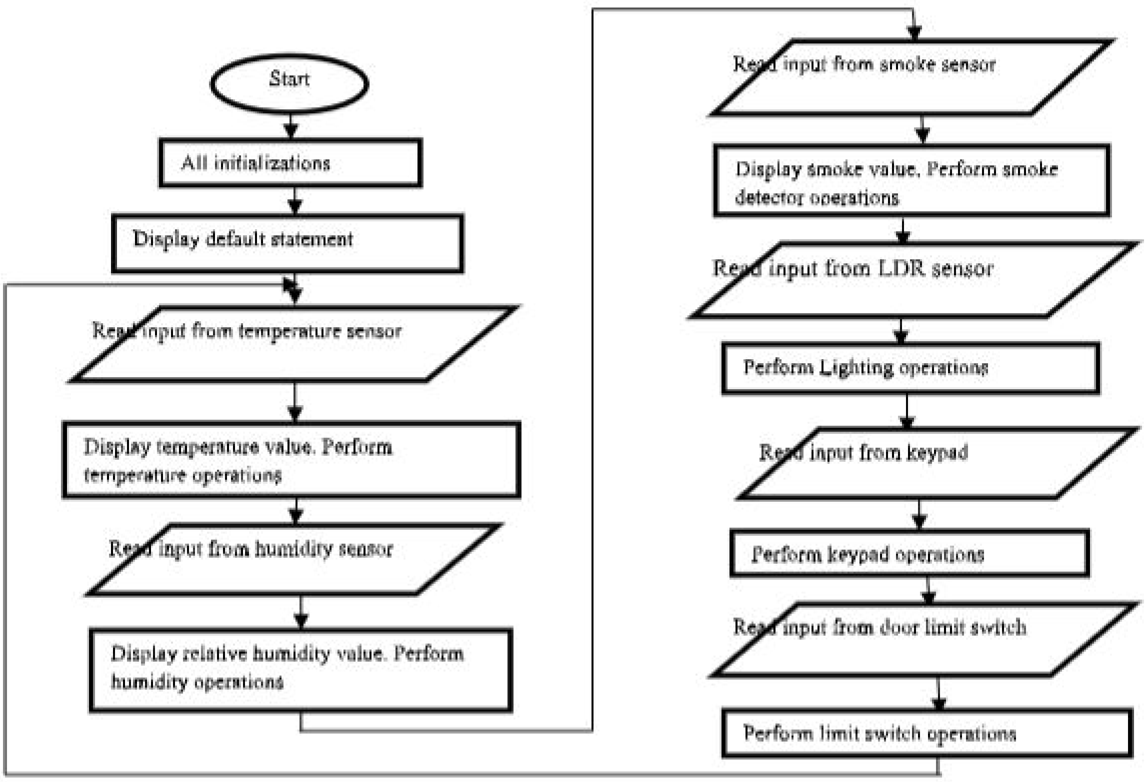

Figure 2: Main Flowchart for the System

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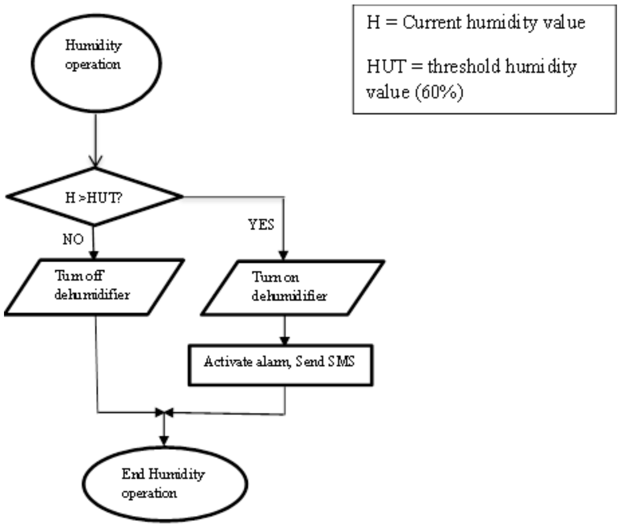

Figure 3: Flowchart for Humidity Subroutine

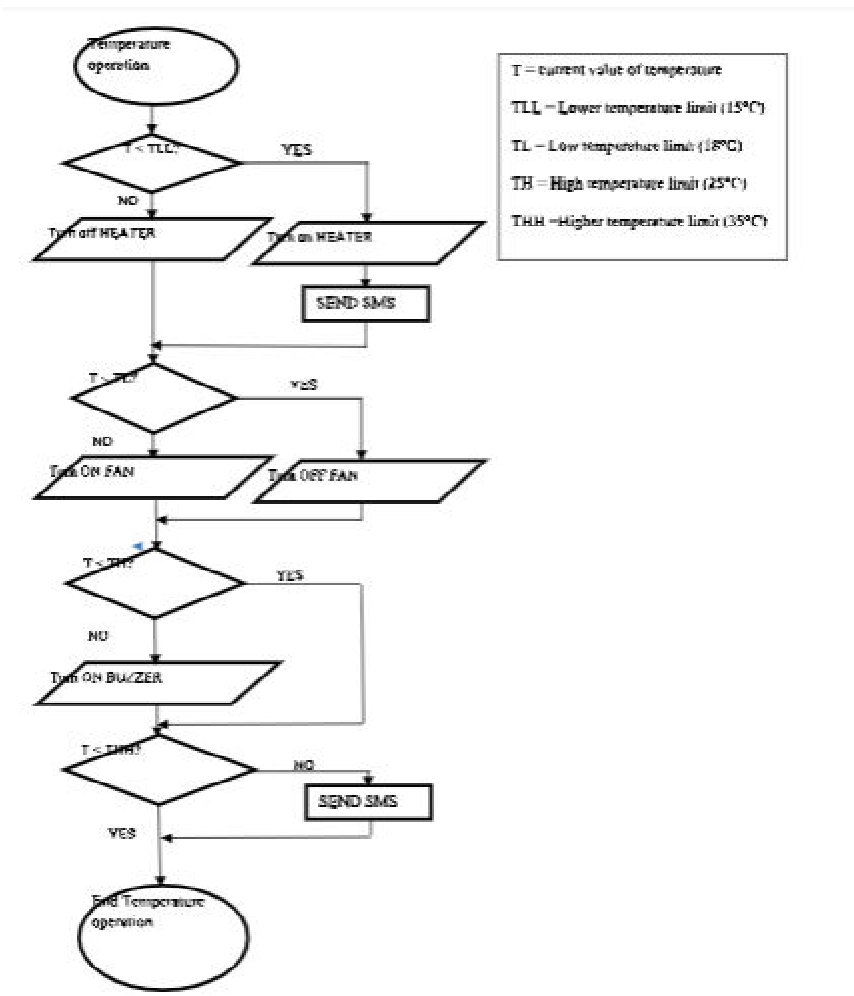

Figure 4: Flowchart for Temperature Subroutine

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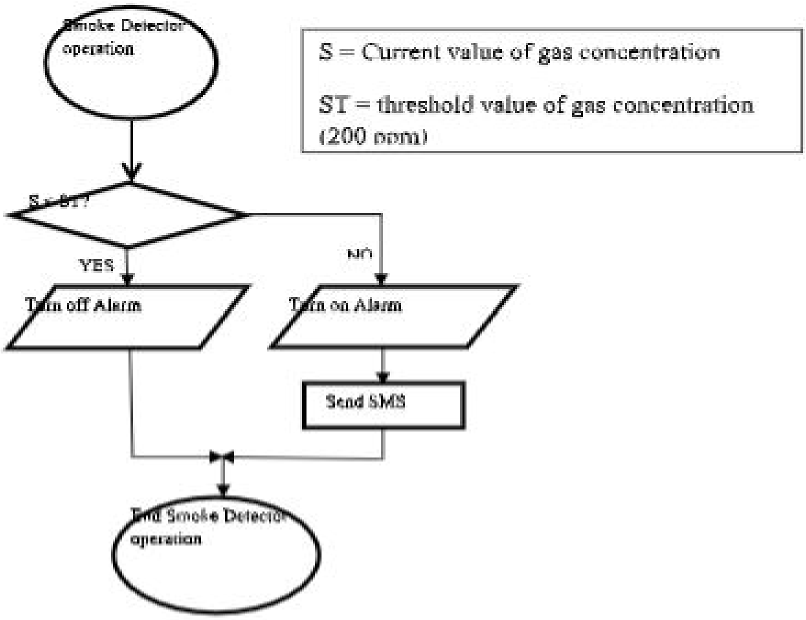

Figure 5: Flowchart for Smoke Detector Subroutine

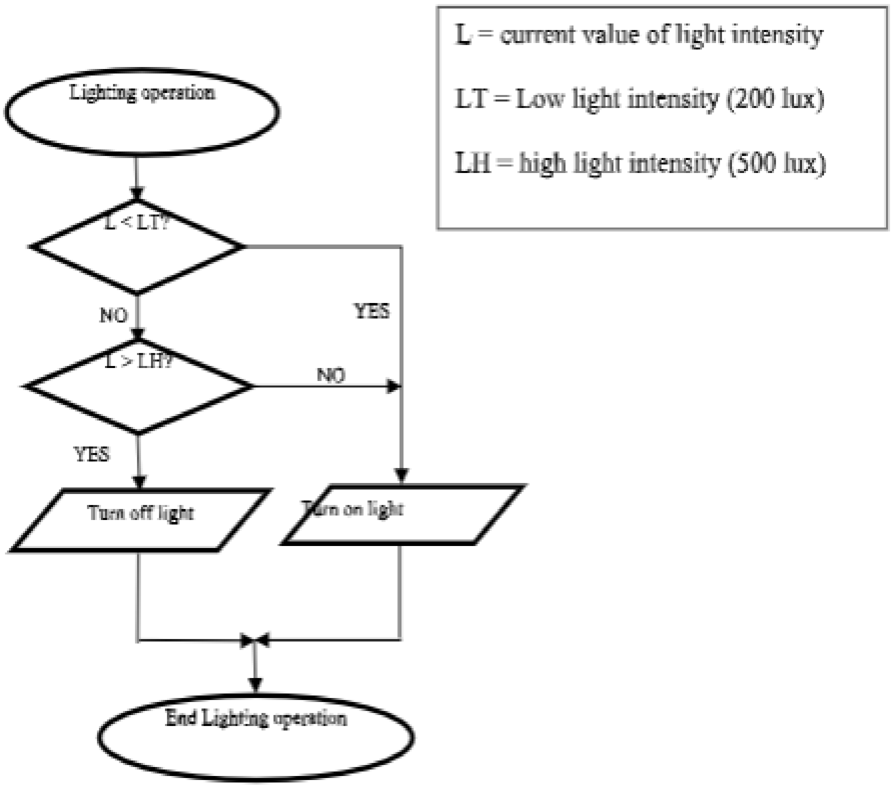

Fig. 6: Flowchart for Lighting Operation Subroutine

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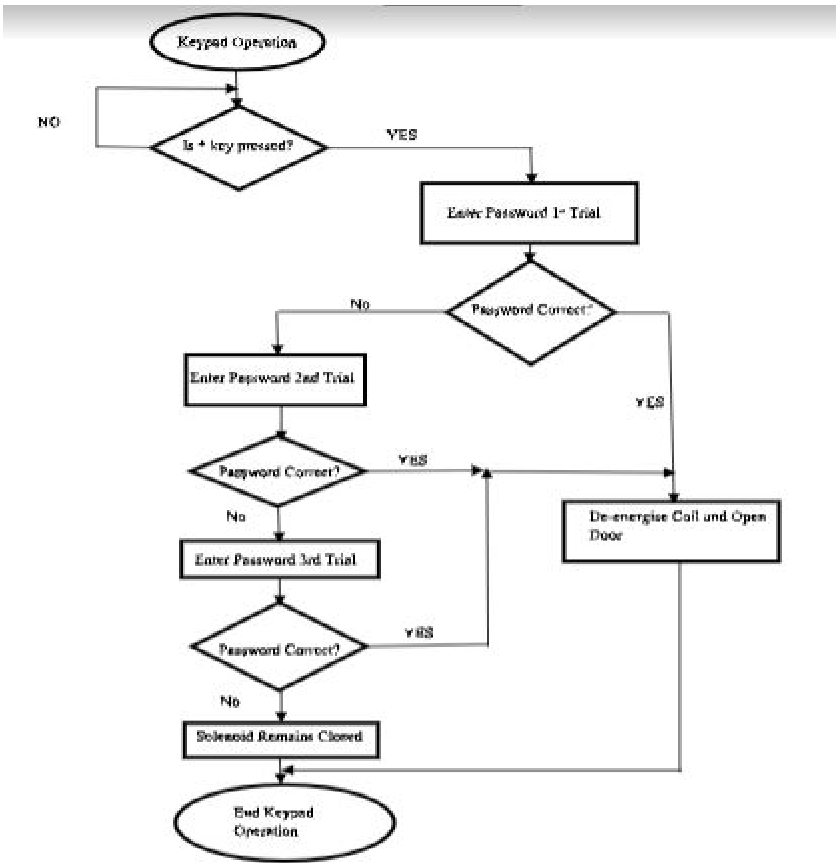

Figure 7: Flowchart for Keypad Subroutine

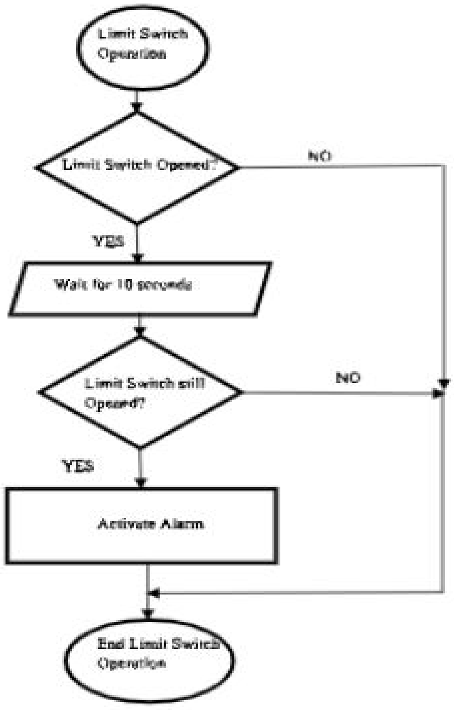

Figure 8: Flowchart for Limit Switch Subroutine

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3.3 Software and Hardware Simulation

The program was written and tested using both software and hardware debugging. The program was written andsimulated in the MikroC PRO for PIC integrated development environments (IDE) asshown in Figure 9 while thePROTEUS Development Environment was used for hardware debugging. The target microcontroller (PIC18F4550) wasloaded with the program and the program was thoroughly tested and observed to have performed as required.This was done to verify the accuracy of the syntax as well as the logical flow of the program. The microcontroller was then successfullyprogrammed using the Hex file generated from the software with the aid of the PICKIT- 3 programmer.

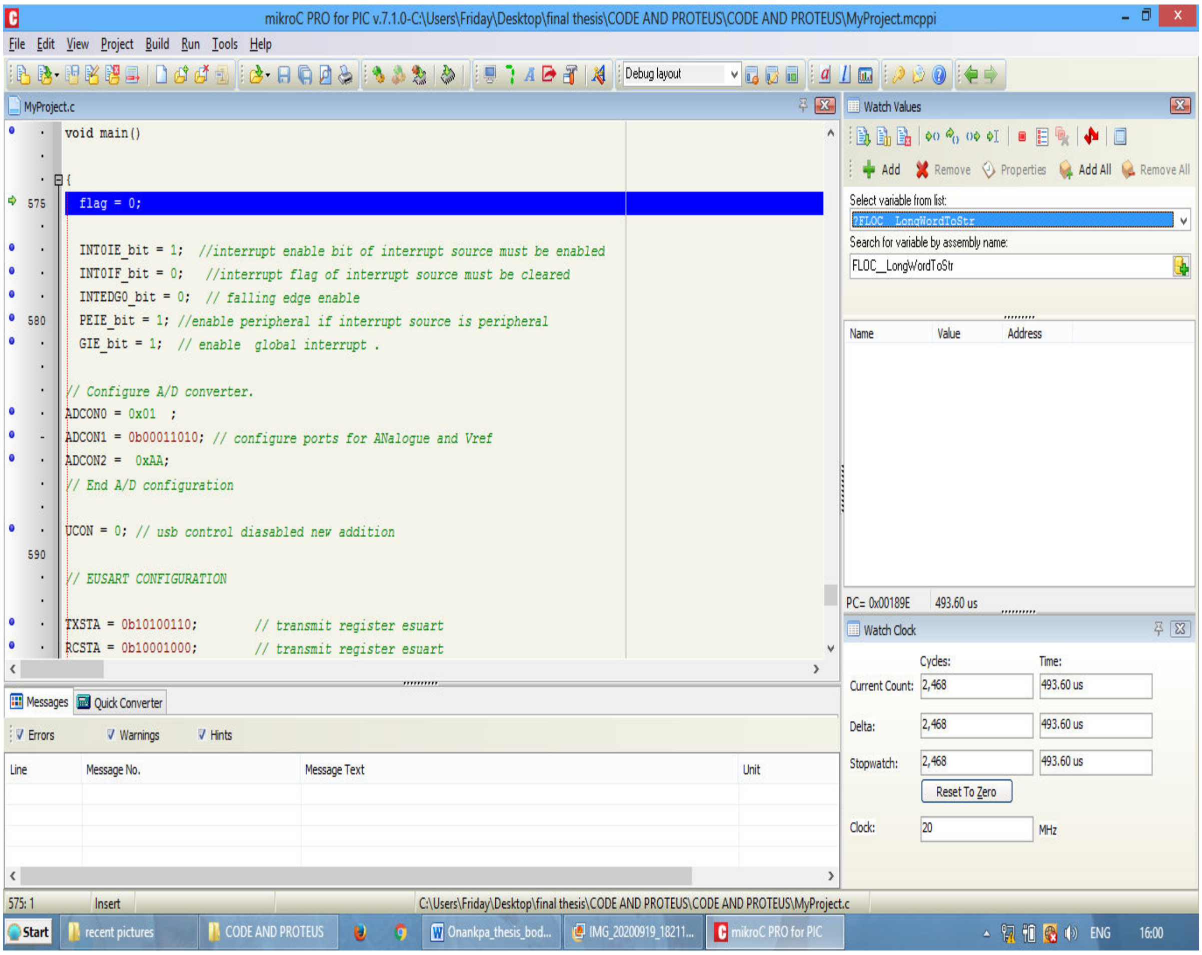

Figure 9: Software Debugging

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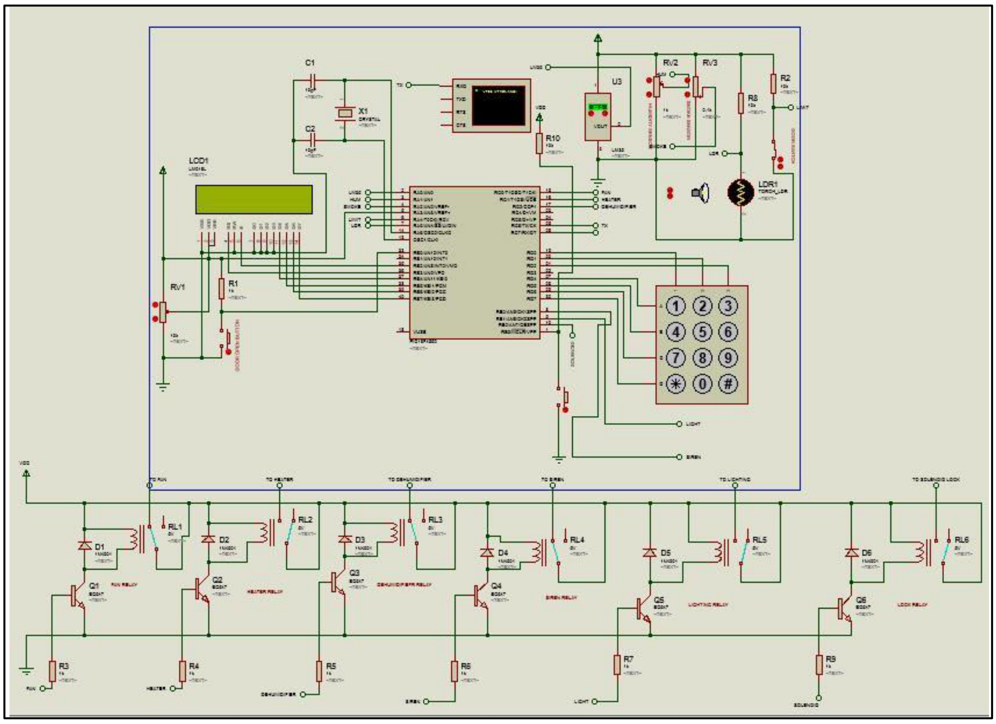

Figure 10: The complete Schematic diagram for the System

3.4 Construction

The circuit components used were locally sourced, assembled and soldered on a Vero board according to the specifications of the circuit diagram. After soldering, the testing of the circuit design took place across the nodes of the circuit. The system constructed was mounted and tested to check its workability. Plates 1 and 2, show constructed prototype of the hardware in working condition.

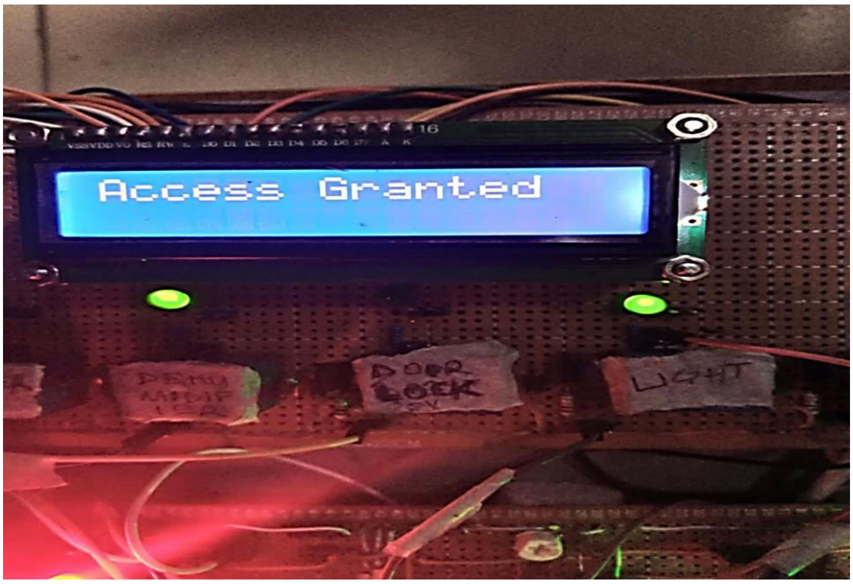

Plate 1: Constructed Prototype of the System in Working Condition: Access Granted

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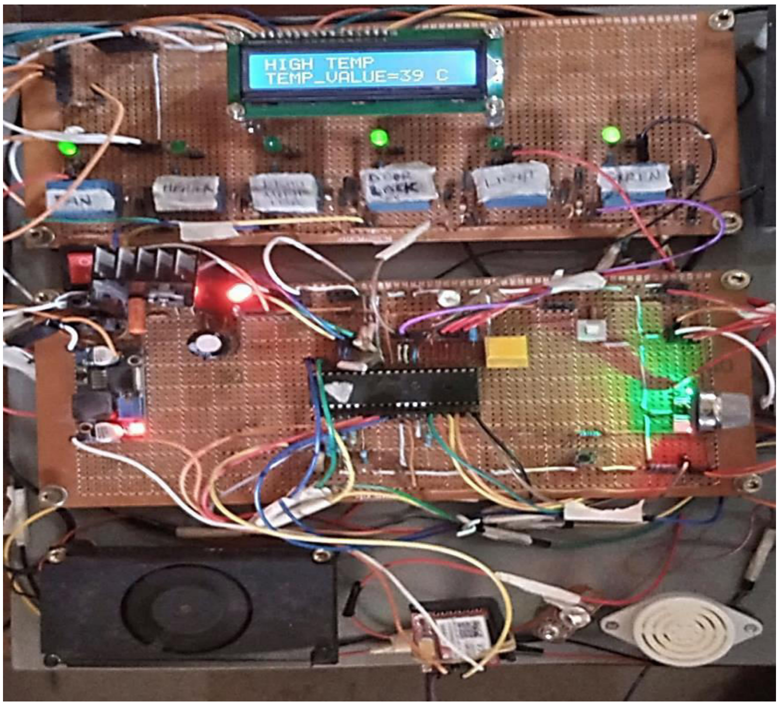

Plate 2: Constructed Prototype of the System in Working Condition: High Temperature

IV. RESULTS AND DISCUSSION

The system was set up and tested and the following observations were made:

i. All the readings obtained were displayed on the LCD.

ii. The heater was switched on when the temperature was below the lower limit of 15°C to increase the room temperature and it was switched off above this limit. The fan was switched on when the temperature was above 18 °C which is the low limit and switched off below this limit to prevent the temperature going too low. Between 15°C and 18°C, both the heater and fan are switched off to maintain the room temperature. The fan and siren were switched on when the temperature was above 25 °C which is the high limit. An SMS was sent when thetemperature was out of range either below 15°C or above 35°C to alert concern persons to take action.

iii. The humidity of the load-centre was monitored and controlled based on the set threshold limit. The dehumidifier was switched on, and an SMS sent to the registered mobile number above the set point of 60%, and was deactivated below the threshold.

iv. The smoke detector program was also observed to have worked properly. Below the set threshold, the siren was switched offbut above the threshold of 200 ppm, the siren was activated and an SMS sent to the registered mobile number.

v. The lighting of the load-centre was also controlled by two thresholds: the high limit of 500 lux and the low limit of 200 lux. The lighting relay was switched off above the high limit and switched on below the low limit.

vi. The keypad was used to open the door when the door open interrupt switch was pressed. The "*" key was used for password request and the request was displayed on the LCD. The correct four digit password (2345) is then inputted. After entering the correct password, the "#" was pressed for confirmation; the solenoid lock was de-energised for up to 10 seconds for the door to be opened and access granted. When the wrong password was entered, access was denied and the system allowed for two more opportunities to correct the error and after three wrong trials, the door remained closed. Password change is achieved when the change password code or master code (23455) was inputted, permission is then granted to enter the new password, which is then captured and used subsequently for de-energising the solenoid lock.

vii. When the door was kept open for more than 10 seconds, the system activated the buzzer to alert the user to close the door so as to maintain the room environment condition. The door limit positions were displayed on the LCD.

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V. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The prototype Factory Load-Centre Monitoring, and Security System successfully designed and built was able to achieve the purpose for the design but the Driver circuit may need relays that can handle the power requirements to drive the actuators for an actual load centre. The system was able to measure and control the load-center room temperature, humidity and security. It also monitored Smoke/gas leakage to prevent possible fire outbreak. The reduction of power/energy consumption was achieved through lighting control and the incorporation of an LCD and an alarm system for alerting concerned persons of a breach was also implemented successfully.

5.2 Recommendations

The practical applications of this project are immense. The system can be used in fields such as remote sensing, robotics, home automation, and many other related fields where continuous monitoring and regulation is needed. A camera can be added to improve on security and an additional memory installed to store data for documentation, analysis and future use.

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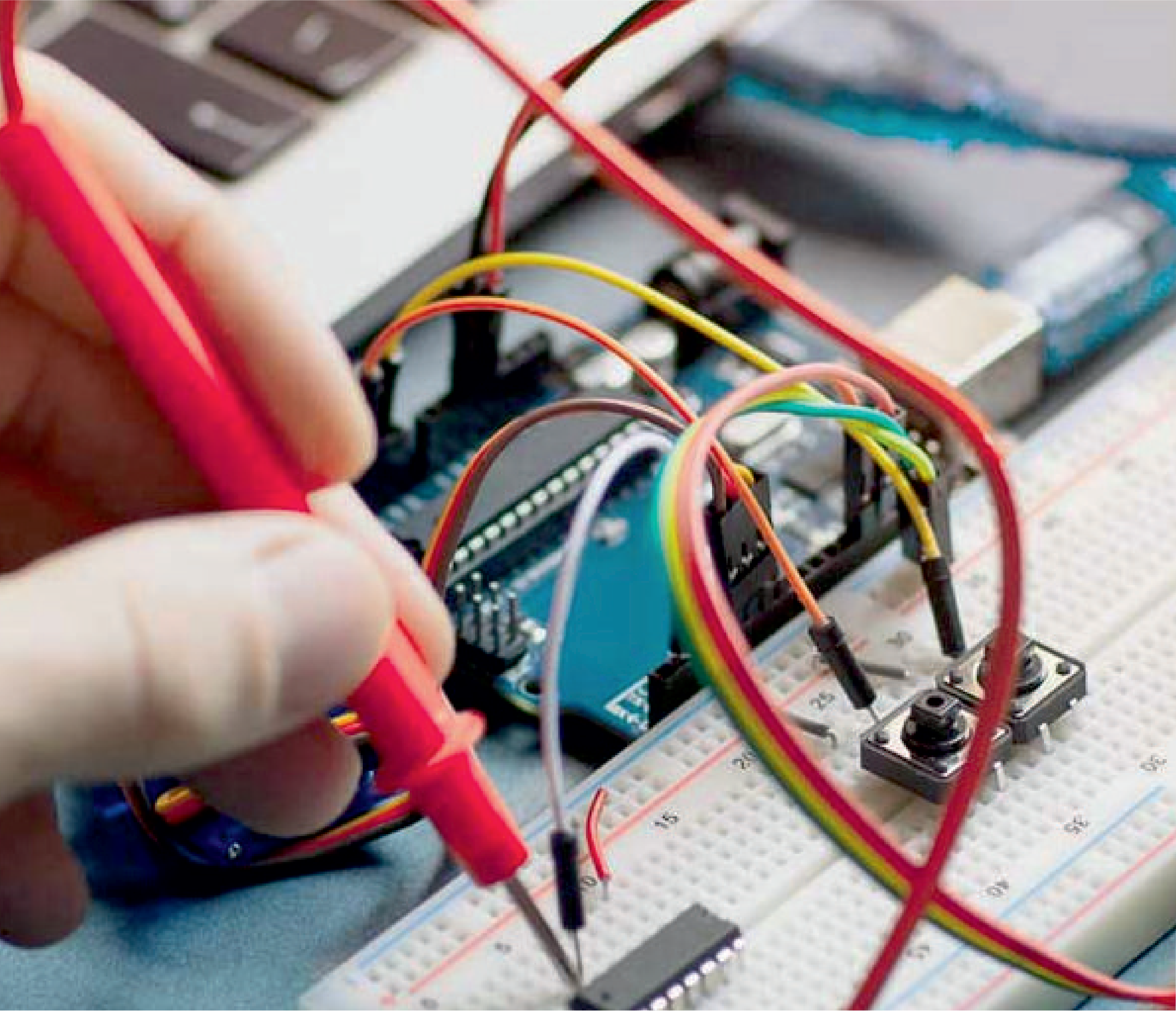

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