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Microcontroller Based Building Automation System using RTD Sensor

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Abstract

The advance technology makes the things simpler and also easy to access. Latest trends in automation technology are controlling the household systems automatically. By making Atomization helps us to save the electrical energy. The main idea behind this Building Automation System is to save the electrical power and avoiding the fire hazards. Building atomization system is very useful to the people like mentally/physically challenged people and senior citizens too. The current paper presents Microcontroller based Building Automation System by using different sensors. The aim of this system is to control the lighting, air-conditioning based on temperature, Gas leakage detection and water flow controlling for the gardens. Software is developed in C using Si-Labs cross compiler.

Keywords: *Building Automation, C8051F120, Sensors and Si-Labs C cross compiler.*

1. Introduction

The main object of this study is to design the green automation [1] system for house-hold appliances and which could also help the people who are physically/mentally challenged.

The physical data from our environment is analog data. To measure the physical data we require a device called Sensor. Sensor is a device which also called as Transducer, is used to measure the physical quantity of the analog data which we have to control or read. We can read or control the physical data by interfacing the sensor with the Microcontroller.

The sensor based [2] BAS (Building Automation System) is a Data Acquisition System which reads the data from the different sensors and communicate the result with the host system.

2. Research and Design Methodology

The word *Automation* [3] means replacing the human operators. To do the automation some transducers are interfaced with the controlling device. The proposed system block diagram is shown below.

2.1 Block Diagram

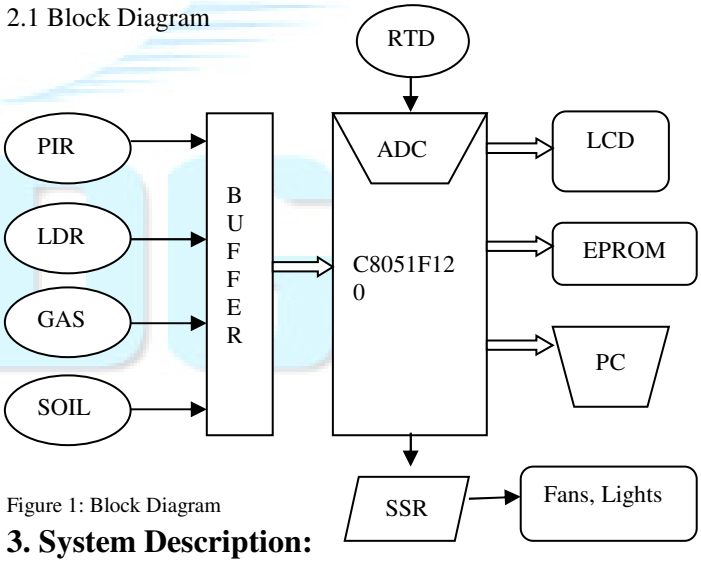


Figure 1: Block Diagram

3. System Description:

The basic block diagram of the BAS is shown in Figure 1.The input sensors are connected to the controller *C8051F120* through buffer. The C8051F120

microcontroller has in-built 12bit ADC and it has internal PLL circuit to increase the oscillator speed. The status of the output devices is displayed on the LCD and also transferred to the host system through the UART. The summary of the hardware configuration is listed below.

- ✓ ***C8051F120:*** Inbuilt ADC, I2C, SPI and UART.
- ✓ ***SENSORS:*** Analog transducers are used to measure the Analog data.
- ✓ ***HOST PC*** **:** Used for Data Acquisition System by using serial communication with MCU.

3.1 ORCAD Schematic:

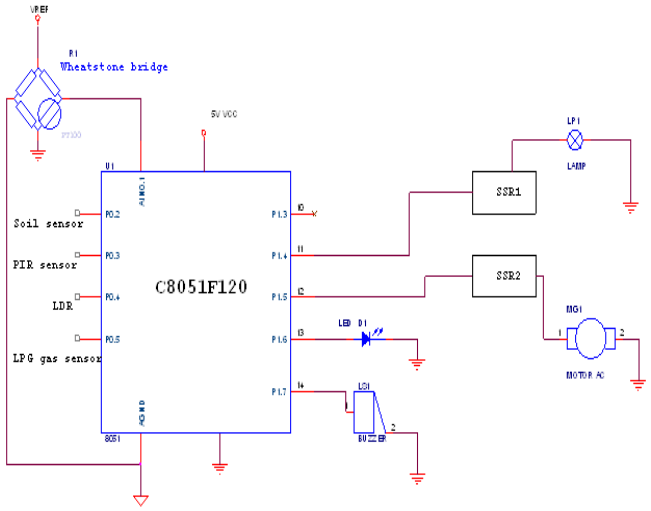


Figure 2: ORCAD Schematic diagram

The figure 2 shows the schematic diagram of Home Automation System using ORCAD tool.

3.2 C8051F120:

The C8051F120 microcontroller is a 100 pin ,high speed 8051 microcontroller core mixed signal controller with 64 digital I/O pin by *Silicon Laboratories* . It has in-built 12bit ADC with 8 channel analog multiplexer. It also has an 8-bit ADC and 12bit DAC. It has 8448 bytes of internal data RAM, 128kB of Flash memory and 64kB of external data memory (XRAM). Two on-chip UARTS, UART0 and UART1[4] are used for the serial communication. C8051F120 has 8 byte wise general purpose in/out ports (P0, P1 ...P7). All port pins are both bit addressable and both byte addressable. We can define the ports from P0 to P3 as general purpose input and output by a digital peripheral or function. And we can define the ports P4 to P7 as a general purpose input and output by reading and writing the port associated special function register.

The main advantage of this CIP-51 microcontroller core is the instruction throughput is very high when compared with the normal standard 8051 microcontroller. In CIP-51 core controllers, more than 70% instructions executes within one or two system clock cycles.

3.3 Input Devices (Sensors):

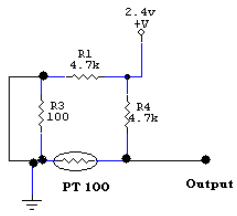
The input devices to this system are the sensors.

A) RTD (Resistance Temperature Detector):

RTD [5] is a kind of transducer which varies the resistance in accordance with the temperature. The most common RTD is PT100 which has a linear variation in resistance for respective temperature approximately.

For a PT100 sensor, a 1 °C temperature change will cause a 0.384 ohm change in resistance, so even a small error in measurement of the resistance can cause a large error in the measurement of the temperature. For precision work, sensors have four wires- two to carry the sense current, and two to measure the voltage across the sensor element. In general as the temperature varies the resistance of the PT100.

A standard resistance Circuit called ***WHEATSTONE BRIDGE network*** is used to calibrate the temperature. The default resistance for 0^0C is 100Ω.



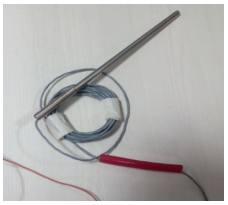


Figure 3: Wheatstone bridge circuit and PT100 sensor

The above figure shows the circuit diagram of PT100 connected to Wheatstone bridge. A three-wire PT100 temperature sensor is used to detect the temperature. The external reference voltage of the signal microcontroller is

connected as reference voltage to the Wheatstone bridge circuit. The output voltage varies from 0V to Vref voltage. The output pin is connected to ADC0.1 pin of the 12bit ADC of signal controller. The ADC reads the value of output as voltage.

B) PIR Sensor:

Passive Infrared sensor [6] is an electronic sensor which detects the infrared radiation from objects in its region also called as Motion sensor. It detects the motion of a heat radiated body.

Figure 4: PIR Module

Operating Principle: All objects with temperature greater than zero emits the heat energy in the form of Infrared radiation. The PIR sensor will detect the Infrared Radiation which is emitted from the object.

Figure 4: PIR Module

The core of a PIR sensor is a solid-state sensor which is made from the materials like Gallium nitride (GaN), Cesium nitrate ($CsNO_3$), Polyvinyl fluorides, derivatives of Phenyl pyridine, and Cobalt phthalocyanine.

- ✓ **Features:**
  - Detecting range : 360 degrees cone angle, 15-20 feet
  - Single bit output
  - Jumper selects single or continuous trigger output mode3-pin SIP header
  - Small size makes it easy to conceal

Compatible with any microcontroller like Basic Stamp, Arduino, At mega, PIC, 8051.

C) SOIL MOISTURE SENSOR:

Soil moisture sensor [7] is a device which detects the water content in soil. In this BAS the moisture sensors are based on two electrodes measuring the resistance of the soil. If the soil is wet, the resistance of the soil is very low then the sensor gives the high output, else the resistance between the electrodes increases which implies a low output from the sensor.

Applications:

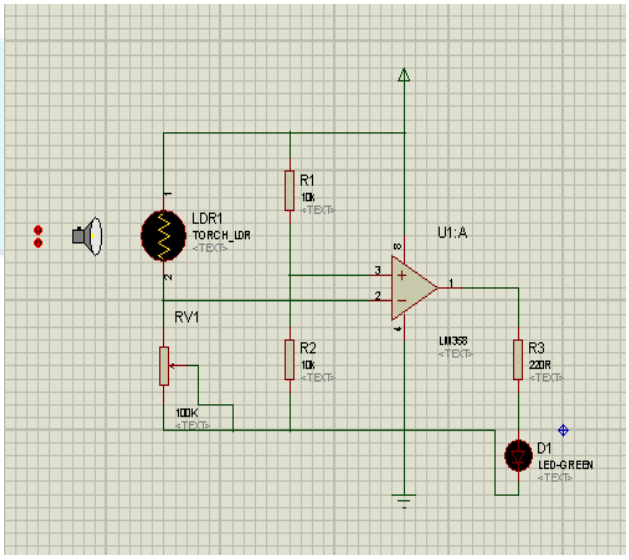
Measuring soil moisture is important in agriculture to help farmers manage their irrigation systems more efficiently, to increase yields and the quality.

The other disciplines using soil moisture sensors. Golf courses are now using sensors to increase the efficiencies of their irrigation systems to prevent over watering and leaching of fertilizers and other chemicals offsite and less favourable conditions to for insects and fungal infections.

D) LDR Light Dependent Resistor):

Light Dependent Resistor (LDR) [8] also called as dark sensor is sensor which changes its resistivity in accordance With the help of illumination of light. The LDR is constructed with the help of Cadmium Sulphide (CdS).The sensors resistance decreases with increase in the intensity of illuminated light. As the intensity of the illuminated light decreases the resistance of the sensor increases.

Figure 5: Circuit diagram of LDR (OFF state)



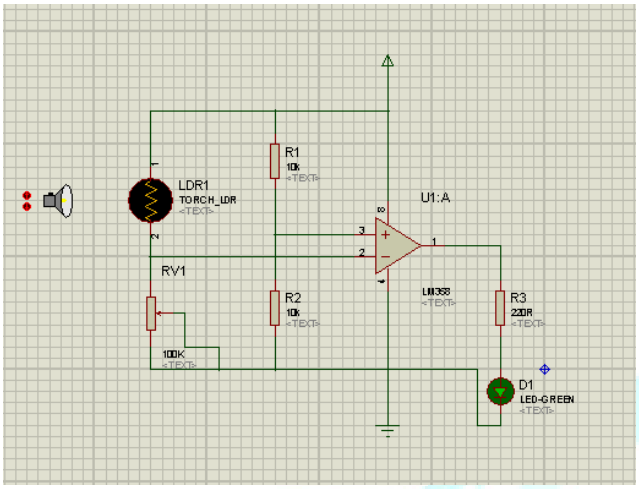


Figure 6: Circuit diagram of LDR (ON State)

In general LDR senses the physical quantity. So to measure the value of LDR output an ADC is used. In this BAS instead of using ADC LM358 is used as comparator to get the digital data as output from the sensor. The circuit of LDR with LM358 is shown below.

The above figure5 and figure6 shows the LDR interfacing with LM358, a dual core low power op-amp, which are designed by using the PROTEUS tool. When light illumination is very low then the output is very high which is shown in fig1. In fig2 some light illumination is illuminated on LDR, and then the output is low. The output is collected from the first pin of op-amp which is directly connected to microcontroller port pin.

E) LPG Gas Sensor:

The sensor MQ-6 [9] is used to detect the LPG gas. This sensor has low conductivity in clean air, as the combustible gas concentration increases; the conductivity increrases.This sensor has high sensitivity to Propane, Butane, LPG and also natural gas.

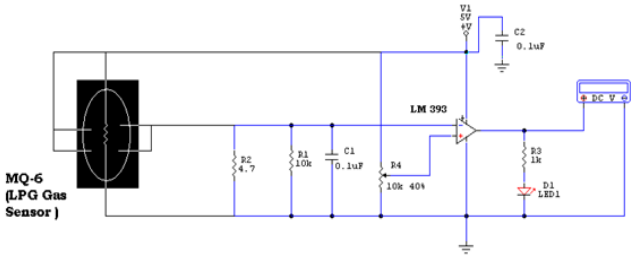


Figure 7: LPG Gas Sensor interfacing with LM393

The output of the LPG sensor is analog value. To convert the analog value into digital LM393 is used. The above circuit shows the circuit diagram of LPG gas sensor, which detects the Butane, Propane or LPG gases.

The structure of MQ-6 gas sensor is shown in above figure. Tin Dioxide sensitive layer is placed in Al_2O_3 ceramic tube. Measuring electrodes are fixed into a crust, which is made by plastic and stainless steel net is mounted on the sensor.

- ✓ **Applications:**
  - Domestic gas leakage detector
  - Industrial combustible gas detector
  - Portable gas detector.

3.4 Output:

The output devices like FAN, LIGHT and FLOW controller are connected to the Solid State Relay (SSR) .

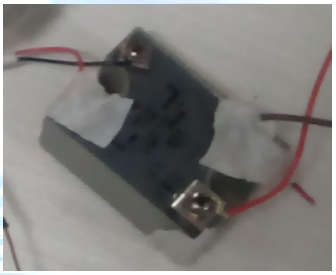


Figure 8: Solid State Relay

3.5 Working:

The working procedure of Building Atomization System is as follows.

The microcontroller unit initializes all the peripherals and it continuously reads the temperature data with the help of PT100, which is connected to 12 bit internal ADC of C8051F120. The PT100 is a type of Resistance based temperature detector. It varies its resistance value with respect to temperature.

Wheatstone bridge circuit is connected to the PT100 to measure the output value in terms of voltage. The output resistance of PT100 for 0^0C is 100Ω. For each ^{0}C the output of PT100 varies 0.392 Ω. Here the supply voltage to Wheatstone bridge is the external reference voltage of C8051F120.

S.NO	Output Voltage (Vout)	RTD output value	Output Temperature (@7.30PM) (Practical value)	Atmosphere Temperature(original – from Google)
1	0.048901 mV	109.088 6Ω	23.6^{0}C	24.2^{0}C

Figure 9: Table contains RTD output value

If the PIR sensor value is high then the MCU will check the status of LDR. If LDR status is high, this means that the light intensity on LDR is very low. Then the MCU switch on both the *light* and *fan*. If temperature value is very low then it automatically switches off the fan. Here the limit value is 20^0 C. PIR sensor and LDR sensors are used to control the light and fan through Solid State Relay.

The LPG gas sensor detects the Butane and Propane gas molecules in the air. When it is clear air the output value of LPG sensor is low. If the concentration of Butane or Propane increases in air then the output will be high. If the output is high the MCU switches on the Buzzer.

The soil moisture sensor is used to detect the wetness of the soil. If the soil is wet then the MCU switches off the *water valve* otherwise it continuously switches on the valve.

The status of each and every module is updated to host PC through the serial communication.

4. Flow Chart:

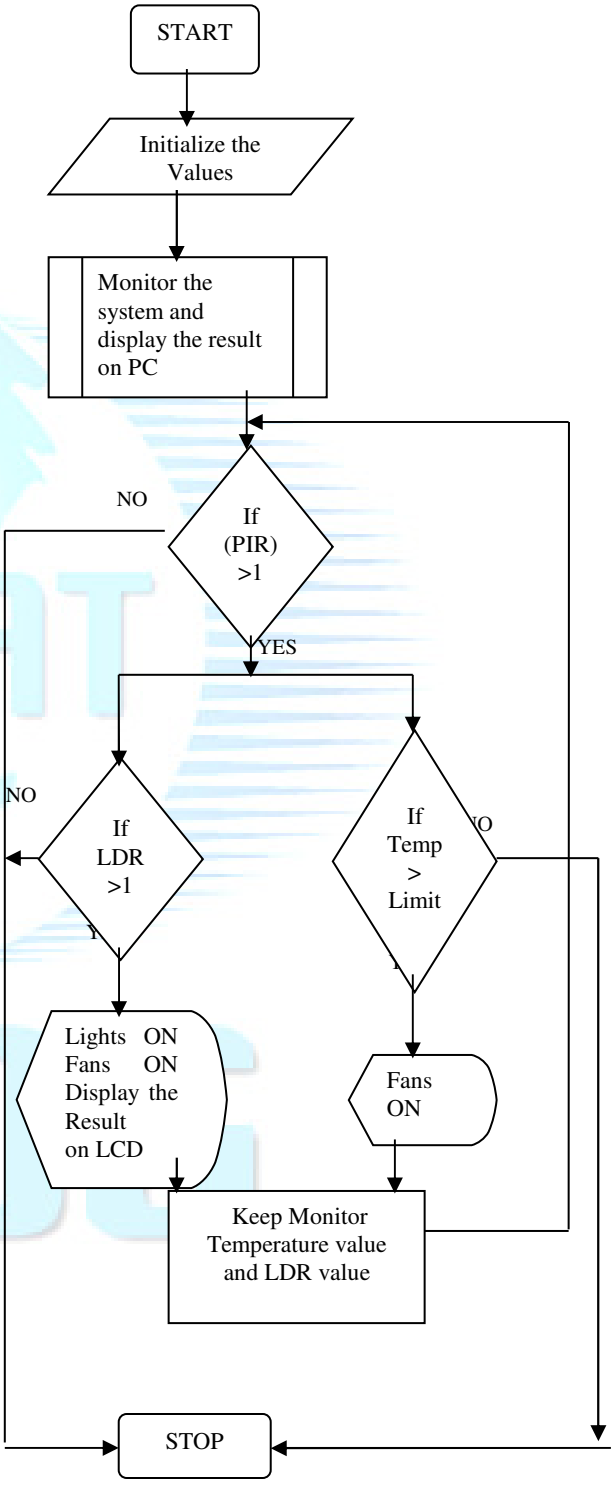


Figure 10: Flow chart for Building Automation system

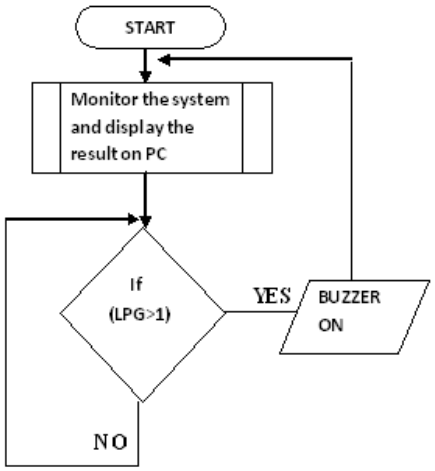


Figure 11: Flowchart for LPG gas detection

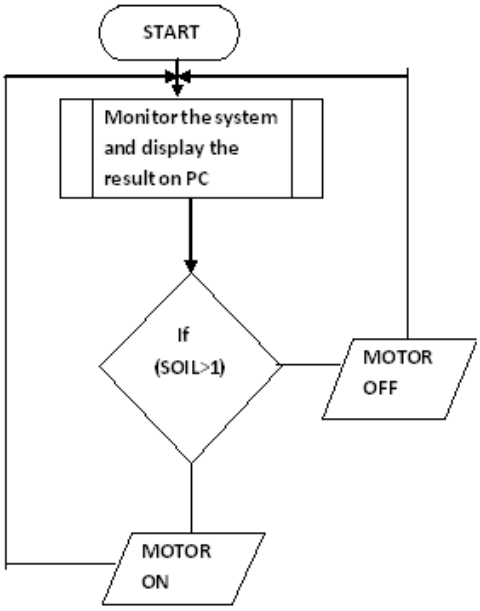


Figure 12: Flowchart for detecting moisture levels in soil

4. Procedure:

The signal microcontroller C8051F120 is interfaced with Sensors like RTD, PIR, LDR, and Soil moisture sensor. The RTD sensor is connected to the 12 bit ADC of microcontroller through Wheatstone bridge. One arm of Wheatstone bridge is connected with 3-wire RTD sensor. The remaining arms are connected with 100ohm, 4.7K resistors. As the temperature varies the resistance of the RTD sensor also varies. The variation of resistance is calculated by using the Wheatstone bridge.

The PIR sensor module is connected to one of the port pin of the microcontroller. This module detects the hot body radiations from moving human beings. If any person enters into the home then this sensor sends a digital signal to microcontroller.

Then the control unit checks the status of LDR and RTD temperature sensor. If the temperature is more than the pre-defined limit then the FAN/AC will be turned ON. Otherwise all FANS/Ac are in OFF mode.

Simultaneously the control unit checks the status of LDR to know whether sufficient light is present or not. If sufficient light is not there, then the microcontroller switch ONs the Lights otherwise all lights will be turned OFF.

The MQ-6 LPG gas leakage sensor is used to detect the gas leakage in home. If there is any gas leakage the microcontroller gives alarm using buzzer.

This system also has intelligent plant irrigation system. The soil moisture sensor is used to detect the moisture level in the fields. If sufficient water is present the controller will not switch ON the motor otherwise the motor automatically turned ON by the microcontroller. The status of soil moisture sensor, LDR, LPG gas sensor and PIR module is transmitted to host PC using the serial communication. The Temperature value from RTD sensor is always displayed on the serial window. The ensample pictures are shown below.

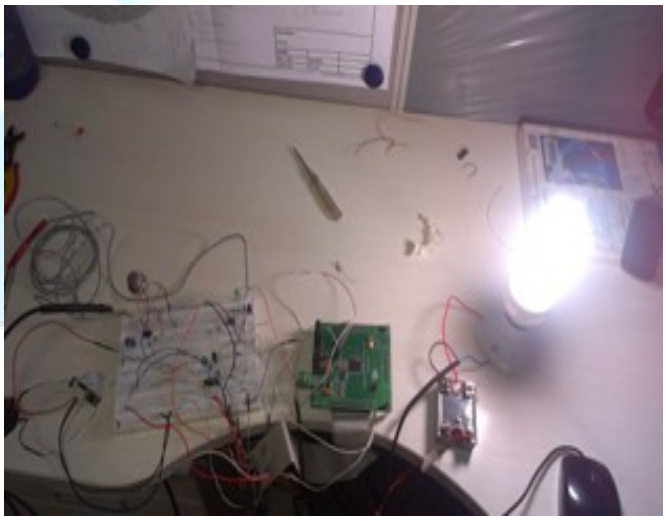


Figure 13: Experimental Setup

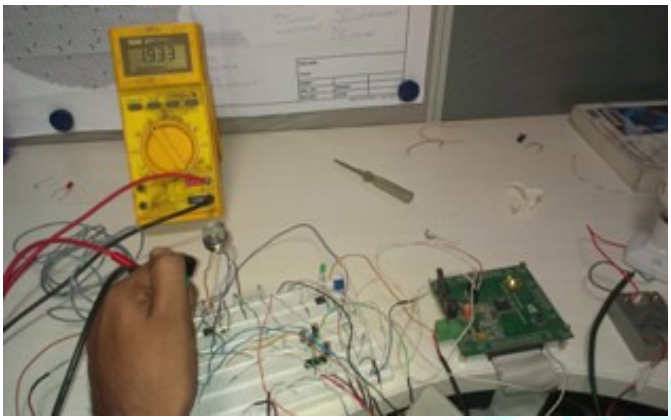


Figure 14: Measuring voltage from LPG gas sensor.

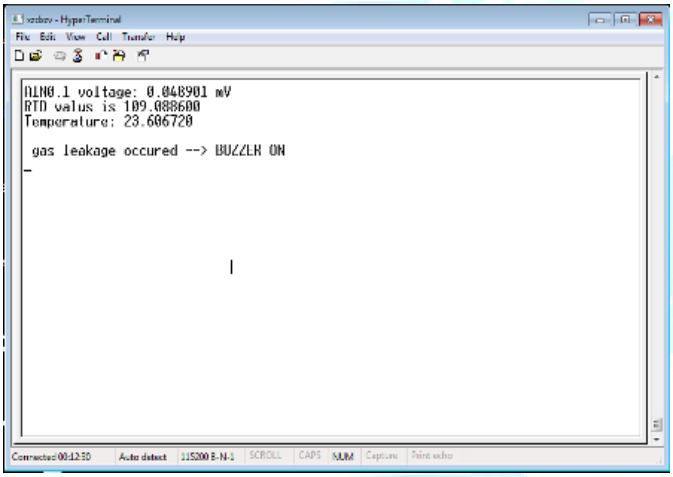


Figure 15: Serial output data

The figure13 shows the experimental setup of Building Automation System. A 60W bulb is connected to the solid state relay. The bulb will turned ON in accordance with the LDR output value. Figure14 shows the LPG gas sensor output value. The serial window contains analog output voltage, RTD resistance value, Temperature value and the status of each sensor which is shown in figure15.

5. Precautions:

- ✓ Always Gas sensor should keep near to the kitchen
- ✓ Check to ensure the communication between MCU and host PC.

6. Result:

The design of Building automation System using Resistance based temperature detector is developed. The advantage of the proposed system is as follows.

- ➢ The proposed system is very useful to Senior citizens, physically and mentally challenged people.
- ➢ Energy and water saving is also possible using this system.
- ➢ This system also detects and alarms if there is any gas leakage occurred.

7. Conclusion:

This Building Automation System (BAS) is very useful for mentally and physically retarded people. This system also reduces the power consumption.

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