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Design of An Embedded System For Monitoring and Controlling Temperature and Light

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Abstract

Each and every part of our life is somehow linked with the embedded products. Embedded systems are the product of hardware and software codesign.Embedded system is becoming an integral part of Engineering design process for efficient analysis and effective operation. From data analysis to hardware work, every where embedded products are the main interest because of its reliability and time bound perfection. There is not much time with anyone now a day to give enough in all aspects, so demand of embedded products which serve as we want is high on demand. The present paper describes the design of an embedded system for the control of Temperature & Light intensity with continuous monitoring in a single system using sensors, microcontroller and LCD.It describes the controlling action incorporated in the hardware to control any device connected when specific conditions are met. Further set up is made such that data can be stored for future offline analysis.

Keyword: Embedded technology, Microcontroller, Sensor, Control and measurement.

Introduction

It is very much essential in case of some industrial as well as experimental setup to monitor as well as control temperature and light continuously. The efficient solution for this problem is to develop a data logger. Earlier development of data logger was done through manual measurements from analog instruments such as thermometers and manometers. Unfortunately this type of data logger can't fulfill the current requirements in terms of time and accuracy. From 1990 a further development in data logging took place as people begin to create PC-based data logging systems [1]. In later stage of development it has been found that microcontrollers (integration of microprocessors and certain peripherals including memory on single chip) are more reliable as well as efficient [2]. Use of microcontrollers in embedded design is not only increased but brought a revolutionary change. At the same time competitive pressures require manufacturers to expand their product functionality and provide differentiation while maintaining or reducing the cost

Monitoring and controlling physical parameters like temperature, pressure, humidity, light etc. by embedded systems using microcontrollers are very much effective in industrial and research oriented requirements. Nature of parameter is ever-changing. They are exposed to huge array of stimuli from its environment. Though temperature can be monitored through variety of sensor, one should adhere to utmost care in selecting sensors due to different levels of complexity associated with the calibration process. If calibration is not implemented properly output of the embedded system may vary from actual temperature measured through standard instruments. Similarly in case of light LDR serves well but its calibration in Lumens is some what difficult due to easy unavailability of Lux-meter. Hence in general reference voltage of ADC can be taken with some precautions as intensity of light.

The purpose of this paper is to explore the possibility to continuously monitor temperature & light intensity. The display in LCD is programmed in such a fashion so that temperature value and light intensity are displayed one by one at a fix interval of time. System is also equipped with necessary hardware to initiate control action for temperature & light intensity as soon as they reach higher than some particular set values. The system developed also enables its users to set the value of temperature & light as desired and set transfer rate of data through RS232 to pc. After every time interval set by the user the momentary values of temperature and light intensity are sent to the pc. Necessary Keypad in the form of push-buttons is provided for setting desired temperature, light intensity and transfer time. For the purpose of storing and some intelligent analysis of data system is connected to pc through RS-232. This setup can be effectively used in industries for single control end. Concept is to connect such hardware in different rooms where control over temperature and light intensity is our main concern and view them from a single control end with the pc connected to all.

Motivation

Main cause of doing this project is its low cost and industrial demand. Such a design can effectively decrease the number of computers used in an industry such as food processing, green house or a packing industry & thus in turn can save power which is the main feature of this project.

Experimental Setup

The hardware and software description of the embedded system for monitoring and controlling temperature described in the following section-

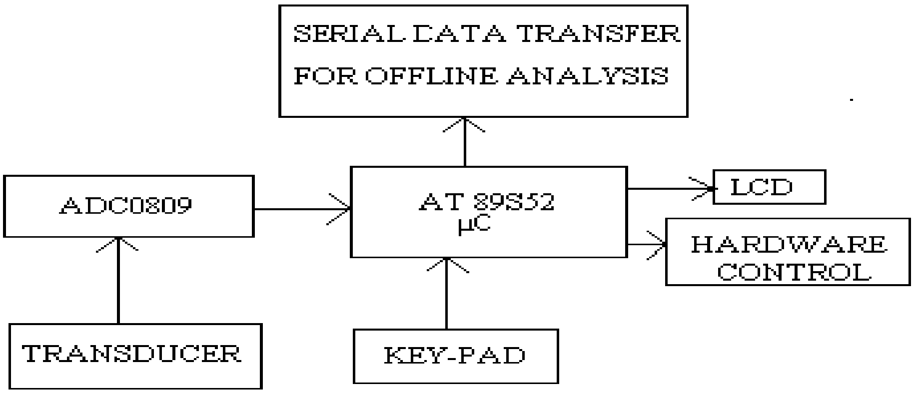

Figure 1: Block Diagram of The Experimental Setup.

Hardware Description

Whole circuit can be divided into following sections:-

(a) **Power supply section:** The regulated power supply section made with full wave rectifier (with IN 4007 diodes) using voltage regulator IC 7805 and IC 7812 which provide a constant voltage of 5V to the circuit as well as constant 12V to relays.

(b) **Analog to digital conversion section:** Since we have to sense analog parameters i.e. temperature and light hence we have to use any analog to digital converter. We have opted for ADC 0809 as it has 8 channels and is microprocessor compatible ADC which is easily available [3]. It will convert the analog signal of the transducer to digital value with respect to the reference voltage which in our case is 2.5V. This reference voltage is obtained using TL431, which is a programmable shunt voltage reference with output voltage range of 2.5V to 36V and works like zener diode [4]. For the conversion ADC requires a reference frequency which is supplied from 555 IC in the form of astable oscillator. The conversion frequency is kept around 150 kHz.

Sensor used for temperature measurement is LM 35 and for light intensity is LDR. LM 35 is calibrated in ºC and is linear in +10 mV/ ºC scale factor with 0.5ºC accuracy [5]. The calibration curve given here with will make the scenario clear.

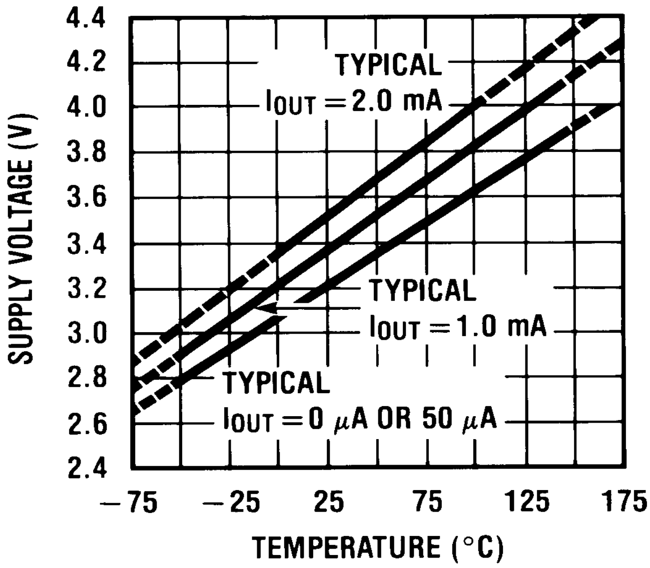

Figure 2: Voltage vs. Temperature Calibration curve.

For light intensity we have considered the reference voltage of ADC as standard. In that process 2.5V is considered as full light and 0V is considered as darkness. The light intensity is hence displayed in LCD as the reference voltage itself.

(c) **Controller section:** The analog value is converted to digital value by ADC and is picked up by microcontroller AT89S52 which is a 40pin device. The AT89S52 is a low-power, high-performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (EPROM) [6].

(d) **Display section:** Since we need to display the data we get from microcontroller a liquid crystal display 44780 LCD is used which is a 2x16 line display [7] [8].

(e) **Temperature control section:** This section consists of a 12V relay to control hardware to start cooling for maintaining temperature as set by the user. [9] [10].

(f) **Light control section:** This section consists of another 12V relay to control hardware such an LED to glow at a particular voltage indicating darkness as set by the user.

(g) **Hardware controlling:** Simple push buttons are used to set temperature and light intensity (in form of voltage) as well as to give the time of data transfer to the pc.

(h) **Data transfer:** Displayed data of temperature and light intensity are transferred to RS 232 which is interfaced with microcontroller through MAX232 [11] [12].

Schematic diagram of the system is given below-

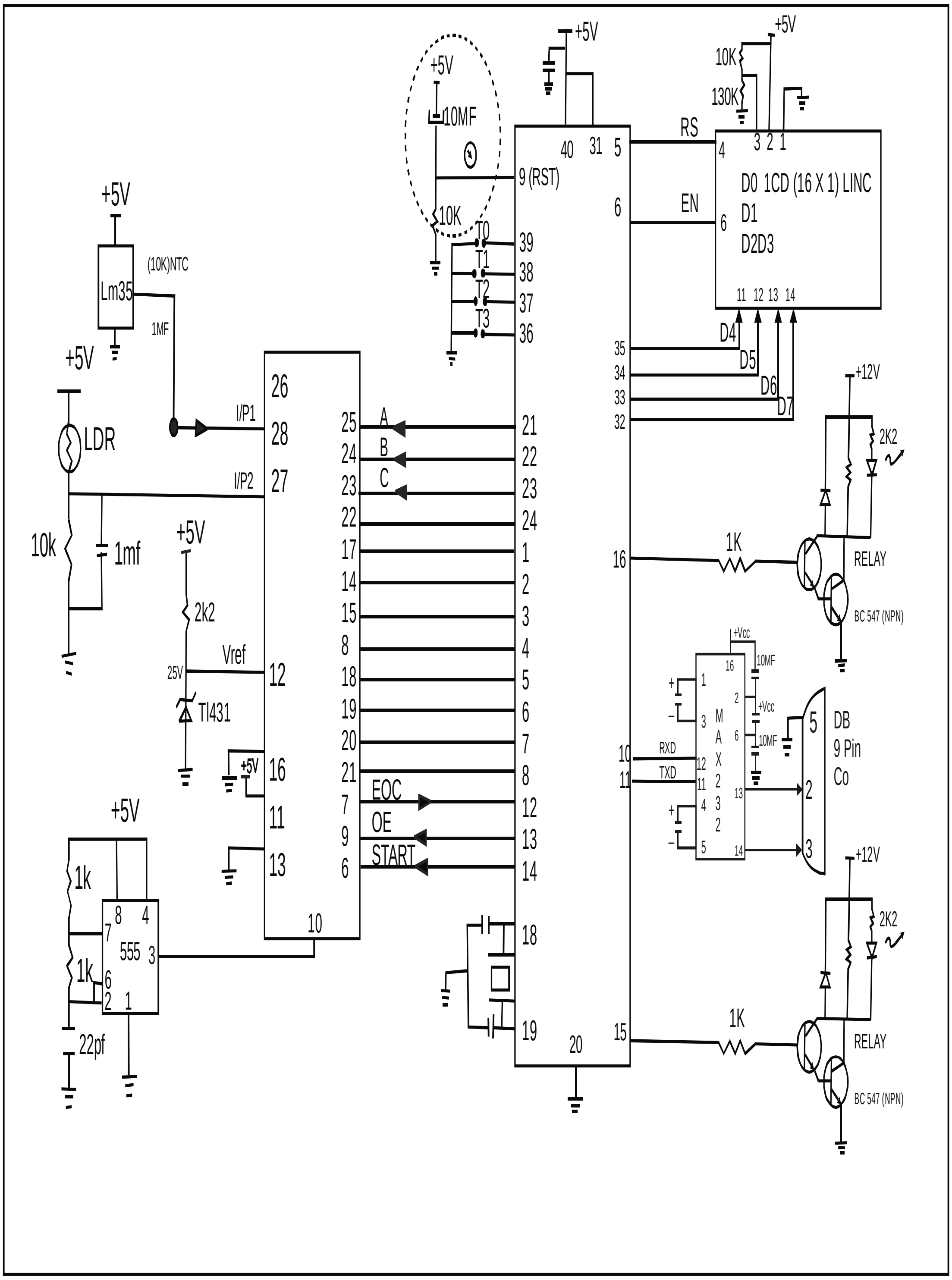

Figure 3: Embedded Control Hardware Circuit --Schematic Diagram.

Figure 4.1: Embedded Control Hardware Circuit (Light display).

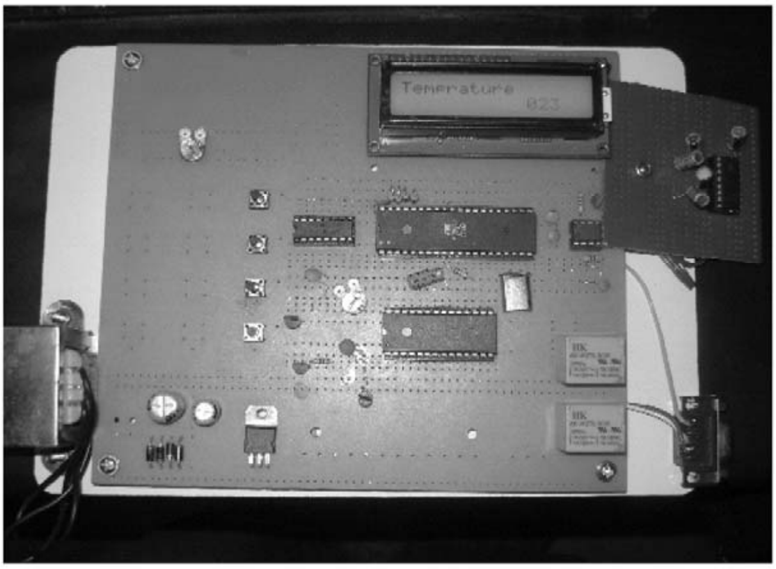

Figure 4.2: Embedded Control Hardware Circuit (Temperature display).

Software description

Software development for the project consists of two main modules one being the online monitoring and controlling and other offline analysis based on data stored in computer .Presently this paper limits its work on first module keeping second module for future development Software is developed in both C and Assembly language.

Algorithm for online monitoring and controlling of temperature**:**

1. First step is to initialize keys, Interrupt vectors panel and LCD

2. Define port P3 of microcontroller ATMEL 89S52 as output port
3. Get data through ADC0809 from two different channels of Temperature and Light Intensity continuously after a fixed interval.
4. Value obtained from different channels converted to appropriate form of display
5. Display the appropriate values of Temperature and Light Intensity in LCD panel in Round Robin pattern
6. Start hardware devices for cooling if sensed temperature is higher than set temperature
7. New value of Temperature can be set using four keys as follows
   - 7.1 Press first key for once to display existing value of temperature set and blink cursor at unit position
   - 7.2 Press second key for increment in unit position
   - 7.3 Press third key for shifting one position left at a time
   - 7.4 Press fourth key for setting new temperature value replacing previous one
8. Start hardware device to glow a light if sensed light intensity is higher than the set value implying darkness.
9. New value of light intensity can be set using four keys as follows
   - 9.1 Press first key twice to display existing value of light intensity set and blink cursor at unit position
   - 9.2 Press second key once for increment in unit position
   - 9.3 Press third key once for shifting one position left at a time
   - 9.4 Press fourth key once for setting new temperature value replacing previous one
10. New value of transfer rate of data to RS232 is set using keypad as follows
    - 10.1 Press first key thrice for display existing value of transfer rate set and blink cursor at unit position
    - 10.2 Press second key for increment in unit position
    - 10.3 Press third key for shifting one position left at a time
    - 10.4 Press fourth key for setting new transfer rate of data to RS232
11. Return to step 3

Results and Conclusion

In this system, temperature measurement and light intensity from the ADC channels are taken. The performances of the channels are distinguished on the basis of its accuracy. The accuracy indicates how closely the sensor can measure the actual or real world parameter value. The more accurate a sensor is, better it will perform. To achieve this, calibration is done with a standard digital thermometer and since LM35 is a linear device so calibration process yields good result (for each degree rise, 10mV is the rise). Then temperature displayed in LCD is compared with the standard temperature from digital thermometer at an interval of 1hour and results are compared & shown graphically below-

Flowchart for monitoring and controlling temperature and light is given below:

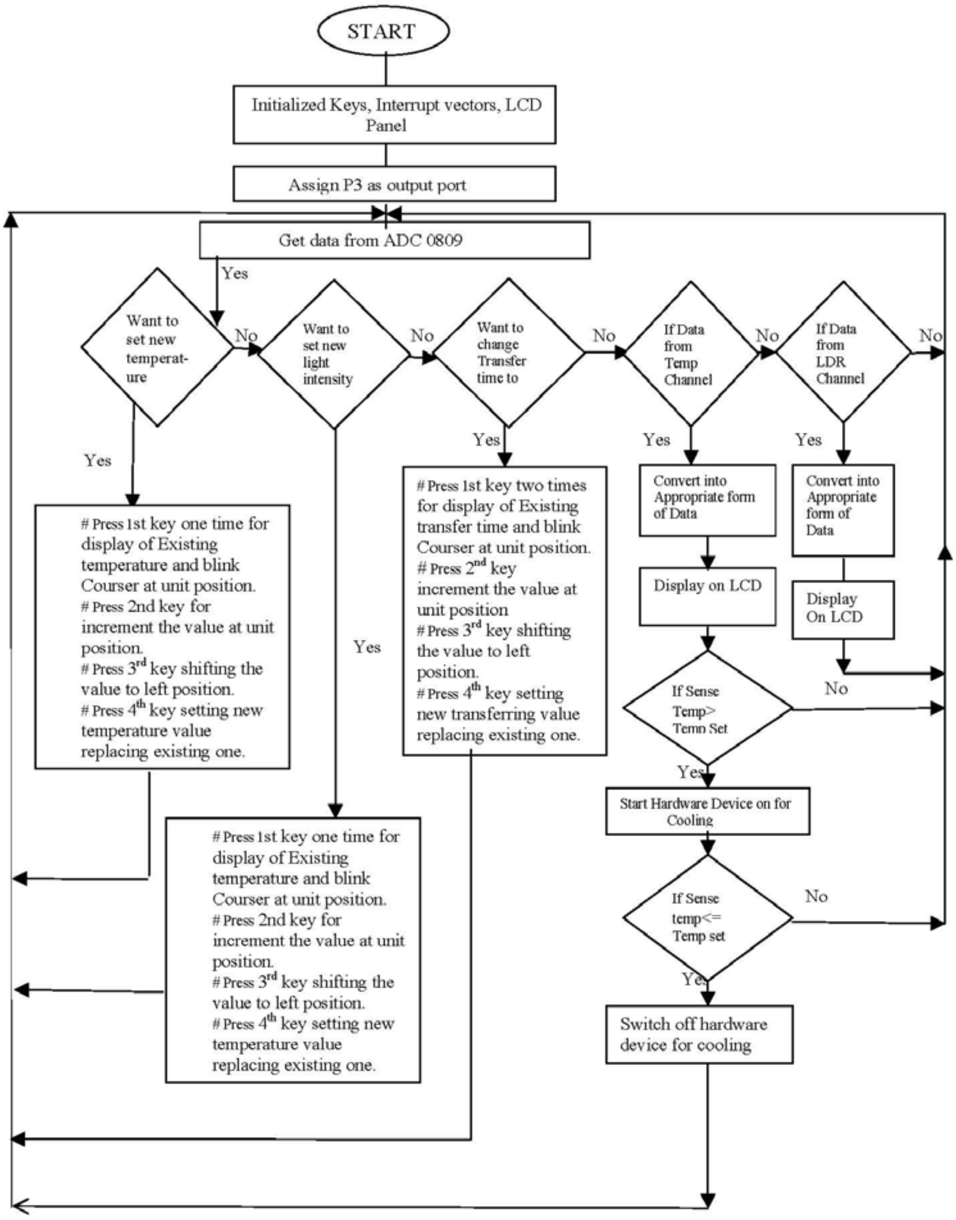

Figure 5: Flow Chart.

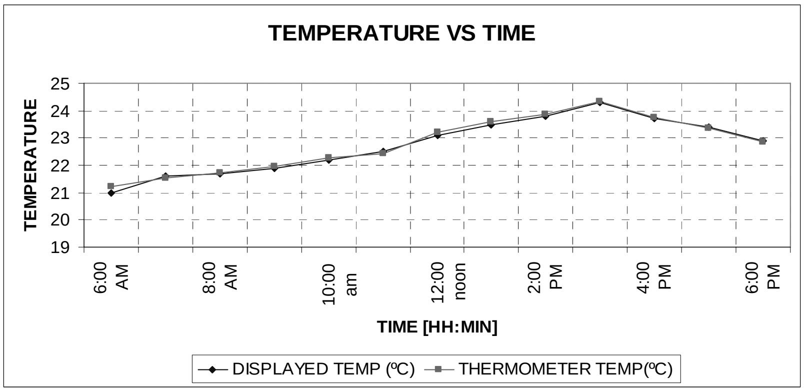

Figure 5: Graphical representation of the experimental data achieved & its comparison With Standard temperature values (digital thermometer).

For light intensity since we have considered the ADC reference voltage (2.5V) as indicating quantity. Its tabulation on a shiny day will make the scenario clear.

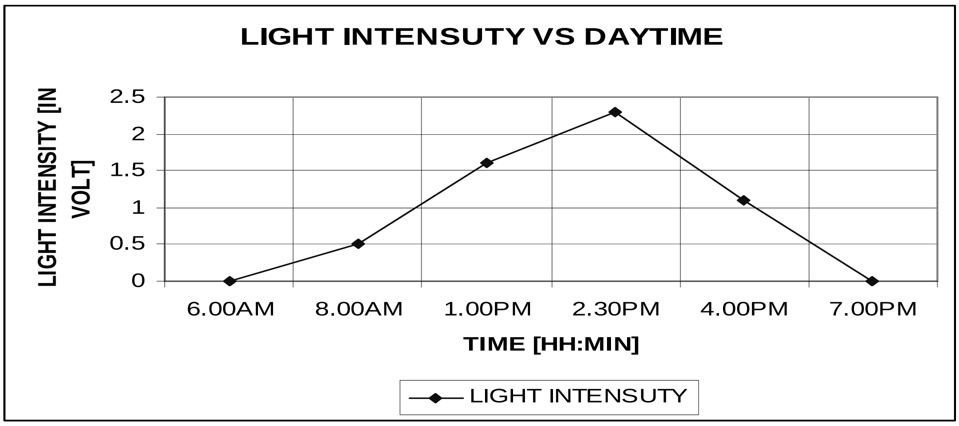

Figure 6: Graphical representation of the light intensity with daytime.

Due to single decimal calibration in the microcontroller the results are correct up to one decimal only. Where two decimal accuracy is needed calibration has tobe made accordingly.

The relays work properly at any set temperature as well as light intensity value. The on/off condition of the relay is set at the same value instead of making a loop of two values. Again set values are possible only up to single decimal in our case. Same set condition can be achieved by creating a loop of as high limit and low limit.

The rate of data transfer through RS232 is controlled through the keypad and whatever the time is declared as the gap at which the data should be transferred to pc is accurately achieved. For example we have set time for data transfer as 2hr, i.e at a gap of 2hr the temperature value at that instant will be transferred to pc. With different values of set value for transfer time, we have experimented and it works properly.

The system can be further enhanced by developing necessary software for offline anlysis.The data stored on PC will enable the system to make historical and intelligent analysis to make efficient decision.

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