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Simple and Cost Effective Environment Monitoring System

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Abstract

Monitoring Environmental factors such as temperature measurement, light intensity, relative humidity and air composition are not only important for industrial purposes but also a cause of growing concern in our day to day life. This paper documents a construction and working of a very simple, easy to use and cost effective Environment Monitoring system which runs on battery power. It is a basic model that monitors temperature in "Celsius" and Light Intensity in "Lumens". It starts working as soon as it is switched on and continuously shows monitored data on a LCD screen and refreshes itself every five seconds. The main objective this project is to construct a simple and effective environment monitoring system for both industrial as well as day to day use for people. It uses two sensors which are LM35 IC for temperature monitoring and Voltage divider circuit of LDR for Light Intensity measurement. It also uses Arduino Uno board which has ATmega328 microcontroller for its functioning. Arduino acts as an interface between the sensors and LCD screen. This project is successfully implemented in hardware and works excellently. The temperature readings are precise and light intensity in lumens is accurate with a negligible error of $\pm 10\%$. The system is cost effective as it uses very cheap sensors, is easy to make, highly portable and compact. This is highly beneficial for low cost industrial applications, travelling situations, outdoor conditions, basic military purposes and household applications.

Keywords: Arduino Uno, Embedded System, Environment monitoring, Light dependent resistor (LDR), LM35 IC, ATmega328-Microcontroller

Introduction

` Today there is need to monitor environmental factors almost in all the industries and for research oriented programs. Especially in remote areas where mobile network is unavailable such as forests, deserts, mountains etc. a small environment monitoring system would prove to be a boon. But the components that are currently available to measure temperature and light intensity require manual operation and are quite bulky to carry everywhere. Also the analog data which they show requires manual effort to note readings so, there is a possibility of human error. For example, the thermometer used to note temperature contains mercury whose height indicates the current temperature is quite inefficient because it fails to provide precise values of temperature, also it takes a lot of time to reach a constant position and the photometer used to measure light intensity is bulky, has a complicated working and operation. So, there is an immediate requirement of an environment monitoring system which is accurate, easily operated, simple in working, has uncomplicated construction, cost-effective, comfortable to carry and lightweight. We aimed to make such a system which fulfills all these requirements.

There have been some previous efforts to develop a microcontroller based environmental monitoring system. One among those is ATMEL89S52 used as microcontroller to display data on LCD, ADC0809 used for Analog to digital conversion of data, and RS232 for serial data transfer which is interfaced with AT89S52 using MAX232 module. This system included data display on computer screen but there were too many components in this and circuit, programming was complicated [1].

There was another attempt to make such a system using PIC16F877A microcontroller in which the sensors were calibrated with the microcontroller and it was interfaced with a LCD [2].

For another system PIC microcontroller was used with relays to control light and temperature using a keypad and LCD. Similarly in for one system a GSM module was interfaced with PIC microcontroller through RS232 module to send data on mobile [3].

In all these systems the microcontroller has complex programming structure for execution of output. In addition, due to too many components the system becomes static and fragile which leads to

difficulty in fabrication. So, our environment system has advantages over the above mentioned systems.

It uses Arduino Uno [5][6] or Induino microprocessor board which contains ATmega328 microcontroller which works at 16-MHz frequency. It also uses LM35 IC which is also called "temperature sensing IC" to measure temperature and has become very popular in last few years because of its accuracy and precision [7]. It uses a LDR voltage divider network to measure light intensity in lumens (lux)[8]. It uses a nominal voltage of 5V which can be easily provided by a 9V battery through 7805IC. For display we used a stunning 16×2 LCD screen which makes it very easy to note the readings. Also the readings are refreshed every 5 seconds to provide updated information. Due to extremely fast working of microcontroller, simple programming codes and clean user interface helps in making this system easy to construct and efficient at work. The components which are used are a lot cheaper than the instruments used for measuring temperature and light intensity. So, this makes this system cost effective also.

This project can prove to be tremendously useful in various areas of application such as in outdoor/climatic monitoring it can be used in glacial temperature monitoring due to broad temperature range of LM35 IC and for wildlife habitat monitoring in forests. It can be used in aquatic environments like river temperature monitoring, Fish farming etc. In indoor conditions it can be used for recording environmental conditions to comply with Health and Safety regulations, monitoring the effects of different types of building materials, e.g. loft or wall insulation, Validating heating, air-conditioning or climate control systems and so on.

Proposed Block Diagram

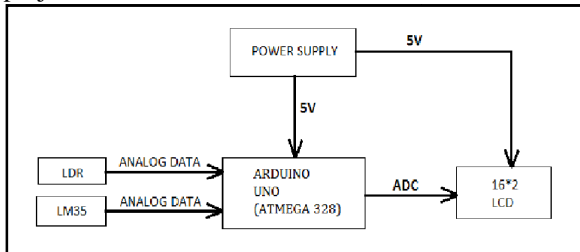A schematic block diagram is shown below in (Fig.1, Fig.2) to explain the general concept of this project.
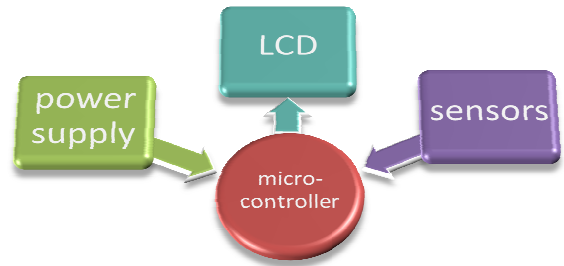

Fig. 1 General block diagram of the Proposed system

Fig. 2 Block diagram showing inputs and outputs of system

The components of the block diagram are briefly explained below:

Arduino UNO board: Fig.3 shows Arduino UNO board. It is open source hardware and can be programmed according to Project requirements. It can be reused again and again with different programs and has a beautifully crafted and very simple coding language. The heart of this board is ATmega328 microcontroller chip. It is a 28 pin IC with ceramic resonator of 16-Mhz and 32Kb of flash memory for storage. It has 14 digital input/output pins (of which 6 can be used as Pulse Width Modulation outputs), 6 analog inputs, a USB connection, a power jack, an ICSP header, and a reset button. It has a operating voltage of 5V. Simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to power the board.
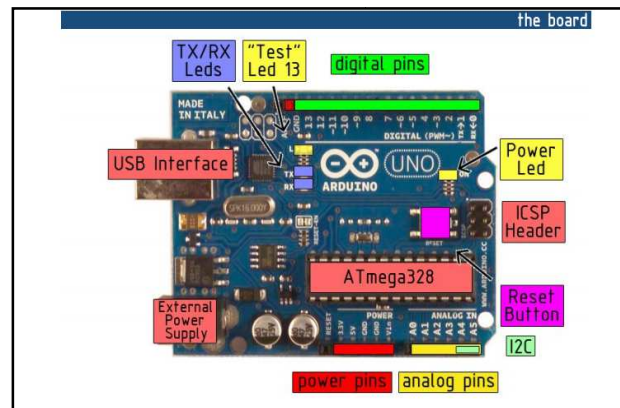

Fig.3 Arduino Uno board

LDR: A photo-resistor or light-dependent resistor (LDR) or photocell is a resistor whose resistance decreases with increasing incident light intensity. They are found in many consumer items such as camera light meters, street lights, clock radios, alarm devices, night lights, outdoor clocks, solar street lamps and solar road studs, etc. Its resistance varies linearly with light intensity, which can be used to predict the ambient light intensity.

Graph of LDR resistance v/s light intensity in lumens (lux) is shown below.(Fig.4)
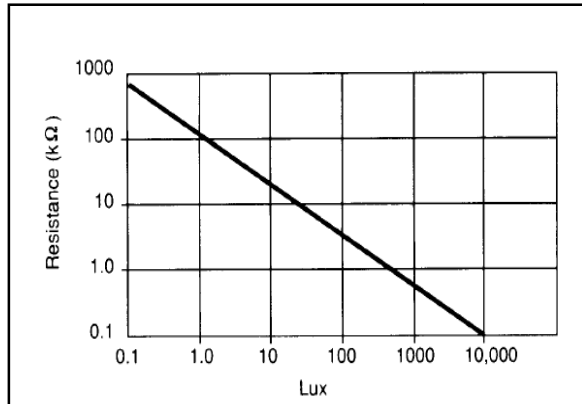

Fig.4 Resistance v/s Intensity of typical LDR

LM35 IC: LM35 is a 3 pin IC for temperature sensing. It has many features like it is calibrated directly in ° Celsius (Centigrade), has Linear + 10 mV/°C Scale Factor, 0.5°C Ensured Accuracy, rated for Full –55°C to +150°C, range suitable for remote application, low cost due to wafer-level trimming operates from 4 to 30 V. Graph of tempreature versus output voltage is shown in Fig.5.
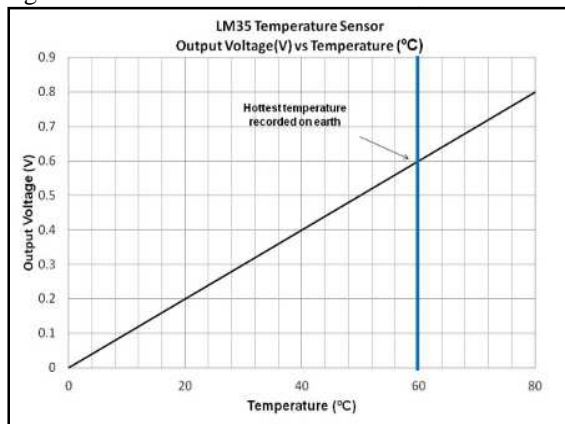

Fig.5 Output Voltage v/s Temperature(°C) of LM35

LCD: LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. It can display 16 characters per line and there are 2 such lines. Fig.6 shows a 16×2 LCD display.
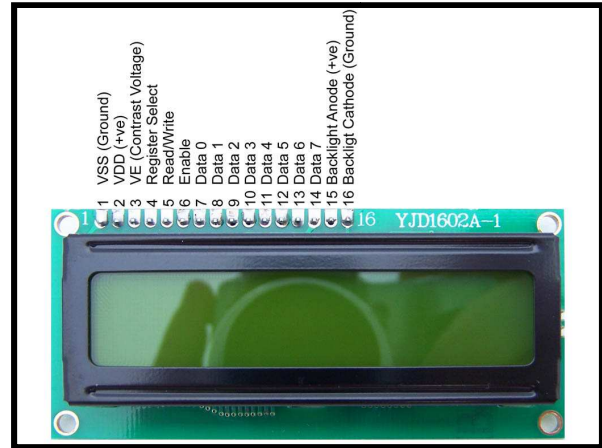

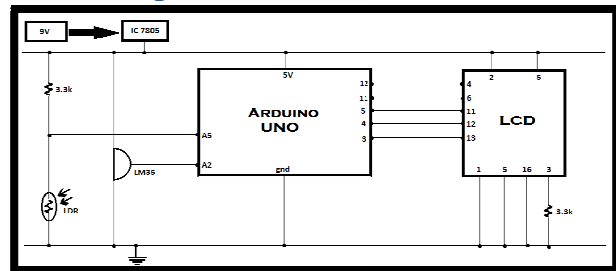**Fig. 6 Pin configuration of a 16×2 LCD**

Circuit Diagram

Fig. 7 Circuit Diagram of Environment Monitoring System

A systematic circuit diagram of the proposed system is shown in figure 7. The power supply and ground wire is common for all the components. Two sensors LM35 and LDR connected to Analog pins (A2, A5) of Arduino Uno board, and this in turn is interfaced with a stunning 16×2 LCD screen display. Corresponding interfacing pins are shown in the diagram. LCD requires supply voltage at two terminals (pin2, pin5) and pin1, pin5, pin16 has to be grounded directly and pin3 has to be grounded through a 3.3kΩ resistor. Pin3 is used to adjust the intensity of characters on the LCD screen, variable resistance (POT) can also be used in place of 3.3kΩ resistor to increase or decrease the value of the resistance.

Working Principle

The circuit has mainly three parts- (i) Acquiring analog values from the sensors (ii) Converting analog values to digital (iii) Displaying data on LCD screen.

(i) Acquiring analog values from the sensors- LM35 IC's analog voltage varies linearly with temperature and gives value directly in degree centigrade (°C) , which varies as 10mV/°C (Fig. 8) and has a high range from -55°C to 150°C. Similarly the junction voltage of the voltage divider circuit of

LDR varies linearly (Fig. 9) with the light intensity. That corresponding change in voltage can then be converted to light intensity [7][8].

(ii) Converting analog values to digital- The voltages are sensed by the microcontroller ADC pins and then converted into their matching digital values by ADC which is inbuilt in Arduino Uno board. The digital values are converted into their respective data's by the program. The LM35 IC's output voltage is directly converted to temperature in degree Celsius. The ambient light intensity is determined using LDR, since the resistance of LDR varies linearly with light intensity the junction voltage also varies linearly and hence, can be easily converted into lux units through programming. ATmega328 works at an amazing speed of 16 MHz, and since analog values have slight variation at every moment, 100 samples of each of the voltages in 100 variables are acquired. The acquired samples are averaged and converted into its corresponding values of temperature and light intensity. This process is done by software programming and it reduces the error prominently.

(iii) Displaying data on LCD screen- This system forms the gift covering of the whole project. The tabulated values are stored each in a separate variable and showed alternatively at a regular interval of 5 seconds. So, this completes one cycle and these cycles will continue infinitely till power is cut off.

Experimental Results And Discussions

We have implemented this project model on a prototype board to demonstrate its working. We tested its accuracy at various places and noted the values at outdoors and indoors. Table.1. shows the place time and corresponding readings for a normal day. For an open area we chose an open garden for noting down the readings and for a closed area we chose a room. Graphs are also plotted for the corresponding reading for better understanding of the reader (Fig. 8, Fig. 9).

Table.1:

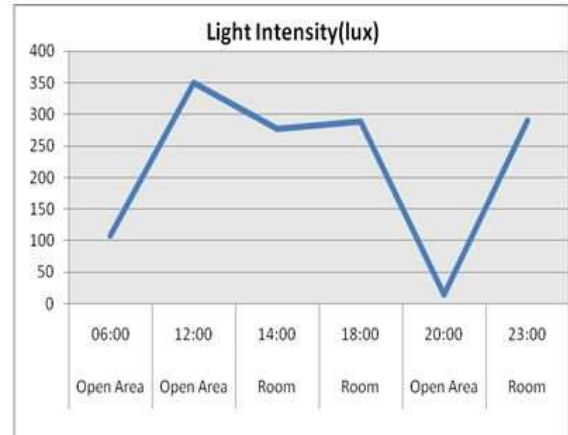| S.no	Spot	Time	Temperature(°C)	Light Intensity (lux)
1	Open Area	06:00	20.82	108.37
2	Open Area	12:00	32.56	350.78
3	Room	14:00	29.48	276.96
4	Room	18:00	25.71	288.57
5	Open Area	20:00	22.13	14.07
6	Room	23:00	23.79	290.45

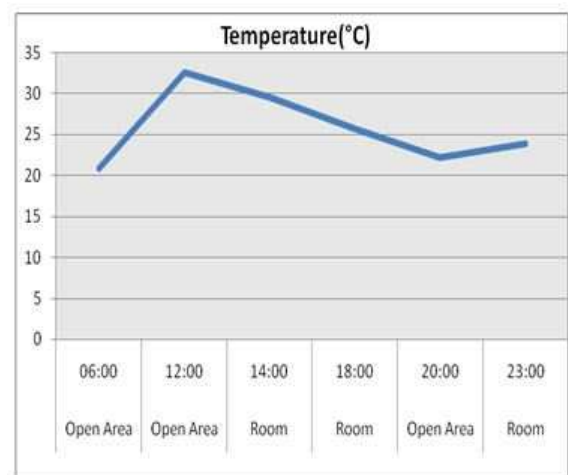**Fig. 8 Graph of light intensity v/s time**

Fig.9 Graph of temperature v/s time

This project work is successfully implemented and the results obtained are accurate with a simple user interface. Since, LM35 is a pre-calibrated IC, it shows temperature with notable precision, and since there are some uncertainties about lumen scale the LDR shows some ($\pm$10%) error in light intensity values. Given below are some pictures of real-time working model of our project on bread-board to demonstrate its effective implementation. Fig. 10 shows measurement of light intensity in lux and in Fig. 11, it is observed that light intensity decreases when we cover LDR with hand. Fig. 12 shows temperature measurement.
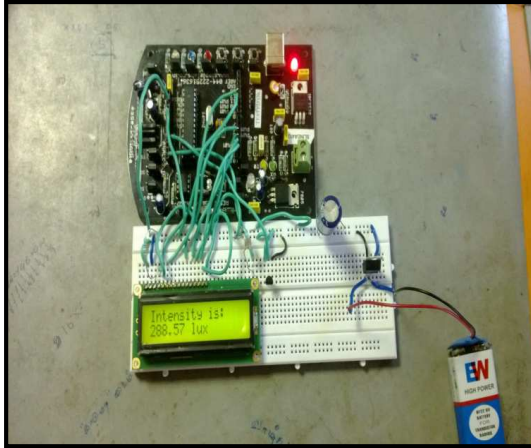
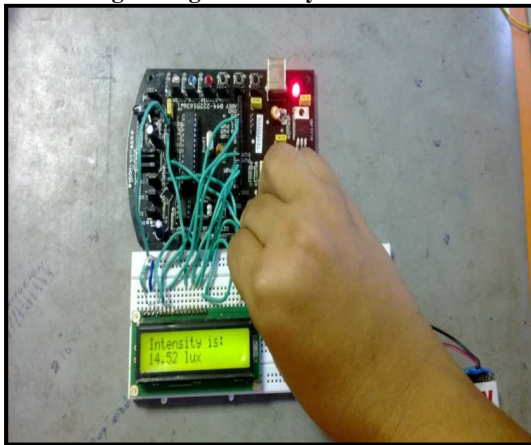factors. In future we would like to add a barometric pressure sensor, air-quality sensor (MQ135), and humidity sensor to monitor the ambient condition along with Zigbee module for wireless transmission at low cost. Arduino Uno has mostly all the capabilities inbuilt and requires less hardware for its operation. So, this makes it a perfect choice for our upgraded system.

Fig. 10 Light Intensity in the Room

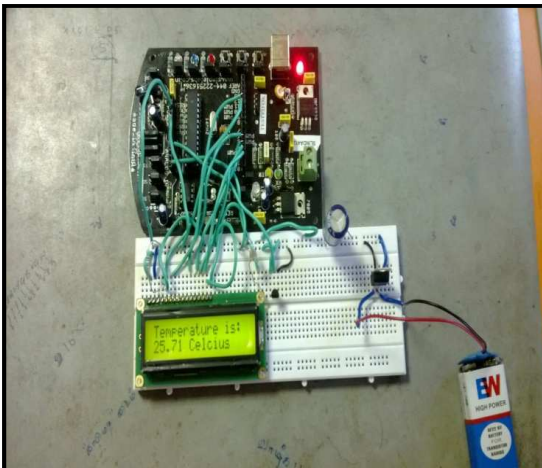**Fig. 11 Light Intensity decreased when LDR covered with hand**

Fig. 12 Temperature of the Room

Conclusion

A simplified environmental monitoring system with least number of components, and less complexity has been constructed. This system is compact and highly cost effective when compared to prices of instruments used to measure environmental

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