RESEARCH ARTICLE OPEN ACCESS

Design of a Microcontroller Based System for Continuous Measurement and Monitoring of Temperature, Soil moisture and Relative Humidity

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Abstract:

This paper proposes a system for the farmers which is cost effective and an improvisation of old techniques to monitor the various environmental parameters required for the growth of crops. This system mainly measure the ambient temperature, soil moisture and relative humidity, using temperature sensor LM35, soil moisture sensing circuit and humidity sensor EMD-4000 and display it on LCD as well as on PC using ARM7TDMI controller. An application is developed in LABVIEW to acquire the data corresponding to temperature, soil moisture and relative humidity graphically in real time. The Temperature Sensor LM35 is capable to measure the temperature with a sensitivity of 10mV / °C and provides accuracy of 0.5°C over a range of -55°C till +150°C.

Keywords — **Embedded System, ARM7TDMI controller, Graphical user interface(GUI), LABVIEW (Laboratory Virtual Instruments Engineering Workbench), LM35.**

I. INTRODUCTION

Agriculture plays an importantl role in the growth of economy of Assam. The Government has, therefore, assigned very high priority to agriculture. Modern agriculture techniques offers a wide range of benefits, including greater production and higher incomes for farmers in both developed and developing countries. Technical advances have sharply reduced environmental impacts, enabling reduced pesticide, herbicide and fertilizer use all decreasing pressure on fragile global ecosystems. Thus temperature, soil moisture and humidity plays a vital role in the growth of agricultural crops.

The concept of this work is used in measuring and monitoring temperature, soil moisture and humidity

on real time basis in agricultural fields. The system mainly measures the ambient temperature, soil moisture and humidity and displays it on LCD as well as on PC using ARM7TDMI controller. Therefore the proposed project can be helpful in measuring constant temperature, soil moisture and relative humidity for better growth of agricultural crops . The data corresponding to temperature, relative humidity and soil moisture is displayed real time graphically on the PC monitor. An application in LABVIEW is developed that is used to display the data on the PC's monitor. A graphical user interface (GUI) is implemented in LABVIEW (Laboratory Virtual Instrument Engineering Workbench) where the user can display all the three parameters on real time and thus monitor continuously.

II. HARDWARE ARCHITECTURE

A. System Block Diagram

The building blocks of the system comprises of the temperature sensor (LM35), humidity sensor EMD-4000, soil moisture sensing circuit, ARM7TDMI controller, USB-to-Serial converter and the PC.

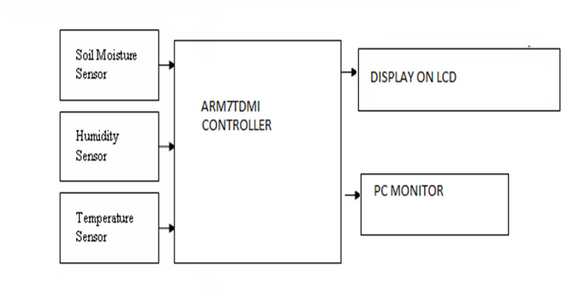

Figure 1: System Block Diagram

The three sensors used here are : Temperature sensor(LM35), Soil moisture sensing circuit and humidity sensor EMD-4000. The soil moisture needs to be monitored continuously for better productivity of the crops. Each crop requires different moisture level. A soil moisture sensor is being used here which continuously senses the moisture and gives the output in terms of an analog voltage. This analog voltage is then fed to the ARM7TDMI controller. The controller has an inbuilt ADC. The analog voltage is thus converted to digital and fed to the microcontroller. To monitor the relative humidity continuous measurement is required. The code is written to display the equivalent moisture level of the corresponding voltage using embedded C. Compiler used here is Kiel compiler which is one of the widely used IDE for LPC family of microcontrollers.It is the software which is used to compile the hex file before downloading to the microcontroller.

Similarly, the ambient temperature is sensed by the temperature sensor LM35. The temperature sensed is an analog voltage which is fed to the microcontroller which is having an inbuilt ADC. The voltage corresponding to the sensed temperature is then converted back to the equivalent temperature by the microcontroller and displayed on the PC and the LCD panel. The humidity sensor EMD-4000 used here senses humidity level present in the surrounding environment and gives a corresponding analog voltage. This analog voltage is then amplified so that the maximum analog voltage corresponds to the maximum value of the ADC of the microcontroller i.e, 3.3V. The amplified voltage sensed by the microcontroller and is then converted back into the corresponding humidity level and displayed on the PC .

Thus the three parameter values are displayed on the PC by the microcontroller via the serial port. A LABVIEW application running in the PC displays all the three parameters graphically in real time.

B. SCHEMATIC DIAGRAM AND WORKING

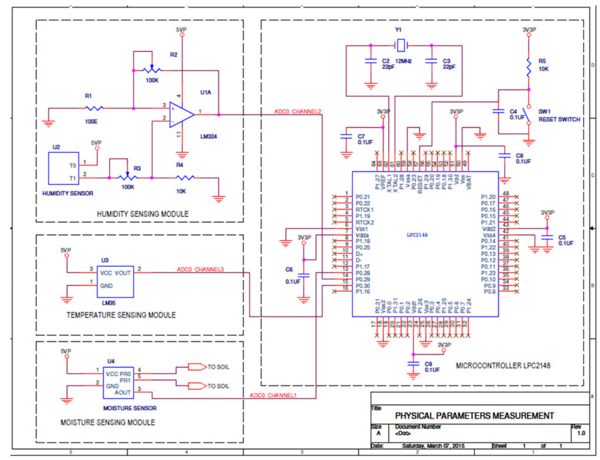

Figure 2: Schematic Diagram-1

Soil moisture sensors measure the water content in soil. Here the soil moisture sensor measures the water content in soil by using direct gravimetric measurement of free soil moisture which requires removing, drying, and weighting of a sample. A soil moisture probe is made up of multiple soil moisture sensors. Since analytical measurement of free soil moisture requires removing a sample and drying it to extract moisture, soil moisture sensors measure some other property, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for moisture content. The relation between the measured property and soil moisture must be calibrated and may vary depending on soil type.

Then we have humidity sensor EMD-4000 which is a bulk resistance-type humidity sensor based on the impedance change of a thin-film polymer due to water vapour absorption. The temperature corresponding to the dry condition is noted first and then the temperature corresponding to the wet condition is noted with the help of wet and dry bulb thermometer. Then the relative humidity is found from the look up table plotted between the difference of these two temperatures with the dry bulb reading in

Fahrenheit .The humidity sensor used here senses humidity level present in the surrounding environment and gives a corresponding analog voltage. This analog voltage is then amplified so that the maximum analog voltage corresponds to the maximum value of the ADC of the microcontroller i.e, 3.3V. The amplified voltage sensed by the microcontroller and is then converted back into the corresponding humidity level and displayed on the PC .

Temperature sensor used here is LM35, a low cost sensor with a sensitivity of 10mV/^{o}C and an accuracy of 0.5^{o}C. Its operating range is -55^{o}C to + 150^{o}C and it has very low self-heating of less than 0.1°C in still air. This sensor senses the ambient temperature and gives the output in terms of an analog voltage. This analog voltage is then fed to the ARM7TDMI controller. The controller has an inbuilt ADC. The microcontroller then converts back the corresponding temperature value and displays on the PC .

C. MICROCONTROLLER FIRMWARE ARCHITECTURE

1. Small Embedded Operating System

The LPC2141/2/4/6/8 microcontrollers are based on a 32/16 bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combines the microcontroller with embedded high speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and a unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty. Due to their tiny size and low power consumption, LPC2141/2/4/6/8 are ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale. A blend of serial communications interfaces ranging from a USB 2.0 Full Speed device, multiple UARTS, SPI, SSP to I2Cs and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power.The ARM7TDMI is a 3-stage pipeline, 32-bit RISC processor. The processor architecture is Von Neumann load/store architecture, which is characterized by a single data and address bus for instructions and data. The CPU has two instruction sets, the ARM and the Thumb instruction set. The ARM instruction set has 32-bit wide instructions and provides maximum performance. Thumb instructions are 16 bits wide and give maximum code-density. Instructions operate on 8-, 16-, and 32-bit data types. The CPU has seven operating modes . Each operating mode has dedicated banked registers for fast exception handling. The processor has a total of 37 32-bit registers, including 6 status registers.

2. Serial Port Driver

The PC sends a command to read the temperature, humidity and soil moistureto the microcontroller through the serial port. The data transmission speed via the serial port is 9600 bps. The microcontroller is programmed to read the sensor values and transmit the corresponding parameter values on receiving the read command from the PC. A memory buffer holds the data to be transmitted through UART. The scheduler that executes the serial port functions checks the buffer if it holds any character to be transmitted and if it does then the character is transmitted.

III. DATA ACQUISITION AND GRAPHICAL USER INTERFACE

The application used here to build a graphical user interface with the microcontroller based system is LABVIEW. The PC is connected through a USB interface to the system via a USB-serial converter. The LABVIEW application gives a read temperature, read soil moisture and read relative humidity command through the virtual serial port to the measurement system. The microcontroller receivs this command and reads the sensors and transmits the corresponding temperature, soil moisture and relative humidity to the PC through the serial port. These datas are received by the LABVIEW application and is displayed graphically in real time.

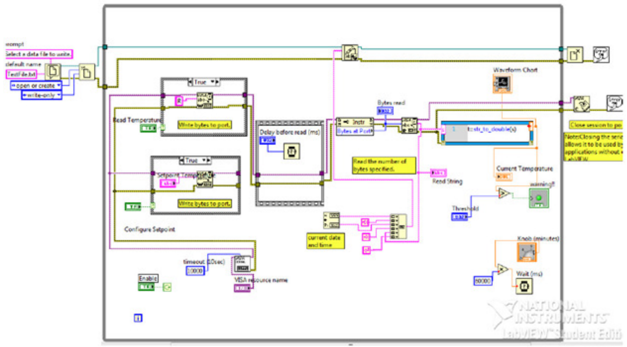

Figure 3: LABVIEW block diagram

IV. EXPERIMENTAL RESULTS: OBSERVATIONS AND MEASUREMENTS FOR:

A. SOIL MOISTURE

To find the moisture the formula used is :
[(Wetsoilweight-Drysoilweight)/Drysoilweight]*100 =Moisture in %

Fig.4:Hot air oven

Table-1:OBSERVATIONS FOR SOIL MOISTURE CONTENT

Weight (in gms)	Moisture content (%)	Voltage (in volts)
49.75 (Dry Soil)	0	1.33
50.52(Slightly wet)	1.5477	1.91
51.42	3.35	2.23
52.1	4.723	2.58
52.73	5.989	2.8
53.5	7.537	2.95
54.16	8.864	3.15
54.77	10.090	3.21
55.34	11.236	3.26
56.11	12.763	3.32
56.88	14.33	3.37
57.82	16.22	3.37
58.97(Slurry Soil)	18.532	3.50
60.02	20.643	3.48
61.06	22.733	3.52
62.04	24.703	3.52
63.11	26.854	3.52
63.95	28.542	3.53
66.28	33.226	3.54
68.34	37.366	3.53
71.73	44.180	3.50
74.11	48.964	3.50
75.52	51.798	3.50
77.11	54.994	3.50
79.64	60.080	3.50
81.96	64.743	3.50
83.29	67.417	3.50
86.05	72.964	3.50
88.75	78.391	3.50
90.76	83.432	3.52
93.63	88.201	3.54
96.02	93.005	3.54
97.55	96.080	3.54
98.89	98.773	3.54
99.55 (Heavily Damp)	100.100	3.53

Figure 5 shows a Graphical representation of soil moisture variation ranging from dry to heavily damp state. The values of the soil moisture are also logged into the hard-disk of PC for offline analysis.

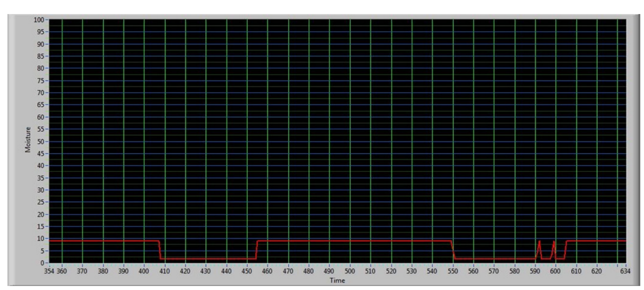

Figure 5: Graphical representation of soil moisture variation ranging from dry to heavily damp state

B. TEMPERATURE MEASUREMENT

Table-2 OBSERVATIONS FOR TEMPERATURE MEASUREMENT

Temperature range in degree Celsius	Temperature sensor output(Vout)
10 ^{0}C	0.1V
10 ^{0}C to 10.3 ^{0}C	0.1- 0.103V
10.3 ^{0}C to 10.6 ^{0}C	0.103- 0.106V
10.6 ^{0}C to 10.9 ^{0}C	0.106- 0.109V
10.9 ^{0}C to 11.2 ^{0}C	0.109- 0.112V
99.7 ^{0}C to 100 ^{0}C	0.997- 1.0V

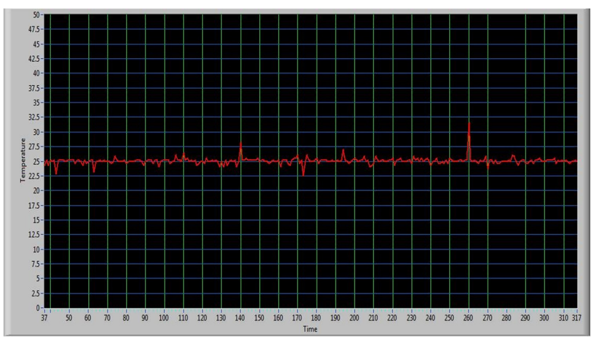

Figure 6: Rise of temperature from 10ºC to 100ºC

Figure 6 shows a Graphical representation of temperature variation ranging from 10 ^{0}C to 100 ^{0}C.

C. RELATIVE HUMIDITY

Table-3: OBSERVATIONS FOR RELATIVE HUMIDITY

dry	wet	difference	voltage of the opamp	humidity
90	74	16	0.09	47
88	73	15	0.1	48
86	72	14	0.11	50
84	71	13	0.13	52
82	70	12	0.16	55
80	70	10	0.23	61
78	69	9	0.28	63
76	68	8	0.36	66
74	68	6	0.4	74
72	66	6	0.43	73
70	66	4	0.83	81

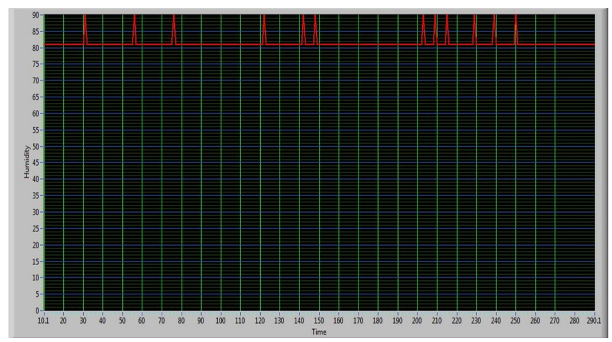

Figure 7: Humidity measurement

Figure 7 shows a Graphical representation of relative humidity ranges from 47 to 81.

V. CONCLUSION

This system finds application in domestic agricultural field. In civilian domain, this can be used to ensure faithful irrigation of farm field, since we have the option of finding out moisture level of soil in a particular area.The advantage of this project is that we can operate it without carrying the whole setup to the field. We can also observe the status of the soil and hence decide the crops that would flourish on that soil. We can use high sensitivity sensors for more accuracy. We can also design for controlling the parameters.

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