Development of a Multichannel Temperature and Humidity Monitoring Device

İsmail Köpüklü, and Gökhan Ertaş

Department of Biomedical Engineering, Yeditepe University, Istanbul, Turkey
gokhan.ertas@yeditepe.edu.tr

Abstract

Environmental temperature and humidity levels have impacts on organisms and therefore care is taken to measure/monitor and maintain them at certain levels in daily life. In this study, a portable multichannel temperature and humidity monitoring device has been developed. The device houses multiple temperature sensors, a humidity sensor, a microcontroller, a display and a +9V battery. Tests with three temperature sensors show that the device is user-friendly and performs consistent measurements. The device is able to operate thirty-six sensors at maximum and can transfer measurement results to any personal computer or Bluetooth device with universal asynchronous receiver input.

1. Introduction

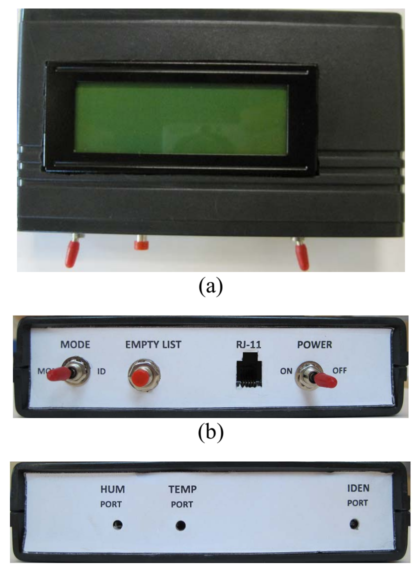
Temperature is a measure of the average kinetic energy of the particles in a sample of matter expressed in terms of degrees designated on a standard scale while humidity is a measure of the amount of moisture in the air. Both environmental temperature and humidity levels have impacts on any organism from a single cell to a complex organism [1]. Therefore, care is taken to measure/monitor and maintain them at certain levels in daily life, for instance, at the operating theaters, intensive care units and clean rooms of the hospitals or at the living spaces of outpatients with certain diseases/illness [2-4].

Humidity and temperature data is easily monitored on a regular basis manually with very low cost by performing readings from a fixed read-out device such as a digital thermometer or a hygrometer [5]. However, this method is inherently very time-consuming and prone to user errors. Many of the issues with manual method are eliminated by using automated ones. Among them, the basic one uses chart recorders that automatically collect and display data on paper charts which are changed and archived on regular basis usually once a week [6]. Although these devices are beneficial and simple to operate, they are prone to periodic mechanical failures and require frequent calibration. Advanced automated methods employ fully electronic devices with dedicated sensors for measurements [6, 7]. These devices are a significant time-saving alternative to chart recorders and manual methods, obviously.

In this study, a portable and easy to use multichannel temperature and humidity monitoring device has been developed. The details of the device are as explained next.

2. The Monitoring Device Developed

The main components of the monitoring device developed are temperature sensor ports, humidity sensor, a microcontroller, a liquid crystal display and a power supply unit. The display is placed on the top of the device (see Fig. 1a) and on the front of the device, there are "IDEN/MON" switch, "Empty List" push button, "RJ11" connection socket and "POWER ON/OFF" switch as seen in Fig. 1b. At the back of the device, there are three 3.5mm female stereo jack plugs as "HUM", "TEM" and "IDEN" ports. The "IDEN" port is to get a new temperature sensor identified to the device. The "HUM" port is for connecting the humidity sensor while the "TEMP" port is to connect several temperature sensors in a row. To do this, a humidity sensor is soldered to a flexible cable terminated with a male stereo jack plug while a temperature sensor is soldered to a bendable cable terminated with a male stereo jack plug at one ending side and a female stereo jack plug at the other ending side (see Fig. 2). This setup allows multiple placements of temperature sensors on a single cable.



(a)

(b)

(c)

Fig. 1. Views of the device developed: (a) Top, (b) front and (b) back.

Fig. 2. Sensors attached to flexible cables.

2.1. Humidity Sensor

The device performs humidity measurements using HIH-4030 (Honeywell Inc., USA). This sensor has three pins: GND (Ground), OUT (Output Voltage) and +5V (see Fig. 3) providing good measurement accuracy and fast response time. It is also chemically resistant and with a typical current draw of only 200µA, it is ideally suited for battery operated systems. It has almost linear voltage output vs. % relative humidity (RH) as seen in Fig. 4 making the RH calculations form voltage output possible. The relative humidity actually describes the humidity as a percentage telling how close the air is to being saturated.

Fig. 3. HIH-4030 Humidity Sensor.

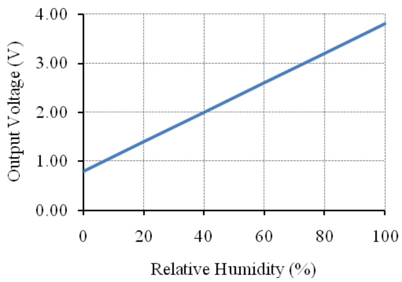


Fig. 4. Typical output voltage vs relative humidity.

2.2. Temperature Sensor

The device performs temperature measurements using DS18B20 (Microchip Technology Inc., USA). This sensor has three pins, namely GND (Ground), DQ (Data) and VDD (+5V) (see Fig. 5) and provides 12-bit Celsius temperature measurements in 750ms from -55°C to +125°C with a resolution of 0.0625°C. On its on-board read-only memory, a unique 64-bit serial code has been stored. The least significant 8 bits of this code contain the sensors family code (28h), the next 48 bits contain a unique serial number and the most significant 8 bits contain a cyclic redundancy check byte. Having a unique code, it is possible to connect and operate multiple sensors on one port pin of any microcontroller.

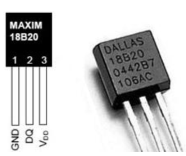


Fig. 5. DS18B20 TO-92 Temperature Sensor.

2.4. Display

The display placed on the top of the device is a 4x20 alphanumeric liquid crystal display providing 4 lines of 20 characters. It is connected to the microcontroller via 4-bit bus architecture and operates at +5VDC.

2.3. Microcontroller

The core unit of the device is the microcontroller PIC16F877 (Microchip Technology, Arizona, USA). This controller is widely used in measurement devices because of its low price, wide range of applications, high quality, and ease of availability. It is equipped with a 8Kbytes FLASH program memory, 368 bytes random access data memory, 256 bytes electrically-erasable programmable read-only data memory (EEPROM) and 40 pins. Thirty-three of these pins can be programmed for digital input or output use. However, some of them are also able to provide analogue inputs for 10-bit analogue-digital conversions. Two of the digital only pins are dedicated to universal asynchronous receive/transmit operations.

In the device developed, the microcontroller can run in two different modes: Monitoring mode (MON) and identification mode (ID). Any mode can be selected by the user via the "MODE" switch connected to one digital input pin of the microcontroller.

In "monitoring" mode, simultaneous humidity and temperate measurements are performed under the control of the microcontroller. First, the analogue output of the humidity sensor connected to the "HUM Port" is read and digitized with 10-bit resolution within the microcontroller. Next, the microcontroller sends sequential temperature measurement requests via its "TEMP Port" to each temperature sensor present in its sensor list. The measurement results are acquired after a while and presented to the user on the display.

The "identification" mode is to empty or to update the sensor list. This list consists of the unique 64-bit serial codes of the sensors identified previously. It is stored in the EEPROM of the microcontroller and therefore is kept safely even though the device is switched off. However, the user can clear the list by just pushing the "Empty List" push-button. To update the list (to insert a new temperature sensor to the device), the "new" sensor is connected to the "IDEN Port". After a while, the microcontroller reads the sensor's unique serial code and compares it with the codes in its sensor list. If it is in the list already, "Device in the list" notification message is shown on the display otherwise "Device appended" message is shown. The display is cleared next and the entities of the sensor list are shown on the display.

2.5. Power Supply Unit

With a +9V battery and using a LM7805 voltage regulator circuitry, the power supply unit provides a voltage level of +5VDC required by the electronic components of the device developed The circuit schematic showing the connections of the components is as seen in Fig 6.

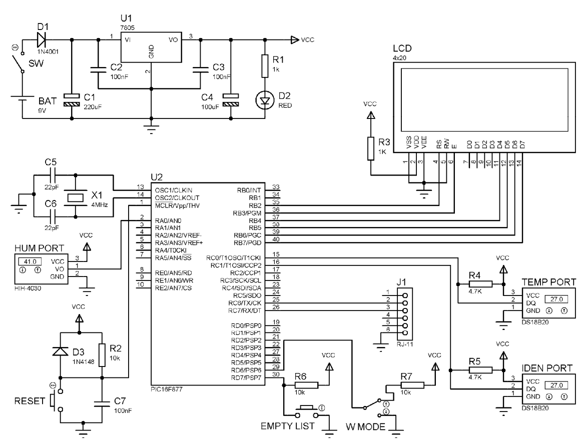


Fig. 6. Schematic of the device developed.

3. Results

The device developed was tested with one three temperature sensors attached to flexible cables each having 30 cm lengths. To do this, first, each sensor was connected to the "IDEN" port and the device was run in "ID" mode to form the sensor list. Once a sensor was identified, the device recognized it later and displayed the messages as seen in Fig. 7. Next, the entities of the final list were presented to user (see Fig. 8).

Fig. 7. Temperature sensor identification.

Fig. 8. Entities in the temperature sensor list.

After completing the identification step, the device was switched off and the sensors were plugged to the "TEMP" port in a row and the humidity sensor was directly connected to the "HUM" port of the device (see Fig. 9). When the device was switched on, the measurement results were presented to the user as seen in Fig. 10. Almost same temperature was measured by all sensors.

Fig. 9. Connections of the sensors.

Fig. 10. Real-time measurement results.

4. Conclusions

The device developed is portable, easy to use and quite functional in real-time environmental temperature and humidity measurements. The temperature and humidity sensors are connected to the device with stereo jack plugs via flexable cables. The use of stereo jack plug mechanism makes it possible to replace both the temperature and the humidity sensor quite easily. The device can operate a number of temperature sensors on the same cable for multiple instantaneous temperature measurements. This provides valuable information on the distribution of temperature in the environment aimed.

The device is tested with three temperature sensors however it is possible to increase the number of these sensors. Considering the memory space available, the device can operate thirty-six sensors at maximum. If larger number of sensors is aimed, the device can still operate after replacing its microcontroller with a larger memory sized one. On the other hand, care should be taken to determine the length of the cable that connects the sensors and the device. Very long cables may cause signal distortions and therefore may lead to measurement problems.

Although the device developed is programmed to perform real-time humidity and multichannel temperature monitoring only, it can also transfer the measurement results to any personal computer, Bluetooth or Ethernet device equipped with universal asynchronous receiver input. This would open new opportunities in remote monitoring via highly distributed architectures and facilitate reporting/recording and alarming [8].

5. References

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