International Journal of Information, Engineering & Technology

Volume 11, Issue 2, PP 42-47, ISSN: 2360-9194, July, 2020
Double Blind Peer Reviewed International Research Journal
garcjournalssubmit@gmail.com
Journal Series: Global Academic Research Consortium (garc)

Design and Implementation of Digital Temperature and Humidity Data Logger and its Comparative Analysis with the Conventional-one

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Abstract: *Data acquisition systems have become inevitable tool for analyses in science and technology. With advancement in research and manufacturing processes, there is a growing demand for sophisticated yet cost-effective data logging systems to address the complexity in data acquisition and analyses. This work addresses the temperature and humidity data acquisition needs in research and manufacturing by implementing an embedded system suitable for monitoring and analyzing temperature and relative humidity at specified intervals of time. The hardware was designed and constructed using five functional parts that comprising of ATMega328P microcontroller, real-time clock, liquid crystal display unit, SD card and a low-cost DHT22 temperature and humidity sensor to capture the temperature and relative humidity. The hardware is powered by an AC source through a regulated power supply comprising of a shunt-regulated IC, LM7805. The captured data is processed and stored to a memory chip (SD card) which can be retrieved at any time and displayed in a Microsoft Excel format by inserting the SD card into a computer system. Data captured is displayed and managed with the aid of a visual interface display unit of a 16 x 2 alphanumeric LCD. This provides a handy system that makes data-logging easy and effective. The hardware was tested and errors of ±2.24 % and ±3.12 % were obtained for temperature and relative humidity respectively. Thus, this hardware is capable of performing the required task with high accuracy.*

Key words: *Temperature, Humidity, Comparative-analysis, Logger, Conventional-ones*

INTRODUCTION

Data logging and recording is a common measurement application. In its most basic form, data logging is the measuring and recording of physical or electrical parameters over a period of time. The data can be temperature, strain, displacement, flow, pressure, voltage, current, resistance, power, and many other parameters. A wide range of products can be categorized as data loggers, from basic devices that perform a single measurement to more complex devices that offer analysis functions and integrated displays.

Temperature is a widely measured quantity in the industry. Accurate and repeatable temperature measurement and control are critical to products' quality and uniformity in many modern semiconductor manufacturing processes (Schroder, 1990).

The monitoring of environmental variables such as temperature, pressure and humidity has a long history of development and the variables have shown significant impact in the productivity of plant growth, the quality of food industry and the efficiency of many temperature and humidity-sensitive equipment (Vleeschouver *et al.,* 2017). The monitoring of temperature and humidity of laboratories, storages, halls, school and hospitals is important with respect to health and hygiene. The reliable measurement and monitoring are crucial in this competitive era of technology (Vleeschouver *et al.,* 2017).

Humidity is the presence of water vapour in air (or any other gas). High humidity makes hot days feel even hotter. Low humidity can give people a feeling of a dry throat, or sensations of "static" when touching things. Humidity affects many properties of air, and of materials in contact with air. A huge variety of manufacturing, storage and testing process are humidity-critical.

Humidity measurements are used wherever there is a need to prevent condensation, corrosion, mold, warping or other spoilage of products (Bell, 2011). This is highly relevant for foods, pharmaceuticals, chemicals, fuels, wood, paper, and many other products.

A data logger is a data-recording apparatus. For the purpose of this dissertation, the term "data logger" shall be taken to refer to a "temperature and humidity recording hardware". A data logger can be configured in a number of ways depending on the application. Loggers can be either stand-alone, i.e., self-contained, with no external supporting hardware, or interface with another hardware to provide ancillary or critical functionalities.

MATERIAL AND METHOD

Material used for the construction of the device are:

i. ATMega 328P 8-bit Microcontroller
ii. 5-volt DC regulated power supply
iii. DHT22 Temperature and Humidity Sensor
iv. SD Card
v. 2-row 16-character Alphanumeric Liquid Crystal Display
vi. DS1307 Real Time-Clock (RTC) Chip
vii. 24C02 Serial Electrically Erasable Programmable Read-Only Memory
viii. 3.3-volt SD Card Power Supply
ix. Power cord
x. Plastic pack

Device Description

The block diagram shown in Figure 1 represents the digital temperature and humidity data logger.

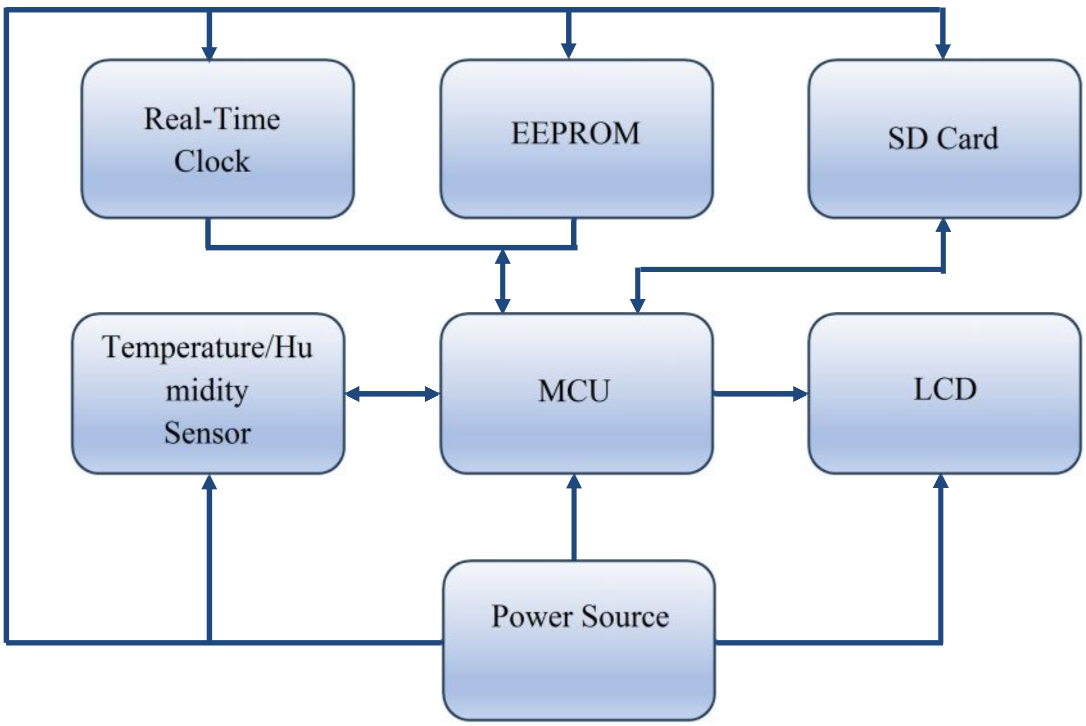

Figure 1: Functional Block Diagram

The hardware consists of five functional blocks: the temperature and humidity module for sensing the temperature and relative humidity of the environment, RTC (Real-Time Clock) for keeping the time and date, the EEPROM (Electrically Erasable Read-Only Memory) for keeping user's settings, SD Card (Secure Disk Card) for data storage (humidity and temperature history), the MCU (Microcontroller Unit) which is the core of the system: it communicates every other subsystem to read and write data, and LCD (liquid crystal display) for visual output. It also includes power source for every sub-unit of the system. The system captures the temperature and humidity data from the sensor module, processes and stores it on the non-volatile memory device (SD card).

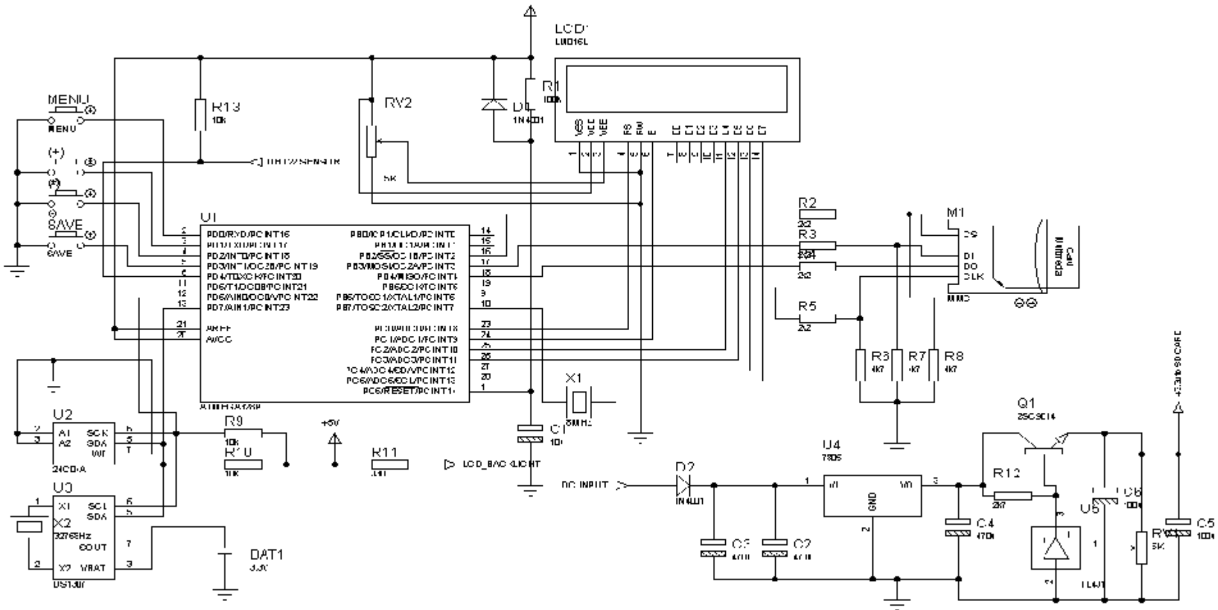

Figure 2: Complete Circuit Diagram of the Device

Operations of the Device

The temperature and humidity data logger was designed to sample temperature and relative humidity values of the surrounding environment of about 20-meters distance in every two seconds. The accumulated values over one minute (60-seconds) were averaged out and stored on the SD card, along with the date and time of logging.

The logs were formatted as (comma separated values) CSV, to allow easy importation into just about any operating system without the need for a custom software to read its content.

To set the system date and time information, four buttons were provided. These buttons enabled programming the integrated DS1307 RTC in the system to reflect the correct date and time required for time-stamping.

Results and Graphs

The table shows the results obtained for temperature and humidity measurements for 20-minutes testing of the constructed and reference devices.

Date (DD:MM:YYYY)	Time (HH:MM:SS)	Constructed Temperature (°C)	Constructed Humidity (%)	Reference Temperature (°C)	Reference Humidity (%)
25/03/2019	13:00:12	34.9	22.3	35.5	22.7
25/03/2019	13:01:12	34.7	21.5	35.3	22.8
25/03/2019	13:02:12	34.7	21.6	35.3	22.3
25/03/2019	13:03:12	34.2	21.9	34.8	22.6
25/03/2019	13:04:12	34.2	21.9	34.8	22.6
25/03/2019	13:05:12	34.1	21.5	35.2	21.8
25/03/2019	13:06:12	34.1	21.5	35.2	21.8
25/03/2019	13:07:12	34.1	21.4	35.2	21.6
25/03/2019	13:08:12	34.1	21.4	35.2	21.6
25/03/2019	13:09:12	34.1	21.4	35.0	21.6
25/03/2019	13:10:12	34.0	21.5	35.0	21.8
25/03/2019	13:11:12	35.1	21.5	35.4	21.8
25/03/2019	13:12:12	35.2	21.4	36.0	21.9
25/03/2019	13:13:12	35.3	21.4	36.1	21.9
25/03/2019	13:14:12	35.4	21.3	36.2	21.6
25/03/2019	13:15:12	35.4	21.2	36.2	21.4
25/03/2019	13:16:12	35.5	21.2	36.3	21.4
25/03/2019	13:17:12	35.5	21.4	36.3	21.9
25/03/2019	13:18:12	35.6	21.6	36.4	22.1
25/03/2019	13:19:12	35.6	21.7	36.6	22.2

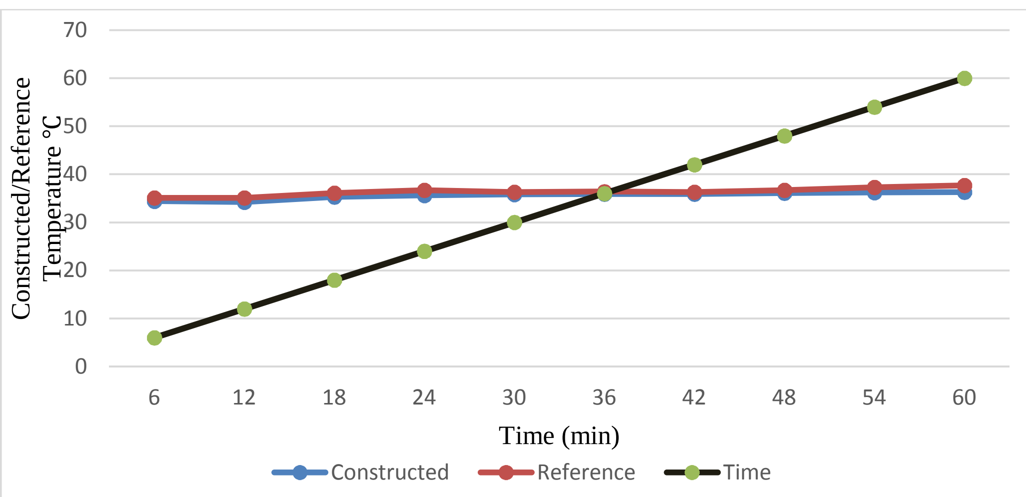

Figure 3: The Plot of Constructed and Reference Temperature against Time

Figure 3 shows the time series plot of the constructed and reference temperature against time. Both temperature measurement devices exhibit clear nonlinear and deterministic trends. On average, the reference temperature is a little bit higher than the constructed temperature with evidence of structural breaks and this could be due to the fact that, the reference device has a probe incorporated to it which is not directly in contact with any object in the ambience. However, the two types of temperature measurement devices are approximately closer and little bit far at 48th and 60th minutes respectively.

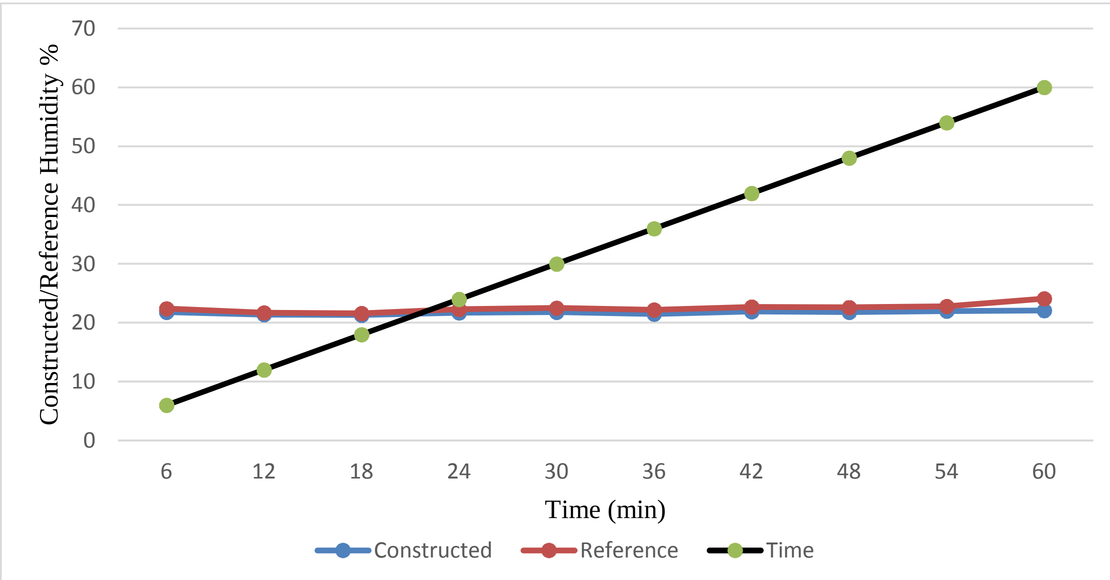

Figure 4: The Plot of Constructed and Reference Humidity against Time

Figure 4 is the time series plot of the constructed and reference humidity against time and both series shows a concurrent increase, decrease and stable trend. However, the constructed humidity measurement device suffers a shock decline of about 7.9% at the 57th minutes and this could be due to the fact that, the reference humidity device's probe was in direct contact with the moisture which indicates that, for it to continue giving a close related measurement(s) its probe ought to be kept moist or in contact with a moist object.

Conclusion

The designed and constructed hardware was capable of measuring temperature and humidity. More so, the device was compared with another device (reference device) to be certain of its capabilities. The results showed that, it can perform the required task.

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