Hardware Implementation of Dew Point Measurement

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Abstract: This research paper presents a portable and low energy consuming embedded system, fabricated through flexibility and ease of designing created by Programmable Systems-on-Chip microcontroller. The designed system uses the dynamic reconfiguration ability of Psoc and the provided pre-packaged libraries to conveniently connect multiple weather parameter sensors on a single chip. Direct data acquisition from LM35 and HIH4000 for temperature and relative humidity measurement was displayed on a Liquid Crystal Display (LCD) and used to compute dew point temperature. Sensor measurements were recorded thrice daily for five days and corresponding dew point temperature measurements were computed from which human perception of environmental comfort was deduced.

Keywords: PSoC, Sensors, Dew point Temperature, Environmental comfort

1. Introduction

An embedded system is used for data acquisition and processing. Majority of embedded systems gather data from one or more sensors, subjecting the data to some form of conditioning and providing it directly, or via a buffer or multiplexing stage in cases involving large amounts of data, to a central processing unit. The CPU processes the incoming data and typically outputs commands to the output conditioning phase (Edwards et al, 2010).

Microcontrollers are the best choices for embedded systems because of their flexibility to connect to other devices, they are programmable, and have low power consumption. They generally have limited computational power and resources but corresponding low cost, which makes them ideal for high volume, low cost electronics where they may serve as the central or auxiliary control (Titzer et al, 2005).

Sensors are a major source of data generation to most embedded systems. They are hardware devices that produce measurable response to a physical condition like temperature, pressure, humidity and more. They respond to physical variables of the area to be monitored. The continual analog signal sensed by the sensors is digitized by an analog to digital converter within the microcontrollers. They are small in size; consume extremely low energy, operate in high volumetric densities and possess adaptability to the environment (Nhivekar and Mudholker, 2011).

It is difficult to implement multiple sensors on a single chip but the Programmable Systems on Chip (PSoC) family provides this flexibility and ease of designing (Patil and Patil, 2015).They also have the advantage of dynamic reconfiguration among other microcontrollers.

2. Related Work

Patil and Patil, 2015 designed multisensory embedded system using PSoC 4 module, chip CY8C4245AXI by Cypress semiconductors of family 4200. This system was used to sense temperature, humidity and light intensity simultaneously, displayed values on LCD and could control power consumption. They concluded that PSoC implementation of dual sensor presents a new methodology to approach sensor solutions using silicon based transducer which takes the advantage of dynamically configuration changing for measuring different physical parameters.

A data logger and remote monitoring system for multiple parameter measurement application was designed by Nhivekar and Mudholker, 2011 with the Atmega 32 microcontroller. Temperature and humidity sensors were interfaced with the microcontroller. The system was confirmed useful for studying the behaviour of industrial and home processes applications having multiple parameters. With slightly modifying the firmware, current monitored parameter can be sent to many users through SMS.

Noordin et al, 2006 designed a low-cost microcontroller-based weather monitoring system. Temperature, humidity and pressure sensors were incorporated into PIC16F877A microcontroller, equipped with 8kb of flash memory and 20MHz of processing speed. The system was tested through extensive experiments and results have proven accuracy and reliability of the proposed system, making it a better choice in terms of costs, portability, memory capacity and logging interval-setting capability.

Weather Parameter Sensing and Environmental Comfort

Weather is a tropospheric phenomenon characterized by variability of physical parameters such as air temperature, pressure, humidity, clouds, wind, dew point and more. Some of these parameters are the environmental factors directly responsible for determining human satisfaction with the thermal environment. Among these are air temperature and humidity. The advancement of technology has made small and reliable electronic sensors capable of monitoring environmental parameters more favorably (Noordin et al.,2006). Moghavveri et al. (2005) have shown that integrating these sensors with data acquisition system will result to reliable monitoring of temperature and relative humidity. Measured parameter readings from two or more sensors can be used to compute other weather parameters useful for prediction, monitoring and modelling.

Programmable Systems on Chip PSoC controlled by an On-Chip microcontroller provides a unique, schematic-based, design-capture functionality with fully tested libraries of pre-packaged analog and digital peripherals (Edward et al., 2010) to accommodate the interface of multiple sensors.

In this paper, an embedded system for some weather parameter sensing has been designed using PSoC interfacing temperature and humidity sensors. Liquid Crystal Display (LCD) was incorporated to display measured data. The fabricated system uses direct data acquisition of temperature and relative humidity to remotely compute dew point temperature expressed by Mark, G. Lawrence, 2005 as;

$$Td = T - ((100 - RH)/5) \quad \text{i}$$

Where Td is dew point temperature in degree Celsius

T is the dry bulb temperature also in degree Celsius

RH is the relative humidity in percentage

the dew point temperature calculated from this expression can be further used to determine thermal environmental comfort.

3. Method

Temperature sensor LM35 and humidity sensor HIH 4000 were interfaced with PSOC microcontroller for data acquisition and processing hence output displayed on the LCD.

System Schematic

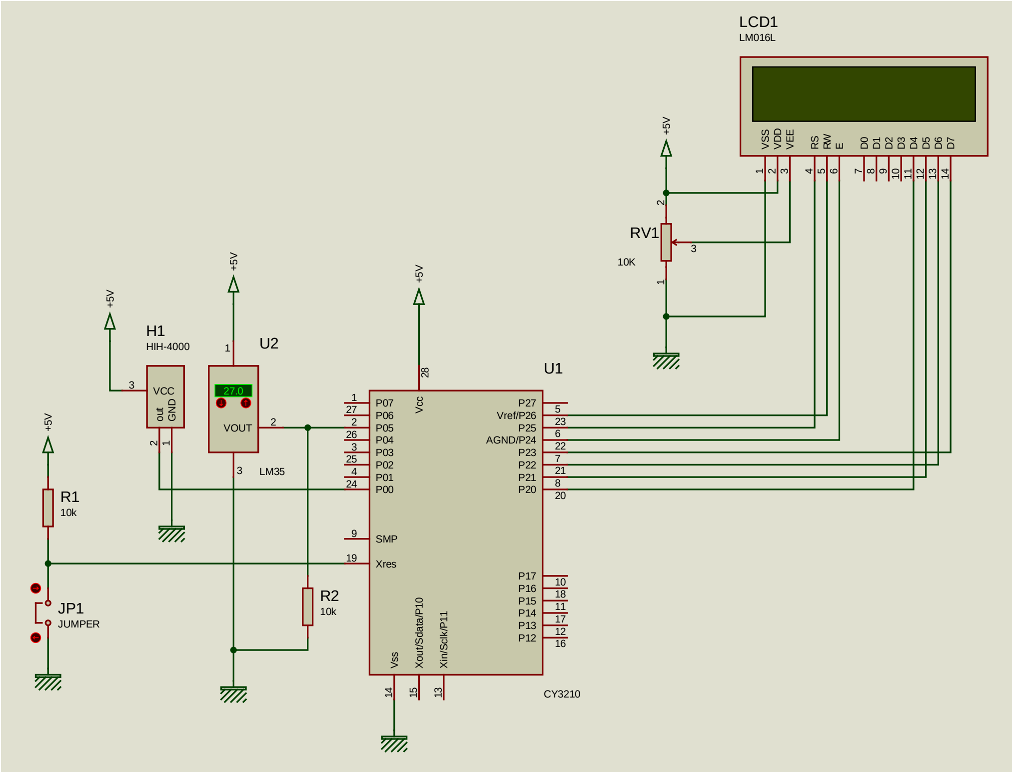

Figure 1: System Schematics

The system schematics as shown in figure 1 consist of a PSoC chip (CY8C29466-24PXI). The two sensors used were connected to the chip through port [0]. Port [0][0] was used for the humidity sensor and port [0][5] for the temperature sensor and both sensors formed a major part of the input stage. After processing the temperature and humidity data measured by the sensors (input data), the digitized output readings were displayed on an LCD connected to port [2] of the psoc chip.

Sensors Used

The sensors used for this system design are: LM35 - the temperature sensor and HIH 4000 -humidity sensor.

LM35 is a precision IC temperature sensor. It has an output voltage proportional to temperature (in ^{o}C), a sealed sensor circuitry therefore not subjected to oxidation and other processes. Its temperature range is from 55°C to 150°C and its accuracy is 0.01V/^{0}C.

HIH4000 has a molded thermoset plastic housing with cover. It has the following features: linear voltage output vs %RH, laser trimmed interchangeability, low power design, high accuracy, fast response time, stable low drift performance and it is chemically resistant.

PSoC Module

PSoC 1 module was used for this project and the chip is CY8C29466-24PXI by Cypress Semiconductors. PSoC distinguishes itself from the typical MCU by its flexibility of dynamic reconfiguration. In the real world, design specifications change constantly. PSoC allows those new specifications to be implemented quickly. This is made possible through an array of programmable analog and digital resources on each PSoC device. These resources act as a blank slate with the potential to be configured as a variety of peripherals. Additionally, you can route these configured peripherals to multiple pin locations on the device, providing flexible routing and eliminating the use of dedicated fixed function pins.

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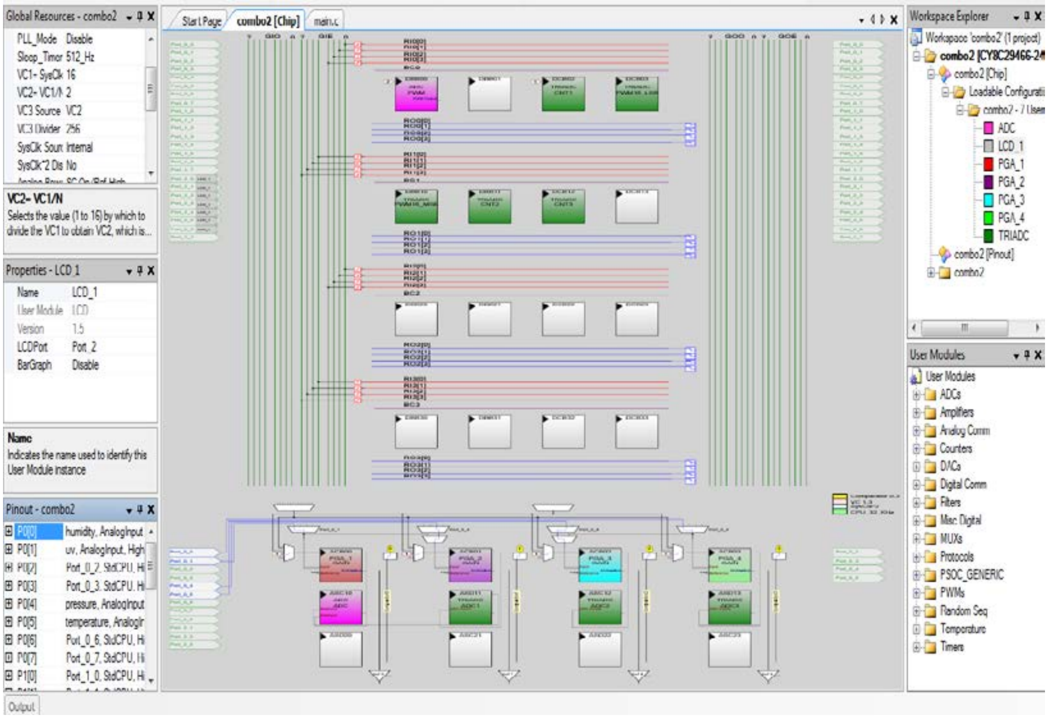

Figure 2: PSoC configuration window

Figure 2 shows the Integrated Design Environment (IDE) with the pre-packaged libraries for the design (the user module, global resources, parameter setting, pinout configuration). For this design, two (2) analog to digital converters, two (2) programmable gain amplifiers and one liquid crystal display were selected from the users module, their specifications for the design were set at the parameter settings and the global resources from their various data sheets for the entire system setting. The sensors were connected to the chip through the pin selection. The CY3217 programmer kit was used to program the chip.

4. Result

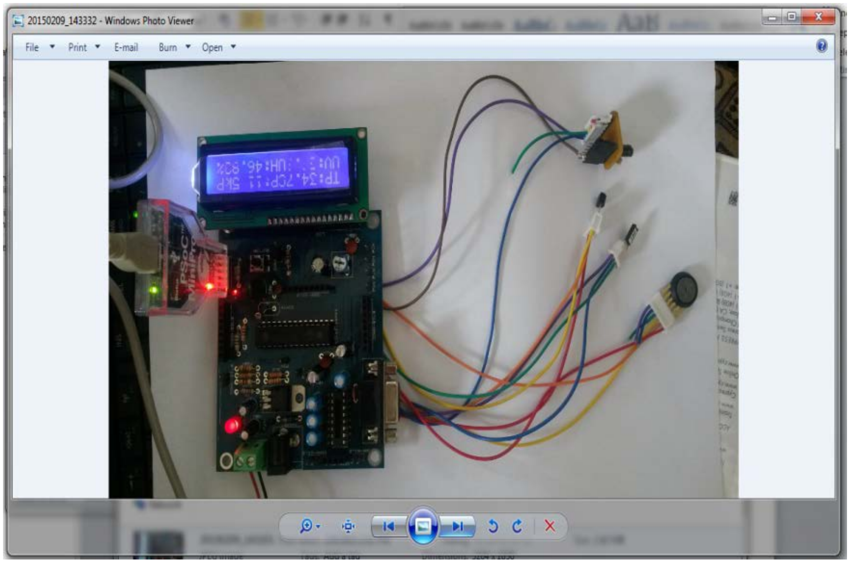

Figure 3: Picture of the data logger

Figure 3 is a picture of the completed data logger with display of parameter readings on the LCD. This fabricated data logger has the capacity to function as a ground-based weather parameter measuring instrument. It also possesses the following features: multi-sensing ability, digital in nature, data logging ability and portability.

True measurements of temperature and relative humidity taken with the fabricated system are shown on table 1 with the computed dew point temperature from Td = T- ((100 – RH)/5) by Mark, G. Lawrence, 2005. The average measurement period was tabulated. The time interval for morning period was taken at 8am, 9am and 10am, the afternoon period was taken at 12noon, 1pm and 2pm and the evening period was also taken at 6pm, 7pm and 8pm. The average period for morning, afternoon and evening period (9am, 1pm and 7pm) respectively were recorded. Readings were taken for five (5) days. The human perception of the dew point temperature and humidity according to table 1 was extracted from dew point table provided by *Steven L. Horstmeyer, 2008*

Table 1: Temperature, Relative Humidity and Dew Point measurements

	TIME	TEMP. ^{0}C	RH %	DEW POINT ^{0}C	HUMAN PERCEPTION
DAY 1	9am	29.80	56.6	21.12	Very Uncomfortable
	1pm	32.00	43.7	20.74	Somewhat uncomfortable
	7pm	30.00	52.5	20.50	Somewhat uncomfortable
DAY 2	9am	26.80	61.4	19.08	Somewhat uncomfortable
	1pm	29.00	57.3	20.46	Somewhat uncomfortable
	7pm	27.30	59.3	19.16	Somewhat uncomfortable
DAY 3	9am	29.40	57.2	20.84	Somewhat uncomfortable
	1pm	31.10	46.5	20.40	Somewhat uncomfortable
	7pm	31.00	46.9	20.38	Somewhat uncomfortable
DAY 4	9am	28.00	58.3	19.66	Somewhat uncomfortable
	1pm	32.80	42.5	21.30	Very Uncomfortable
	7pm	31.00	46.9	20.38	Somewhat uncomfortable
DAY 5	9am	29.50	56.9	20.88	Somewhat uncomfortable
	1pm	32.30	43.1	20.92	Somewhat uncomfortable
	7pm	30.80	48.2	20.44	Somewhat uncomfortable

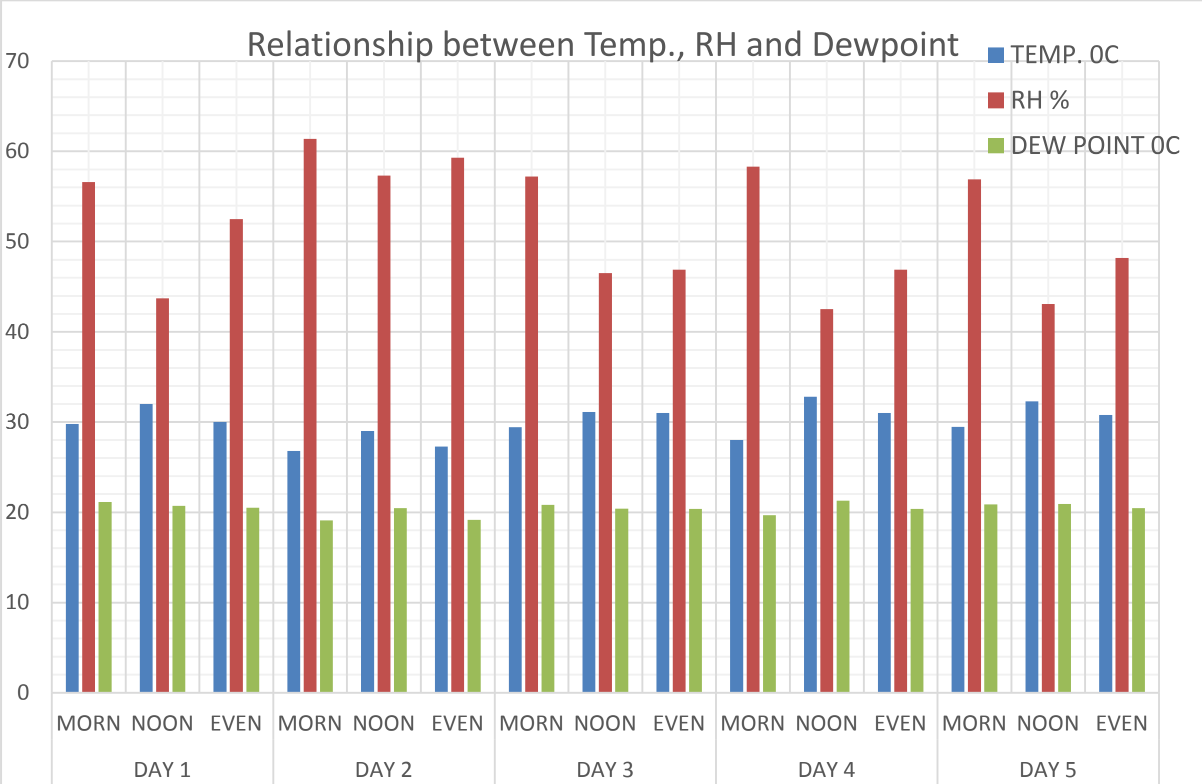

Chart 1: Relationship between temp., relative humidity and dew point

Across the days from chart 1, the highest relative humidity occurs in the morning and as temperature increases at noon, relative humidity decreases as confirmed by Ahrens, 2009. While dew point temperature increases as air temperature increases.

5. Conclusion

Using PSoC from Cypress Semiconductors, an embedded system was fabricated. It has the capacity to give true temperature and relative humidity measurements displaying them on LCD. From the temperature and RH measurements, dew point temperature the sole factor for determining environmental comfort was remotely computed using the Mark, G. L dew point formula. The PSoC implementation of dual sensor system presents a new methodology to approach sensor solutions using silicon based transducer. The implementation takes the advantage of dynamically configuration changing for measuring different physical parameters (Patil and Patil, 2015). Its simplicity and effectiveness makes it suitable for fast prototyping and low cost solutions (Bo Chang, Xinrong Zhang, 2011).

Recommendation

The fabricated system can in further studies be mounted on atmospheric balloons with sondes to take readings far into the troposphere.

References

[1] Ahrens, C. Donald, “Meteorology Today: An Introduction to Weather, Climate and the Environment”, Ninth edition, 2009, Brooks/cole, USA.

[2] Bo Chang, Xinrong Zhang “Design of Indoor Temperature and Humidity Monitoring System Based on CC2430 and Fuzzy-PID” Lecture notes in Electrical Engineering vol. 107,pp 283-292, Nov. 2011, Springer Netherlands publisher.

[3] Datasheet- HIH4000-001

[4] Edward, H.C and David, V.E, PSoC 3/5 Reference Book 2010, Cypress Semi-Conductor Corporation (65-70).

[5] LM35 Temperature Sensor - Datasheet & Pin Diagram - Engineers Garage

[6] Mark, G. Lawrence "The Relationship between Relative Humidity and the Dewpoint Temperature in Moist Air" American meteorological society, 2005, page 225-233.

[7] Moghavvemi ,M and Tan, S "A reliable and economically feasible remote sensing system for temperature and relative humidity measurement" Sensors and Actuators. 2005, page 181-185

[8] Nhivekar, G.S, Mudholker, R.R "Data logger and remote monitoring system for multiple parameter measurement application" e-journal of science and technology, 2011, pages 55-62,2005.

[9] Noordin, K.A, Onn, C.C and Ismail, M.F "A low-cost microcontroller-based weather monitoring system" CMU journal(2006) vol.5

[10] Patil, P.D and Patil, R. D"Designing Multisensor Embedded System using PSoC" International Journal of Current Advanced Research, Vol. 4 Issue 8' pp 271-274, August 2015.

[11] Titzer, B. L and Palsberg, J, (2005) Non Intrusive Precision Instrumentation of Microcontroller Software in proc. of the 2005 Conf. on Languages, Compilers, and tools for Embedded Systems (LCTES) Chicago, USA

[12] Steven L. Horstmeyer, 2008, http://www.shorstmeyer.com/wxfaqs/humidity/humidity.html