Application Note AN2xxx

Design and Develop Temperature, Humidity, Dew-Point Monitoring Device THDP-1 Using PSoC Technology

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Summary

Temperature, humidity, and dew-point monitoring in goods and rice storehouse, storage of agricultural, industrial and medical products etc. have very large demand. In this paper, we introduce the process of research, design and develop of Temperature, Humidity, and Dew-point monitoring device THDP-1 using PSoC technology. The device is neat, low-power consumption, highly reliable, lower cost compare to imported device with comparable characteristics.

1. INTRODUCTION

Nowadays, with the rapid development in agriculture, the more products are produced, the more demands in storing and preserving them are increased. Temperature, humidity and dew-point monitoring plays an important role in preservation and storage of agricultural and industrial products. Specially, in preserving goods, grains and rice, machines, and medcines, the monitoring and maintaining the temperature, humidity and dew-point of the atmosphere are very crucial. Normally, the temperature and humidity in the warehouses must be kept at certain degree to make sure all products are kept in good condition. In Vietnam, the temperature and humidity in most of the warehouses are adjusted manually with the help of technical engineers in measuring and maintaining the temperature degree as requested. Similarly, the technicians have to monitor and adjust the temperature, humidity, and illumination propriately in laboratory, hospital, and greenhouses of flowers and fresh vegetable so that the plants are grown up in good environment.

The manual method in preservation and storage of products will certainly not only consume a lot of time and efforts but also uneffective. However, the rapid development of information technology has been gradually making our lives more convenient and comfortable with all modern and automatic devices. THDP-1 device is one of the best technologies in not only measuring the temperature, humidity and dew-point but also collecting data from the computer and giving appropriate solutions. In difference to normal existing devices, THDP-1 does not only display the measured data but also connect together to form a RS-485 network as well as receive and manipulate data from the computer. With only one PC, a person can monitor simultaneously many different measured points in a wide range.

Most of the current intelligent devices for measuring temperature and humidity have used some microprocessors and simple softwares to enhance the seft-adjustment function. All the remote systems usually follow the transmission standard of 4-20mA, 0-10V or serial digital transmission RS232/485. Those devices need importing and are fairly expensive.

In order to reduce the product cost and expenditure as well as to increase product quality and competitive edges, we have designed and developed THDP-1 devices for measuring temperature, humidity and dew-point based on the following technologies:

1. Programmable System on Chip (PSoC) technology from Cypress Microsystems as the key to develop the Temperature, Humidity and Dew-Point (THDP) measuring device. PsoC has the ability to manipulate mixtures of data. It speeds up the process of measuring data and is easy to extend its scope and functionalities later on. This technology provides many selective solutions and supports various applications such as measurement, processor, control, transmission, and network connection on the same chip at low cost.

2. Sensor chip SHT15 of SENSIRION Company. This chip provides sufficient technical features for sensoring temperature and humidity at a reasonable price.

2. OPERATION PRINCIPAL

- **Operation Diagram**

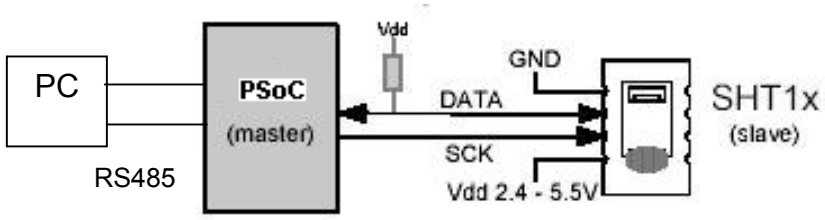


Figure 1: Operation Principal

- ***Independent device***

Sensor chip SHTxx receives the command and sends data back to PsoC based on serial transmission I2C: PSoC signals the synchronous clock SCK to request data from SHTxx, the command is sent through bilateral DATA line, SHTxx sends data back to PsoC via DATA line (2 pins in PsoC chip are used). Data are manipulated by PsoC and displayed on LCD. The displaying time for sequence of temperature, humidity and dew-point is decided by block *CounterTimer*.

- ***RS485 Network device***

4 CT switches are used to address RS485 for the device. A PC can obtain data from maximum 16 THDP-1 devices through RS485 to process, display, and measure data. The transmission speed of RS485 is 9600 Baud, this is due to block *CounterBaudRate,* providing clocking for Transmitting and Receiving function blocks: *Rx8* and *Tx8*. A MAX485 device is used to convert the signals to the RS485 standard (Figure 2).

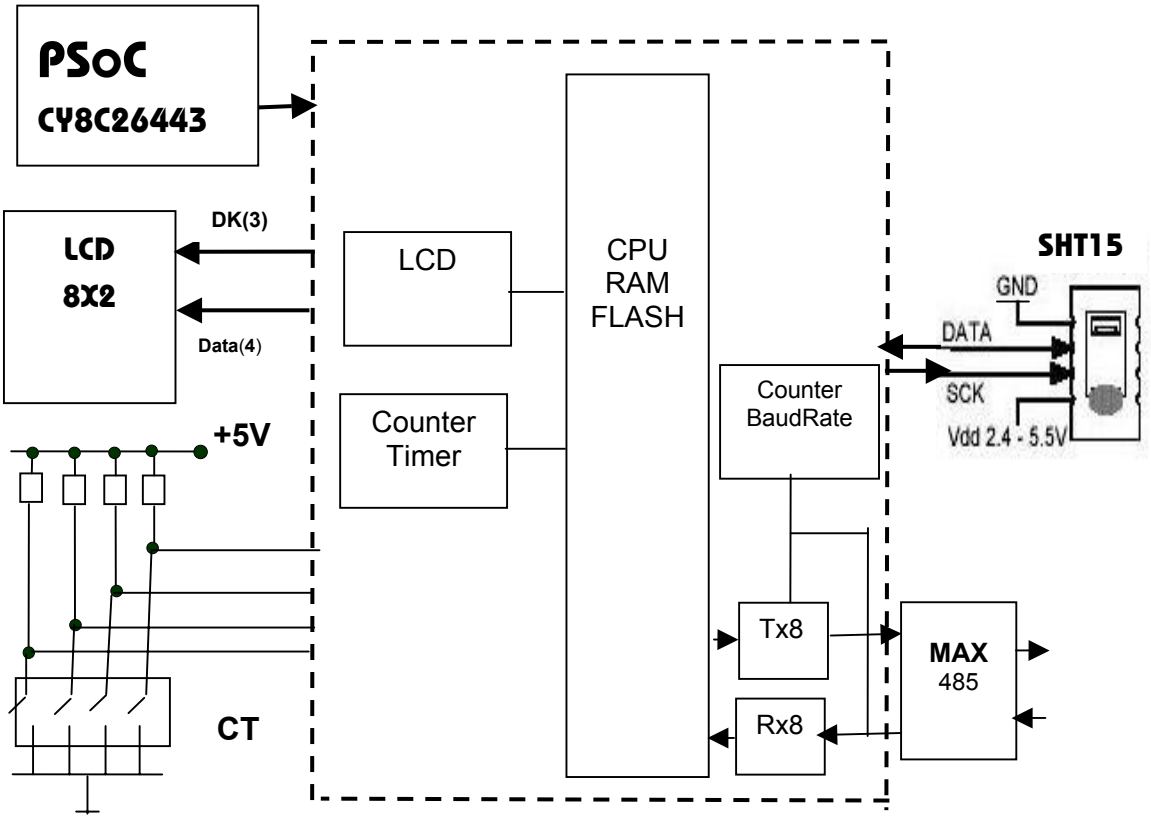


Figure 2: Block diagram of THDP-1 Device

3. SHT15 FOR TEMPERATURE AND HUMIDITY MEASUREMENT

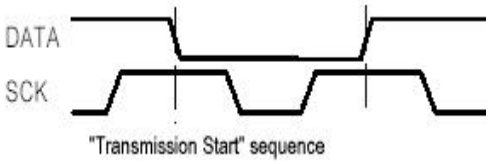
Figure 3: A SHT15 chip

SHT15 is a low-cost sensor which measures temperature and humidity, and translates them into digital numbers: 14-bit for temperature, and 12-bit for humidity.

This module produces high quality signal, fast response, and no jam affection. The two-wire serial connection circuit and internal voltage adjustment allow separating and assembling system easier and faster. With a small size, low power consumption and a competitive price, SHT15 device family has become widely used in a majority of applications.

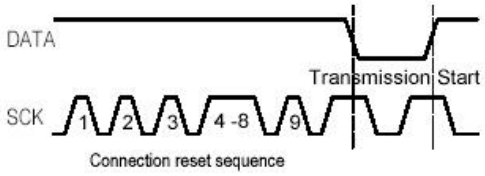
Operation of SHT15 Chip

As shown in Figure 3, SHT15 chip sends data when PsoC requests and signals the SCK synchronous clock. This process is started up according to a sequence called "Transmission Start" as follows:



"Transmission Start" sequence

If this process is disconnected, we have to restart the sequence as shown below:



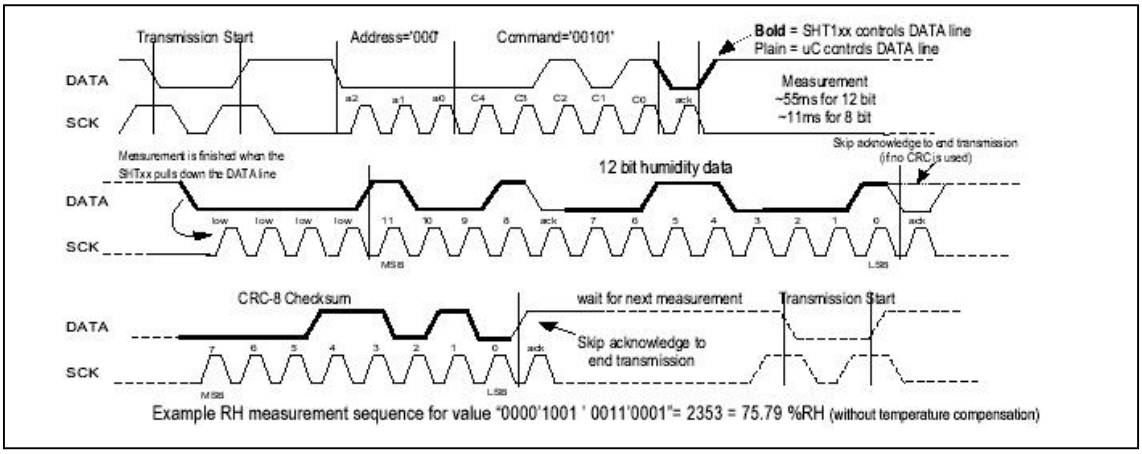
Connection reset sequence

SHT15 has commands to measure temperature and humidity separately (Table 1).

After sending the request, SHT15 send data to PsoC on bilateral DATA line. The data are synchronized through SCK signal from PsoC (Figure 4).

Table 1: SHT15 command codes

Command	Code
Reserved	0000x
Measure Temperature	00011
Measure Humidity	00101
Read Status Register	00111
Write Status Register	00110
Reserved	0101x-1110x
Soft reset, resets the interface, clears the status to default values Wait minimum 11 ms before next command	11110



Example RH measurement sequence for value "0000'1001 ' 0011'0001"= 2353 = 75.79 %RH (without temperature compensation)

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4. DESIGNING PSOC

As described in Figure 2, to get data from SHT15, we use a 28-pin CY8C26443 PSoC device as the Master device.

4.1. Global resource configuration

Amongst the current system-on-chips, the most remarkable devices come from Cypress Microsystems: Programmable System-on-Chip (PSoC) device family. A PSoC device consists of an 8-bit 24MHz microcontroller unit, flash memory, SRAM, analog blocks, digital blocks, and pinouts. The most powerful feature of a PSoC device is the ability to reconfigure analog blocks, digital blocks, and pinouts dynamically, giving the system high flexibility. Analog blocks can be reconfigured to common modules like: ADCs, DACs, filters, amplifiers, etc. Digital blocks can be reconfigured to common modules like: timers/counters, LCDs, MUXs, UARTs, etc.

The global resource configuration for the PSoC Master chip is described in Table 2.

Table 2: Global Resource Configuration

Global Resource	
CPU_Clock	12_MHz
32K_Select	Internal
PLL_Mode	Disable
Sleep_Timer	512_Hz
24V1=24MHz/N	12
24V2=24V1/N	16
Analog Power	SC On/Ref High
Ref Mux	(Vcc/2)+/-(Vcc/2)
Op-Amp Bias	High
A_Buff_Power	High
SwichModePump	ON
VoltMonRange	5.0V
VoltMonThreshold	92%
Supply Voltage	5.0V

4.2. Block configurations

In this application, we use digital blocks to interact with various components:

- *LCD:* To display temperature, humidity, and dew-point on a 8x2 character LCD.
- *Counter_Timer:* To clock bitrate to control signals for SHT15.
- *Counter_BaudRate:* To generate clock for UART at 9600bps.
- *Tx8:* To send data to RS485 network.
- *Rx8:* To receive data RS485 network.

Displaying to LCD

The character LCD is controlled by sending data via two signals as illustrated in Figure 2:

- DK(3): controlling signal to LCD
- Data(4): data signal to LCD

These signals are controlled from the LCD module. Cypress has provided a robust API to control standard character LCDs, which becomes handy in this application.

Communication with SHT15

SHT15 uses a mechanism similar to serial communication for data transmission. As showed in Figure 2, SHT15 is controlled using the following signals:

- SCK signal (output): to provide clock for bit-synchronization
- Data signal (output): Data requests to SHT15
- Data signal (input): Responses from SHT15

Communication with RS485 network

The system is connected to RS485 network via blocks *Counter_BaudRate*, *Tx8*, and *Rx8*. Four mini switches are connected to four PSoC pins to identify the system over the network. Signals from blocks *Tx8* and *Rx8* are converted by a MAX485.

4.2. Pinouts

The 28 pinouts for this application are showed in Table 3.

Table 3: Pinouts table

Pin#	Port	Label	Select	Drive	Interrupt
1	P0[7]	Port_0_7	StdCPU	Pull Dn	DisableInt
2	P0[5]	Port_0_5	StdCPU	Pull Dn	DisableInt
3	P0[3]	Port_0_3	StdCPU	Pull Dn	DisableInt
4	P0[1]	Port_0_1	StdCPU	Pull Dn	DisableInt
5	P2[7]	Port_2_7	StdCPU	Pull Dn	DisableInt
6	P2[5]	LCD_1RS	StdCPU	Strong	DisableInt
7	P2[3]	LCD_1D7	StdCPU	Strong	DisableInt
8	P2[1]	LCD_1D5	StdCPU	Strong	DisableInt
9	SMP				
10	P1[7]	Port_1_7	StdCPU	High Z	DisableInt
11	P1[5]	Port_1_5	StdCPU	High Z	DisableInt
12	P1[3]	Port_1_3	StdCPU	Strong	DisableInt
13	P1[1]	Port_1_1	StdCPU	High Z	DisableInt
14	VSS				
15	P1[0]	Port_1_0	StdCPU	High Z	DisableInt
16	P1[2]	Port_1_2	StdCPU	Strong	DisableInt
17	P1[4]	Port_1_4	Global_IN_4	High Z	DisableInt
18	P1[6]	Port_1_6	Global_OUT_6	Strong	DisableInt
19	XRES				
20	P2[0]	LCD_1D4	StdCPU	Strong	DisableInt
21	P2[2]	LCD_1D6	StdCPU	Strong	DisableInt
22	P2[4]	LCD_1E	StdCPU	Strong	DisableInt
23	P2[6]	LCD_1RW	StdCPU	Strong	DisableInt
24	P0[0]	Port_0_0	StdCPU	High Z	DisableInt
25	P0[2]	Port_0_2	StdCPU	Pull Dn	DisableInt
26	P0[4]	Port_0_4	StdCPU	Pull Dn	DisableInt
27	P0[6]	Port_0_6	StdCPU	Pull Dn	DisableInt
28	VCC				

4.3. Embedded system software

Computing dew-points

Dew-points are calculated based on temperature and humidity using the following equations:

$$\log Ex = 0.66077 + \frac{7.5 * temperature}{237.3 + temperature} + (\log_{10}(humidity) - 2)$$

$$dewpoint = \frac{(\log Ex - 0.66077) * 237.3}{0.66077 + 7.5 - \log Ex}$$

Figure 5 Dewpoint equations

The block diagram of the software is showed in Figure . When power-on, the system configures and initializes the digital blocks, and presets serial-communication settings to 9600bps, 8 bit data, no parity, and 1 bit stop. After the initialization, it constantly reads temperature, humidity from SHT15 and computes dew-points. It displays information on the LCD. Temperature and humidity are displayed for 10 seconds, followed by dew-points with the same interval. It also sends the data to RS485 if there is a request.

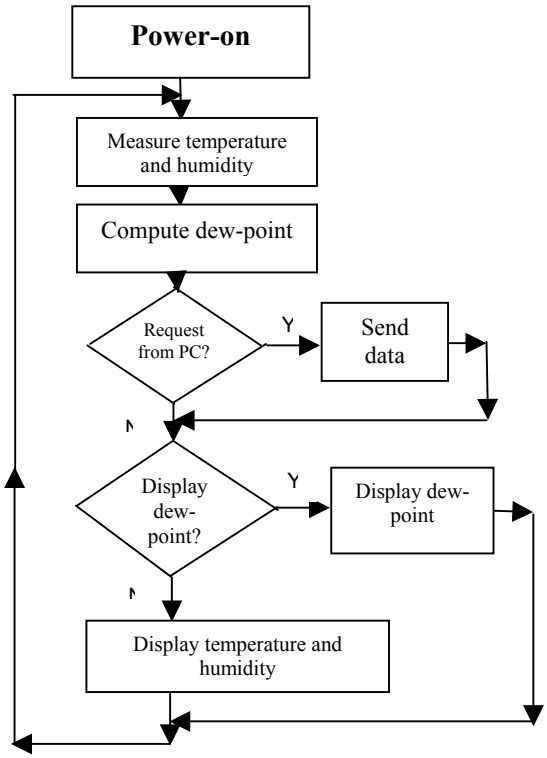

Figure 5: Software block diagram

5. DEVELOPING THDP-1

The system is built up as a single whole Temperature, Humidity, and Dew-Point monitoring device (THDP-1), as showed in Figure 6. The specifications of the device are shown below.

Table 4 Specifications for THDP-1

	Min	Typ	Max	Unit
Temperature				
Range	-40		123.8	°C
Resolution	0.04	0.01	0.01	°C
	12	14	14	Bit
Error		0.4		°C
Humidity				
Range	0		100	%RH
Resolution	0.5	0.3	0.3	%RH
	8	12	12	Bit
Error		2.0		%RH

- Size: 85x80x25 mm
- Weight: 150 g
- Power supply: 9 - 15V DC
- Current: < 200 mA
- Network port: RS485

6. CONCLUSIONS

In compared with devices for monitoring temperature, humidity, and dew-points, our THDP-1 provides a more advantaged solution in terms of low costing, low power, light weighting, and high reliability. THDP-1 is designed to be well-suited to warehouses, factories and enterprises. Through the use of THDP-1, we hope to provide customers with a better quality in protecting products from temperature and humidity defects, helping increase product quality, and decrease product cost.

References

[1] CY8C26xxx Data sheet
[2] PsoC Designer 4.0 Usermanual
[3] SHTxx Data Sheet
[4] MAX 485 Data sheet

Figure 6: THDP-1 device

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