Implementation of Microcontroller Based Sensing Unit in Transmitter for Wireless Weather Station

Lay Nandar Soe, Kyaw Soe Lwin, Hla Myo Tun

***Abstract*— This paper deals with the design, development and implementation of sensing unit in transmitter for wireless weather station. The main aim of the proposed system is to design and implement a simple, inexpensive and reliable wireless weather station. The microcontroller scans the sensors, calibrates and compensates their data and communicates the resulting information to the transmitter. These resulting informations are displayed on the LCD that is temperature (ºC), humidity (%), pressure (KPa) and wind speed (MH). The transmitter is selected a radio transmitter module that operates at frequency of 433 MHz with optimal range 150m. The transmitter module takes serial input and transmits these signals using radio frequency. The system allows one way communication between two nodes, namely, transmission and reception. The system has many advantages as compared to other weather monitoring systems in term of its smaller size, on-device display, low-cost and greater portability.**

***Index Terms*— Sensor, Microcontroller, Wireless Communication and RF Transmitter Module**

I. Introduction

Wireless weather stations are becoming increasingly more popular. Weather stations are either wired or wireless. A wireless system has the advantage of not requiring the customer to run wires between the sensors and the main station; however, a wireless system is susceptible to RFI (Radio Frequency Interference). A wire system has the advantage of providing a clear signal; however it is limited by the cables, which must be run away from strong magnetic or electrical fields and which cannot be extended.

Sensors are important components in many applications, not only in the industries for control but also in daily life for human's safety and security monitoring, traffic flow measuring, weather condition monitoring and etc. DeHennis and Wise (2005) introduced wireless sensing microsystem for environmental monitoring, using capacitive-based sensors. Vlassov et al., (1993) and Buff et al., introduced the usage of surface acoustic waves (SAW) devices as temperature sensor and pressure sensor respectively. These systems are quite expensive and complex in nature as some of them the use of on-chip transmitter circuit and involve fabrication processes.

This paper aims to build a low-cost, reliable, weather monitoring system. The proposed system has five sensors that measure the temperature, relative humidity, pressure, wind speed and direction. The outputs of the sensors are given to the microcontroller. The analogue signal is converted into the digital signal and further processed by the microcontroller. LCD is connected to the microcontroller to display the measurements. The calculated measurement data will be displayed on the LCD. The output pin of the microcontroller is connected to the data line of the RF transmitter module. The microcontroller is programmed to transmit this data serially using RF transmitter module.

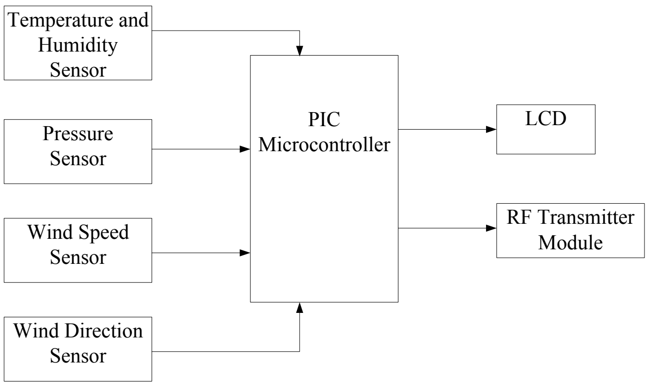

Fig. 1. Block Diagram of Sensing unit in Transmitter for Wireless Weather Station

II. Sensing Unit of The System

Sensing unit of the system is consisted of pressure sensing unit, temperature and humidity sensing unit, wind speed, direction sensing unit, display unit and transmission unit of the system.

A. *Pressure Sensing Unit*

In this system, MPX4115A pressure sensor is chosen to sense pressure. The output pressure sensor with 5V power supply change by 4.59mV/0.1KPa. Sensor measure pressures from 15KPa to 115KPa. Its output voltage changes for the pressure range from 0.2V to 4.8V. For the output value of atmospheric pressure varies from about 3.8V to 4.3V.

For pressure measuring sensor, the input is pressure, and the output is voltage.

Nominal Transfer Value:

Manuscript received April, 2014.

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ISSN: 2278 – 7798

Vout = Vs * (0.009 * P – 0.095) +/- Error

Error = Pressure Error * Temp Factor * 0.009 * Vs

Vs = 5.1 +/- 0.25Vdc

Table1. Relation between input pressure and output voltage

Input Pressure	Output Voltage
15KPa	0.24 +/- 0.06885 V
35Kpa	1.122 +/- 0.06885 V
55KPa	2.04 +/- 0.06885 V
75KPa	2.958 +/- 0.06885 V
95KPa	3.876 +/- 0.06885 V
115KPa	4.794 +/- 0.06885 V

B. *Temperature and Humidity Sensing Unit*

When you submit your final version, after your paper has been accepted, prepare it in two-column format, including figures and tables.

DHT11 is capable of measuring both temperature and humidity and provide fully calibrated digital outputs. It can measure temperature range from 0 to 50ºC accuracy with +/- 2ºC and humidity range from 20 to 90%RH accuracy with +/- 5%RH.

It has got its own proprietary one wire protocol, and therefore, the communication between the sensor and microcontroller is not possible through a direct interface with any of its peripherals. The protocol must be implemented in the firmware of the microcontroller with precise timing required by the sensor. Single bus data is used for communication between microcontroller and DHT.

DHT11's power supply is 3-5.5 VDC. When power is supply to the sensor, do not send any instruction to the sensor in within one second in order to pass the unstable status.

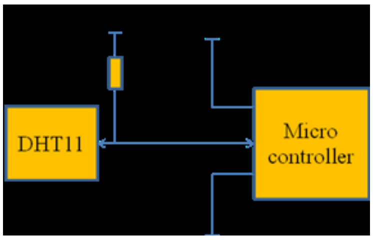

Fig. 2.Connection between MCU and DHT

Communication format of DHT11 can be separated into 3 stages;

- Request
- Response
- Data reading

The microcontroller initiates data transmission by a start signal. The microcontroller pin must be configured as output for this purpose. The MCU first pulls the data line low for at least 18ms and then pulls it high for next 20-40us before it releases it. Next, the sensor responds to the MCU start signal by pulling the line low for 80 us followed by logic high signal that also lasts for 80us. Remember that the MCU pin must be configured to input after finishing the start signal. Once detecting the response signal from the sensor, the MCU should be ready to receive data from the sensor. The sensor sends 40 bits or 5 bytes of data continuously in the data line. While transmitting bytes, the sensor sends the most significant bit first. Logic 0 can be defined as 50us low and 26-28us high. Logic 1 can be defined as 50us low and 70us high. One communication is about 4mS.

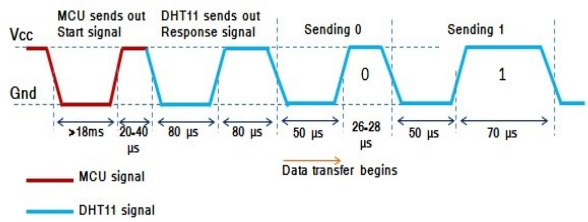

Fig. 3. Communication Process of MCU and DHT11

The 40-bit data from the sensor has the following structure.

Data (40-bit) = Integer Byte of RH + Decimal Byte of RH + Integer Byte of Temp. + Decimal Byte of Temp. + Checksum Byte

For DHT11, the decimal byte of humidity and temperature are always zero. Therefore, the first and third bytes of received data actually give the numeric values of the measured relative humidity and temperature. The last byte is the checksum byte which is used to make sure that the data transfer has happened without any error. If all the five bytes are transferred successfully then the checksum byte must be equal to the last 8 bit of the sum of the first four bytes.

Checksum = Last 8 bits of (Integer Byte of RH + Decimal Byte of RH + Integer Byte of Temp. + Decimal Byte of Temp.)

C. *Wind Direction Sensing Unit*

Potentiometer can be used as wind direction sensor in sensing unit in transmitter for wireless weather station. . For direction, the specific direction is determined at every 45º rotation of potentiometer. While the direction will be displayed in specific direction which is North, Northeast, East, Southeast, South, Southwest, West and Northwest.

An analogue output voltage directly proportional to wind direction is produced when a constant DC excitation voltage is applied to the potentiometer. The output voltage of the potentiometer can be varied 0 to 5V according to the wind direction 0º to 360º. The voltage on potentiometer is read by using a 10bits serial analogue-to-digital converter.

Directions can be divided 8 parts, thus the voltage difference between two directions will be 5V/8 = 0.625V.

D. *Display Unit of the System*

The measurement of weather conditions are displayed on the Liquid Crystal Display. The LCD connects to the microcontroller using 14 pins.

Depending on how many lines are used for connecting an LCD to the microcontroller, there are 8-bit and 4-bit LCD modes. The 8-bit LCD mode uses outputs D0- D7 to transfer data. The main purpose of the 4-bit LCD mode is to save valuable I/O pins of the microcontroller. Only 4 higher bits

ISSN: 2278 – 7798

(D4-D7) are used for communication, while others may be left unconnected. Each piece of data is sent to the LCD in two steps- four higher bits are sent first (normally through the lines D4-D7), then four lower bits.

Display contrast depends on the power supply voltage and whether messages are displayed in one or two lines. For this reason, varying voltage 0-Vdd is applied to the pin marked as V_{EE}. A potentiometer is usually used for this purpose. Some of the LCD displays have built-in backlight (blue or green LEDs). When used during operation, a current limiting resistor should be serially connected to one of the pins for backlight power supply (similar to LED diodes).

E. *Transmission Unit of the System*

In transmission section, RF Transmitter module which is a 433 MHz serial data transmitter can be used. PIC18F452 is programmed to transmit its ADC data serially using 1200 baud with no parity. RF modules perform best at 1200 baud. While data transmission at 2400 baud is also possible, it will not be error free. Baud rates more than that are not useful at all. It is very easy to use for RF transmission and it can be employed Amplitude Shift Keying (ASK). The module generates 433 MHz signal when '1' is present on its data line and generates no output for '0' on the data line. This transmitter module takes serial input and transmits these signals through RF. The typical antenna length of the RF transmitter module is 17 cm.

RF Transmitter module has 4 pins (Vcc, antenna, GND and Data). In this circuit, Vcc is connected to 5V and GND pin is connected to GND of circuit board. The data pin should be connected to transmit pin of PIC18F452. Data one pin of port D (RD1) is used as a Manchester transmit pin of Microcontroller and RD0 pin is used as a receive pin.

F. *PIC18F452 Microcontroller*

Microcontroller is the heart of the system. It receives analogue and digital signals equivalent to the quantity of the weather variable to be measured; from sensors connected to it and conversion and processing through pre- programmed instructions written in MikroC language to ensure that corresponding measurement made by these sensors are available in forms that are meaningful and useful for human analysis, interpretation and record.

In this proposed system, we have used PIC18F452 microcontroller for the measurement of weather conditions and transmission of data to the base station. The microcontroller is responsible for the analogue-to-digital conversion, LCD control, user interface and communication with a serial device. The microcontroller uses a 4MHz clock.

III. Software Implementation

C' programme language is used for the sensing unit in transmitter for wireless weather station. The popular and powerful mikroC, developed by MikroElektronika (web site: www.microe.com) is easy to learn and comes with rich resources, such as a large number of library functions and an integrated development environment with a built-in simulator and an in-circuit debugger (e.g., mikroICD). A demo version of the compiler with a 2K program limit is available from MikroElektronika.

The flowchart of the program is presented in figure 4. The microcontroller program controls the external devices and measures the input signals from the sensors. Pressure, temperature and humidity, wind speed and direction are sensed sequentially by the sensors. These data are displayed on LCD and then data are transmitted to the receiver by using RF module.

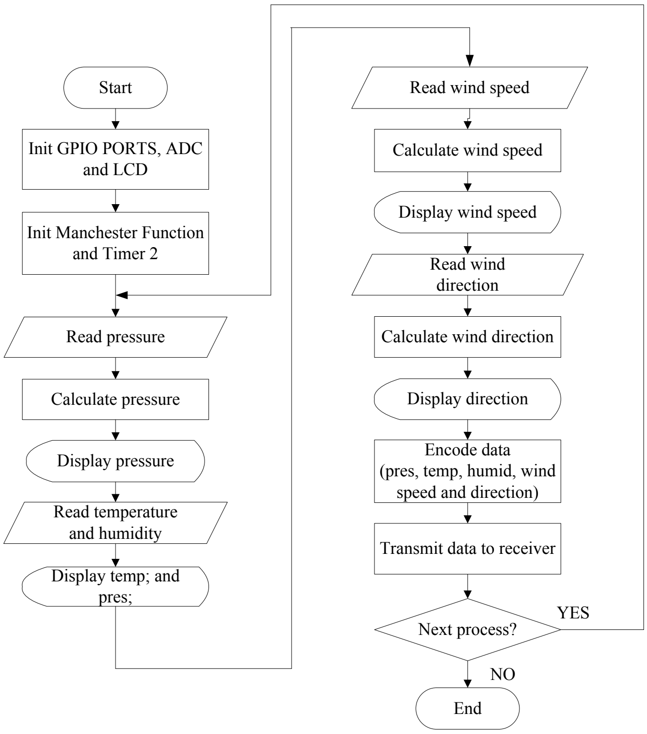

Fig. 4. Flowchart for sensing unit in transmitter wireless weather station

The hardware transmit pin of microcontroller is not used for data transmission. In this system, software pin of microcontroller is used to transmit data. So, the system needs an encoding method. MikroC provides a library for handling Manchester coded signals. Manchester code is a code in which data and clock signals are combined to form a single self-synchronizing data stream; each encoded bit contains a transition at the midpoint of a bit period, the direction of transition determines whether the bit is a 1 or a 0; second half is the true bit value and first half is the complement of the true bit value.

The chief advantage of Manchester encoding is the fact that the signal synchronizes itself. This minimizes the error rate and optimizes reliability. The main disadvantage is the fact that a Manchester-encoded signal requires that more bits be transmitted than those in the original signal.

IV. Result and Discussion

The sensing unit in transmitter for wireless weather station is simulated using Proteus software. At first, 5V is applied to MPX4115A and output pin is connected to the port A pin RA0 of the microcontroller. According to the pressure output equation, 95KPa input pressure equal to the 3.876 +/- 0.06885 V. Although input pressure is 95KPa, the value of pressure on LCD is 93KPa. The simulation result of pressure sensor is described in figure5.

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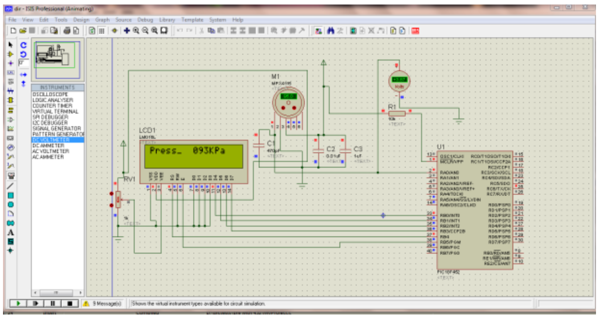

Fig. 5. Screenshot of Running for Pressure Sensor

Variable resistor is used to sense wind direction in this design. When variable resistor is changed, the output voltage is also changed. The supply voltage of direction sensor is 5V. 5V is divided into 8 portions for 8 directions. The voltage 0-0.625 V on direction sensor is referred to the NORTH direction. The input pressure is 100KPa, the output voltage is 4.105 +/- 0.06885 V. The simulation result of 100Kpa, 2MH and NORTH are described in figure 6.

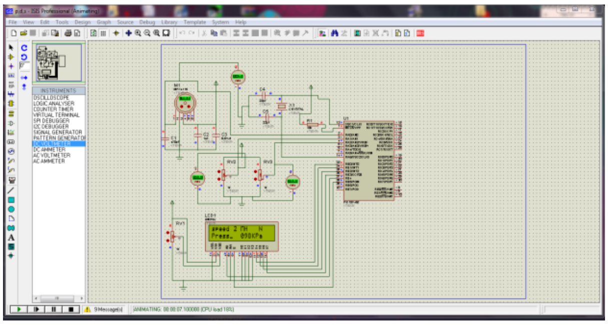

Fig. 6. Screenshot for the simulation result of pressure (100Kpa), wind speed (2MH) and direction (NORTH)

DHT11 is not included in the Proteus software. The program for DHT11 is inserted into the microcontroller. According to the protocol between the microcontroller and DHT, microcontroller initiates data transmission by a 'Start' signal. The microcontroller sends the data line low for 18ms and then sends it high for next 20-40 us. If the sensor does not respond to the microcontroller 'Start' signal, no data will be displayed on LCD. Finally, pressure, temperature, relative humidity, wind speed and wind direction are transmitted to the based station using radio frequency.

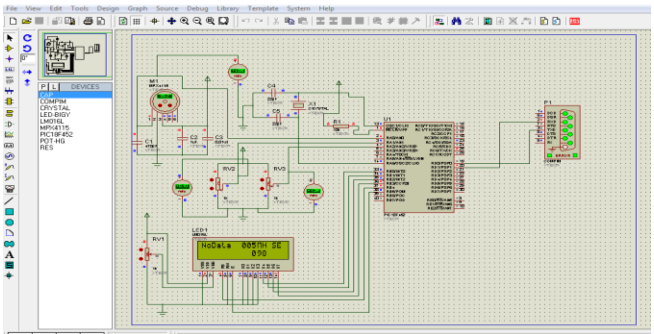

Fig. 7. Screenshot for the simulation result of DHT11

After design and construction of the whole circuit, test and result is carried out. Figure 8 shows complete constructed circuit of sensing unit in transmitter for wireless weather station.

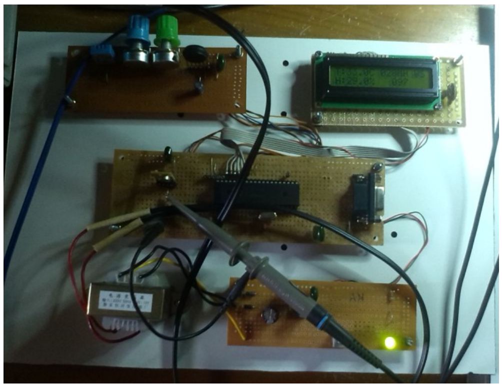

Fig. 8. Circuit Overview of the system

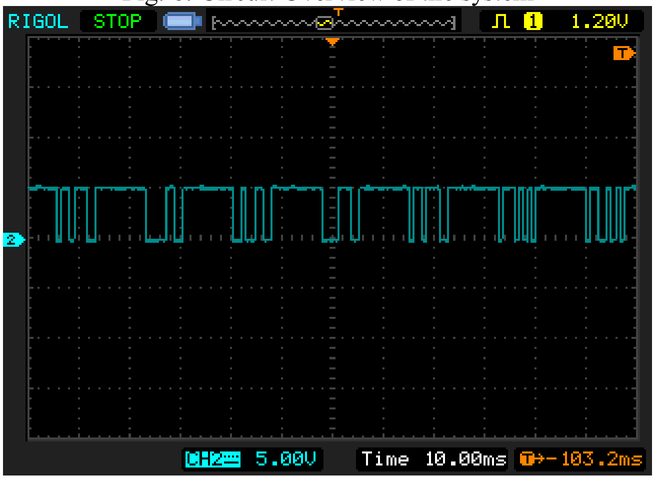

Fig. 9. Waveform of data transmission

The byte of the transmitted data is 18 bytes. They are pressure for 3 bytes, temperature for 4 bytes, relative humidity for 4 bytes, wind speed for 3 bytes, wind direction for 2 bytes and handshake for 2 bytes. We used Manchester encoding so the total bytes of transmitted data is (18 * 2) 36 bytes or 228 bits. The start bit and stop bit do not include in the total bytes of transmitted data. The data format is start bit, handshake, pressure, temperature, relative humidity, wind speed, direction, handshake and stop bit. The RF transmitter module transmits 1200 baud rate. The time between the two bytes is 10 mS. So the time for the total bytes of transmitted data is (0.19 + 360 mS) 0.55 seconds.

V. Conclusion

The main motivation of this system is to develop and implement a simple and inexpensive wireless weather station that get the weather conditions at the remote station and transmit the data to a wireless receiver board connected to the RS-232 port of the PC. The low-cost RF transmitter can be used to transmit signal up to 150 meters (the antenna design, working environment, data rate and supply voltage will seriously impact the effective distance). Wind speed sensor cannot be built, so potentiometer can be used as wind speed sensor.

C program was written for the transmitter to collect the data, process and transmit the data format to the receiver. Overall, the hardware and software implemented fulfill the goal are successful. The system is highly optimized with only

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a few components on the transmitter and receiver boards therefore the system is cost-effective.

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ISSN: 2278 – 7798