Embedded System for Monitoring Atmospheric Weather Conditions Using Weather Balloon

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Abstract— In this project ,embedded system is used for measuring pressure, temperature and humidity in the atmosphere for up to date weather monitoring- Weather is monitored at different levels of the atmosphere ,by using an hydrogen balloon in which pressure, temperature and humidity sensors are embedded .These measured values are then transmitted to the ground station for display. Radio frequency signals are used for communication between ground station and balloon floating station (space station) respectively.

Index Terms— Embedded System, hydrogen balloon, AT-mega, sensors, microcontroller, temperature, pressure and humidity

1 INTRODUCTION

Weather is the state of the atmosphere at any given time and place. Most weather takes place in the lower layer of the atmosphere. Weather occurs because our atmosphere is in constant motion. Some determining factors of weather are temperature, pressure, humidity, precipitation, fronts, clouds and wind. Other more severe weather conditions are hurricanes, tornadoes, and thunderstorms. Weather changes every season because of the Earth's tilt when it revolves around the sun. Meteorology is the study of weather and meteorologists are scientists who study and predict weather.

At present, the Indian meterological department measures the practical weather (temperature, pressure, humidity wind direction etc.) by using hydrogen balloons. In order to measure the practical weather, they have to send hydrogen filled balloons every four hours. the equipments are placed outside the hydrogen filled balloon and sent in the atmosphere for measuring weather-this method is very expensive. In order to reduce costs the equipments are placed in the atmosphere at a fixed place by using ropes or strings. For initial test, we send the equipments to an altitude of about 100 to 200 meters.

Compared to other air filled balloons, the Hydrogen balloon is easy to purchase and also low cost. In this paper, we designed and implemented low cost and reliable instrumentation system for short-range measurement with the help of hydrogen balloon and various sensors required to measure the temperature, pressure and humidity.

Though we have many types of temperature sensors like thermistor, thermocouple and resistance temperature detectors (RTD) for measuring temperatures in the range's 0-200, 0-500 and 0-1000 degree Celcius upwards.NTC Thermistor is used because of its higher sensitivity, reliability and accuracy in 0-200 degree Celcius range. The Fujikura pressure sensor was used for measuring pressure, and the EPA-600 humidity sensor used for measuring humidity.

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2 GENERAL BLOCK DIAGRAM

Space station is the balloon for measuring atmospheric data and measured data has to be displayed in the ground station. These are explained below.

2.1 Space station

Using pressure, temperature and humidity sensors,the data is collected from the atmosphere and this data has to be processed by the ATmega 48 microcontroller. Processed data are sent to RF transmitter RDM-A4FZ. These transmitted signals are received by the ground station system.

2.2 Ground station

Data which has been received from the space station is given to the receiver microcontroller. and the calibrated data are displayed in the LCD display unit. Also the received data is given to the PC.

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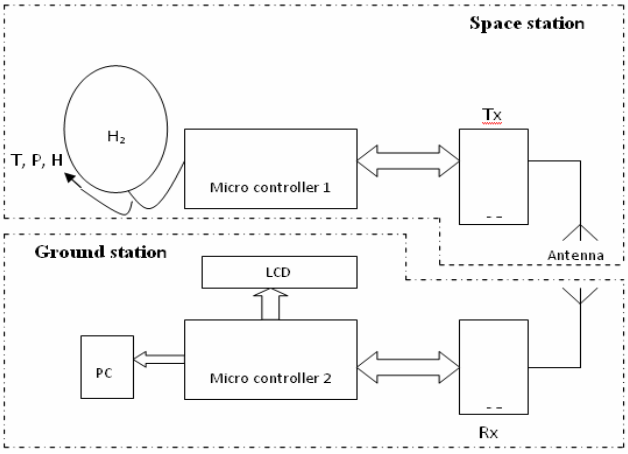

Fig.1 General Block diagram

3 ENVIRONMENTAL SENSORS

A sensor is a device that produces a measurable response to a change in a physical condition, such as temperature or thermal conductivity, or to a change in chemical concentration ,pressure ,humidity etc.

Sensors are particularly useful for making in-situation measurements. Sensors play an important role for measurement and automation applications. The sensor is responsible for converting some type of physical phenomenon into a quantity measured by a data acquisition (DAQ) system. The sensors were selected by the following parameters.

1. Accuracy - The statistical variance about the exact reading
2. Cost –low cost
3. Repeatability - The variance in a sensor's reading when a single condition is repeatedly measured
4. Resolution - The smallest increment the sensor can detect

The three main sensors used for monitoring atmospheric weather are

1. Temperature sensor
2. Pressure sensor
3. Humidity sensor

4 NTH5G10 THERMISTER

Thermistor is a type of resistor, whose resistance varies with temperature. Thermistors are widely used as inrush current limiters, temperature sensors, seif–resulting protectors, and self-regulting heating element. In this thermistor low cost, highly accurate, stable devices designed specifically for temperature sensing and control applications. Negative Temperature Coefficient (NTC) thermistors exhibit a decrease in electrical resistance when subjected to an increase in body temperature and Positive Temperature Coefficient (PTC) thermistors exhibit an increase in electrical resistance when subjected to an increase in body temperature. Thermistors are capable of operating over the temperature range of -100° to over +600° Fahrenheit.

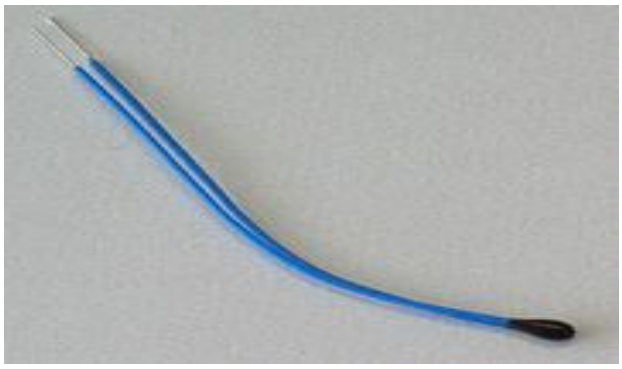

Fig : 2 NTC Thermister sensor

4.1 Features

1. High accuracy
2. Low cost
3. Fast thermal response
4. High stability
5. Small size

4.2 *Specification*

1. Thermal time constant: 1-second max.
2. Dissipation constant: 1 mw/°C.
3. Interchangeability tolerance of ±0.5°C or ±1.0°C

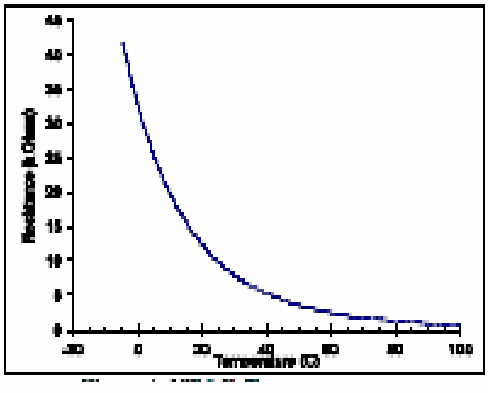

Fig.3 Temperature vs Resistance characteristics

The resistance is inversely proportional to the temperature. Hence, when the temperature increases, proportionately, resistance decreases.

5 FUJIKURA ATMOSPHERIC PRESSURE SENSOR

The term atmospheric pressure refers to the pressure generated by the weight of the air surrounding the earth. The pressure is a function of altitude it is not a linear function, and due to the compressibility of air, the atmosphere is denser at lower altitudes. The atmosphere is also not uniform, these are mounds and valleys that create high and low pressure areas. The atmosphere is in constant motion like the oceans- wind blows from high pressure areas to low pressure areas and rises and falls as the air is heated and cooled by land. The pressure sensor measures the atmospheric pressure and is typically normalized to sea level. This application note will discuss atmospheric pressure measurements not normalized barometric measurement readings.The following diagram could be used to measure the atmospheric pressure.

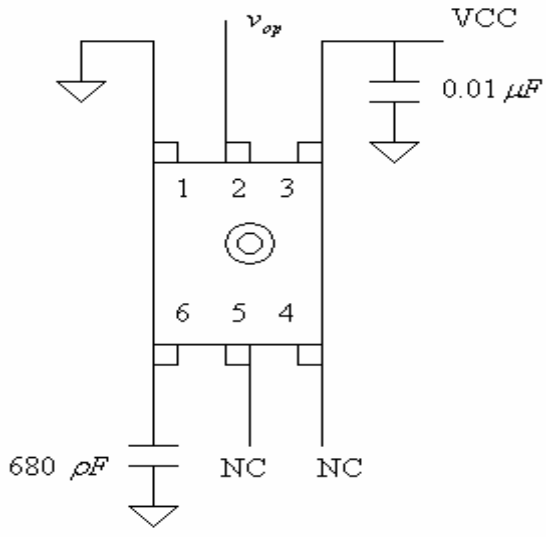

Fig : 4 Pin diagram for pressure sensor.

6 FUJIKURA PRESSURE SENSOR

Fig .5 XFPM-50KPGP1 Atmospheric pressure sensors.

7 EPA-600 HUMIDITY SENSORS

Humidity sensors are used to measure the humidity in air, as a fraction of the maximum amount of water that can be absorbed by air at a certain temperature. Under normal atmospheric conditions and a given temperature this fraction can vary between 0% (absolute dry point) and 100 % (Condensation starting point). This relative humidity measurement is only valid under the above-mentioned temperature and atmospheric conditions, thus making very important the fact that the sensor must not be affected by temperature or pressure changes. As a result it is obvious that temperature or pressure dependent sensing elements, such as mechanical devices and resistive type sensors, are far behind of the respective non-dependent ones, such as capacitance sensors. Absorption based humidity sensors provide both temperature and %RH (Relative Humidity) outputs. Humidity cells are mainly capacitance sensors characterized of excellent longterm stability, good resistance to pollutants, precise measurements, high sensitivity, interchangeability and wetability.

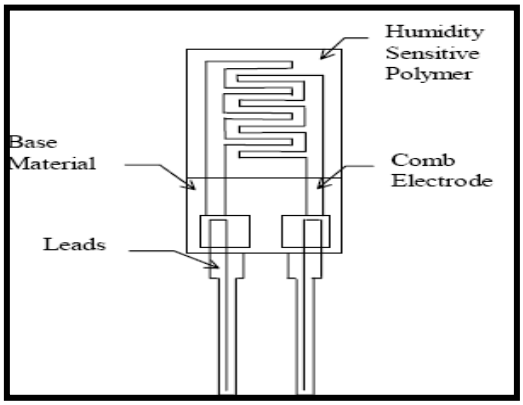

Fig.6 EPA-600 Humidity sensor

8 MICROCONTROLLER

In this project AT-mega48 microcontroller is used for the purpose of measuring and controlling the weather monitoring. By executing powerful instructions in a single clock cycle, the ATmega48 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

8.1 AT-mega 48 Features

1. High Performance
2. Low Power AVR 8-Bit Microcontroller

8.2 Advanced Risc Arichitecture

1. 32 powerful Instructions
2. 32 x 8 General Purpose Working Registers
3. Fully Static Operation

8.3 Peripheral Features

1. 6-channel 10-bit ADC in PDIP Package
2. Programmable Serial USART
3. Master/Slave SPI Serial Interface
4. Byte-oriented 2-wire Serial Interface

The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers. The AVR has a programmable Watchdog Timer with internal Oscillator, and five software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, USART, 2-wire Serial Interface, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or hardware reset.

9 ADC CONVERSION

The Atmega48 features a 10-bit successive approximation ADC. The ADC is connected to an 8-channel Analog Multiplexer which allows eight single-ended voltage inputs constructed from the pins of PORTC. The ADC has a separate analog supply voltage pin, AVCC. AVCC must not differ more than ± 0.3V from VCC. Internal reference voltages of nominally 2.56V or AVCC are provided On-chip. The voltage reference may be externally decoupled at the AREF pin by a capacitor for better noise performance.
The ADC converts an analog input voltage to a 10-bit digital value through successive approximation. The minimum value represents GND and the maximum value represents the voltage on the AREF pin minus 1 LSB. Optionally, AVCC or an internal 2.56V reference voltage may be connected to the AREF pin by writing to the REFSn bits in the ADMUX Register. The internal voltage reference may thus be decoupled by an external capacitor at the AREF pin to improve noise immunity.

In this project three channels are used to read the analog value from the humidity, temperature and pressure sensors.

10 RADIO FREQUENCY COMMUNICATION

The RF communication system consists of RF transmitter and receiver. The RF transmitter collects the data from the sensors, which are present in the space station. The collected data is transmitted to the ground station receiver using the RF transmitter .The RF receiver, receives the transmitted data and send it to the display section for inference. The following specifications of the Tx and the Rx are given bellow .The RDM-A4FZ is a low power, highly integrated FSK/GFSK transceiver designed for operation in the low UHF and VHF bands.

The RDM-A4FZ uses an external VCO inductor that allows users to set the operating frequency anywhere between 135 MHz and 433 MHz. Using the divide-by-2 circuit allows users to operate the device as low as 80 MHz. The typical range of the VCO is about 10% of the operating requency. A complete transceiver can be built using a small number of external discrete components, making the RDM-A4FZ very suitable for price-sensitive and area-sensitive applications.The transmitter output power is programmable in 63 steps from -−20 dBm to +13 dBm. The transceiver RF frequency, channel spacing, and modulation are programmable using a simple 3-wire interface. The device operates with a power supply range of 2.3 V to 3.6

10.1 Characteristics

1. Operating Voltage 2.3 to 3.6 Volts.
2. RX/TX turnaround time 152 µS.
3. Maximum Radio Data rate 250Kbps.
4. RF frequency range from 135 MHz to 650 MHz

10.2 SPI Interface

The serial interface allows the user to program the eleven 32-bit registers using a 3-wire interface (SCLK, SDATA, and SLE). It consists of a voltage level shifter, a 32-bit shift register and 11 latches. Signals should be CMOS compatible. The serial interface is powered by the regulator and therefore is inactive when CE is low.

Data is clocked into the register MSB first on the rising edge of each clock (SCLK). Data is transferred to one of the 11 latches on the rising edges.

11 CONCLUSION

Weather is the state of the atmosphere at any given time and place. At present, the main factor in measuring weather conditions is cost and also reliability. In this project, the different kinds of atmospheric weather conditions are measured by using hydrogen balloon with temperature sensor, pressure sensor and humidity sensor. The Communication is carried out by radio frequency from the space station to the ground station. The work was carried out for implementing this system in our college premises.Further, calibration of sensor weather data and storage of the data is to be done & time stamping.Also new communication methods can be adopted.

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