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Weather Monitoring Station: A Review

Mr. Dipak V. Sose[1], Dr. Ajij D. Sayyad[2]
[1]*PG Research Student, Department Of Electronics and Telecommunication Engineering, Maharashtra Institute of Technology, Aurangabad (MS), India*
[2]*Associate Professor, Department Of Electronics and Telecommunication Engineering, Maharashtra Institute of Technology, Aurangabad (MS), India*

ABSTRACT
Weather monitoring plays a very important role in human life hence study of weather system is necessary. Currently there are two types of the weather monitoring stations available i.e. wired and wireless. Wireless system has some advantages over the wired one hence popular now a days. The parameters are include in weather monitoring usually temperature, humidity atmospheric pressure, light intensity, rainfall etc. There are many techniques existed using different processor such as PIC, AVR, ARM etc. Analog to digital channel are used to fetch the analog output of the sensors. The wireless techniques used in the weather monitoring having GSM, FM channel, Zigbee, RF etc Protocols.
Keywords: ADC, Microcontroller, Sensors.

I. Introduction

Climate is very important factor in our life. Weather monitoring have great importance and uses in several areas like agricultural field weather condition to industrial weather condition monitoring. Weather monitoring allows us to keep track of different climates behavior including temperature, humidity, atmospheric pressure, light intensity rainfall, wind speed and wind direction. All the parameters of the weather are necessary to maintain the balance in the agricultural field as well as industrial processes. Weather affects a wide range of the man's activities. Modern weather monitoring systems and networks are designed to make the measurements necessary to track these movements in cost effective manner. Temperature and humidity are indicates for both indoor and outdoor location. Programmable alarms are also available in the monitoring system which indicates out of range condition.[1]. The space based weather monitoring in [2] consist of two major components. The satellite with its data collection sensors and the data processing system. The data processing system is responsible for requesting (from the satellite) data that must be collected and scheduling the task need to be executed.

Weather monitoring is very much helpful to the farmer to monitor weather parameters at their farms. This is also helpful for the industrial processes, ultimately the weather monitoring hold the great importance and having positive impact on the society.

II. Parameters Of Weather Station

Temperature:

A temperature is an objective comparative measure of hot or cold. Temperature usually measure by the thermometer. Several scales and units are available for the temperature most common is Celsius (^{0}C formally known as centigrade), also measures in Fahrenheit (^{0}F) and Kelvin (^{0}K)
1 K = 273+ ^{0}C and 1 F= 32 + 9/5^{0}C.

Humidity:

The amount of water vapor in the air is known as humidity. Water vapor is the gaseous state of water and is invisible
Relative humidity measures in %
Absolute humidity $\Delta H = mH_2O/V_{net}$
mH_2O = mass of water vapor.
V_{net} =Volume of air and water vapor mixture.

Atmospheric pressure:

The pressure exerted by the weight of air in the atmosphere of the earth.
The force over the one centimeter is a pressure of 10.1 N/m^2.
1 milli bar = 1hecto Pascal
At sea level = 101325 Pascal or 101.325 hecto Pascal.

Light intensity:

There are several measures of the light are commonly known as intensity. A photometric quantity measured in the lumens per steradian (lm/sr) or candela is known as luminous intensity.

The SI unit of the illuminance measuring luminous flux per unit are is lux.
1 Lux = 1 Lumen per square meter.

Rainfall

Rain is the liquid water in the form of droplets that have condenses from atmospheric water vapor and the precipitated that is become heavy enough to fall under gravity.

Raindrops have sizes of 0.1 to 9 mm diameter above which they tends to break up. Rainfall is measured in the millimeter/24 hours.

Wind

Wind is a flow of the gaseous on a large scale on the surface of the earth. Wind consist of bulk movements of the air.

Wind speed are usually calculated in meter/second or kilometer/hour.
1 m/sec = 2.237 miles/hour = 3.60 km/ hour.

III. Monitoring Approaches

1.1 Traditional Approach/ Manual Approach

There are many methods which are helpful to calculate the weather parameters. Manual methods need to take the readings at the place of the station by human being. This method of traditional approach is accurate and depend on the person who takes the values. Before going for any method we must know the definitions and standard unit of the weather parameters.

A manual inventory system is relies heavily on the action of the people which increases the possibilities of human error.

Human Error

People might forget to record the weather parameters or simply made mistake in writing any value. This can affect the systems integrity. The time taken for sensing using this types of analog instruments is very much hence it also cause the error. As far as the accuracy is concern this system is less accurate than now days digital system

Table 3.1 Traditional Approach/Manual Approach

Visited places	**Hydrology Project, Godavari Pathbandhare Vikas Mahamandal, Aurangabad MS India**		
Parameters	**Instrument used**	**Range**	**Difficulties**
Temperature	Thermometer 1	-35 ^{0}C to +55^{0}C	Readings need to take manually
	Thermometer 2	-40 ^{0}C to +50^{0}C	
Humidity	Dry bulb Wet bulb	10% to 80%	Readings are not accurate.
Rainfall	Conical flask of 25 cm fixed itself inside cylindrical jar	10 mm to 250 mm for 12 hour	Reading are taken after 12 hours
Wind Velocity	Anemometer Cups	Max 74 m/sec	
Wind Direction	Arrow like structure	-	Direction decide by observing

Table 3.2 Traditional Approach

Visited Places	**Department of Meteorology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani MS India**		
Parameters	**Instrument used**	**Range**	**Difficulties**
Temperature	Thermometer 1	-35 ^{0}C to +55^{0}C	Need to take readings manually.
	Thermometer 2	-40 ^{0}C to +50^{0}C	
Humidity	Dry bulb Wet bulb	10% to 80%	Readings are not accurate.
Rainfall	Cylindrical jar and Conical flask	10mm to 250mm	Need to calculate value manually
Wind Velocity	Anemometer Cups	Max 74 m/sec	
Wind Direction	Arrow like structure	-	Direction decide by observing

Disadvantages:

1) Readings are need to take manually by human causes human error.
2) Sensing time is very high.
3) High installation cost.
4) Complex installation.
5) Hard to replace any elements

3.2 Modern Approach

Now days wireless technology is rapidly increases and also used to monitor weather parameters remotely. Instead of analog instruments now day we can use with internally calibrated. In addition with above all features sensing time is very less hence digital method is advantageous.

The system design consist of transmitter as well as receiver. Transmitter section consist of different types of sensing units such as temperature measurement, Humidity measurement, Atmospheric pressure measurement, Air quality measurement, Rainfall measurement, Wind speed and wind direction measurement. The output can be shown on the either LCD or Computer Monitor. In case of the wired system output is usually displayed on the Liquid crystal display, while using wireless protocol output shown on the computer monitor at remote place.

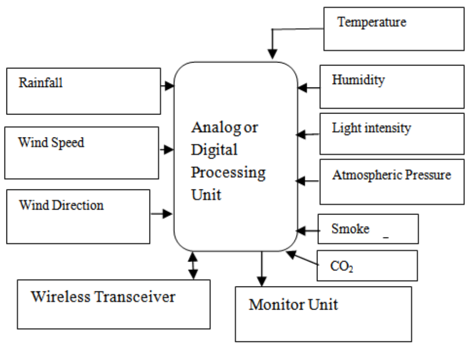

Fig 3.1 Typical Block Diagram of Weather Monitoring Station

3.3 Components of Monitoring System

3.3.1 Microcontroller

ARM Processor (LPC2148)

LPC2148 microcontrollers are based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine microcontroller with embedded high speed flash memory ranging from 32kB to 512kB. A 128-bit wide memory interface and a unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30% with minimal performance penalty. Due to their tiny size and low power consumption, LPC2141/42/44/46/48 are ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale. Serial communications interfaces ranging from a USB 2.0 Full-speed device, multiple UARTs, SPI, SSP to I2C-bus and on-chip SRAM of 8kB up to 40kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers suitable for industrial control and medical systems.[1][7]

ATmega328 Microcontroller

ATmega 328 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega328 achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed. 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 core combines a rich instruction set with 32 general purpose working registers. The 328 provides the following features: 4K/8Kbytes of In-System Programmable Flash with Read-While-Write capabilities, 256/512/512/1Kbytes EEPROM, 512/1K/1K/2Kbytes SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte-oriented 2-wire Serial Interface, an SPI serial port, a 6-channel 10-bit ADC (8 channels in TQFP and QFN/MLF packages), 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.[8][10]

PIC 16F877 Microcontroller

The PIC microcontroller was originally designed around 1980 by General Instrument as a small, fast, inexpensive embedded microcontroller with strong I/O capabilities.. PIC stands for "Peripheral Interface Controller". General Instrument recognized the potential for the PIC and eventually spun off Microchip, headquartered in Chandler, AZ to fabricate and market the PIC microcontroller. A microcontroller is an integrated chip that is often part of an embedded system. The microcontroller includes a CPU, RAM, ROM, I/O ports, and timers like a standard computer, but because they are designed to execute only a single specific task to control a single system, they are much smaller and simplified so that they can include all the functions required on a single chip.PIC 16F877 is one of the most advanced microcontroller from Microchip. This controller is widely used for experimental and modern applications because of its low price, wide range of applications, high quality, and ease of availability.[3][5][6][16]

ATmega16 Microcontroller

The main components of the circuit above is the ATmega16 controller that will receive data from the output of the LM35 sensors, signal conditioners Optocoupler, and LDR. These three sensors are connected to one port ADC0, ADC1 and INT2. Port C is used as the data path to the viewer on the LCD. X-tal used is 11.0592 MHz x-tal lines of communication so that the error in the USART can reach 0%. This microcontroller output to port facilities on the USART RXD and TXD will be linked to the Kyl-1020U radio frequency to transmit data and received by the radio frequency IC Kyl-1020U with 232 max uses to pin female DB9 serial data transmission to a computer. So that the output or display can be displayed on the computer.[4]

3.3.2 Sensors

Temperature Sensor

LM35

For temperature sensing, an integrated circuit temperature sensor LM35 is used. The output voltage of the sensor is linearly proportional to the temperature (in Kelvin or Celsius) with the gradient of 10mV/°C and able to operate in the range of -55°C to 150°C. As the device is to be used in the tropical climate area where the temperature never drops below 0°C, the temperature range for this system has been offset to the range of 0°C to 80°C, using an op-amp.[1][3][4]

A temperature sensor is a device that gathers data concerning the temperature from a source and converts it to a form that can be understood either by an observer or another device. Temperature sensors come in many different forms and are used for a wide variety of purposes, from simple home use to extremely accurate and precise scientific use. The LM35 thus has an advantage over linear temperature sensors calibrated in° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. It also does not require any additional calibration or trimming in order to get typical accuracy. Low cost is assured by trimming and Calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60µA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a 55°to+150°C temperature range, while the LM35C is rated for a -40°to+110°C range(-10° with improved accuracy).[7][8][12][16]

DHT11

The Temperature and Relative Humidity Relative IC supplies digital equivalent of the temperature and relative humidity of the environment at a particular time upon demand from the microcontroller, however the data supplied is raw and not useful by human, hence the microcontroller processes it and manipulate it to give accurate and corresponding reading. The temperature is measure in Degree Celsius (°C) and Humidity is measured with respect to perfect vacuum (%RH). [6][10]

The DHT11 sensor provides the current temperature are humidity readings. The DHT11 gives out analog output and is connected to the analog input of the Arduino micro-controller A0. The dht11 sensor has 3 pins. Along with temperature and humidity the other values that are calculated or derived from the dht11 sensor is the dew point, heat index etc. The dew point is the temperature at which air in the atmosphere freezes to become water droplets and the heat index is the heat felt by the human skin from the environment.

This is important in places with high humidity. Even though the temperature maybe lower, the body still feels warm. This is due to the high humidity in the air. Humidity is the moisture content in the air. High humidity in the air generally makes one to sweat or perspire.[11]

Humidity

Relative humidity measurement is performed by the resistive-based humidity sensor, HSP15A from GE. The change in electrical impedance is inversely proportional to the relative humidity. This sensor can only be biased using AC voltage. Biasing with DC voltage can damage the sensor due to the electrolysis of the conductive polymer that causes polarization. Therefore, a pulse generator is used to drive the sensor, as shown in Figure 2, and the output of the sensor is rectified, using a rectifier circuit to obtain a DC voltage.[16]

SHT21 is digital humidity and temperature sensor from Sensirion. The SHT21 utilizes a capacitive sensor element to measure humidity, while the temperature is measured by a band gap sensor. Both sensors are seamlessly coupled to a 14-bit ADC, which then transmits digital data to the Arduino over the I2C protocol. Because of the sensor's tiny size, it has incredibly low power consumption, making it suited for virtually any application.

Atmospheric Pressure

MPX4115A

For pressure measurement, the barometric pressure sensor, MPX4115A is employed. Its output voltage in the range of 0.2V to 4.8V is linearly translated into pressure measurement of 15kPa to 115kPa. This sensor is also temperature-compensated from -40°C to 125°C, thus suitable to be used with this system.[16]

BMP085

We are using barometric digital pressure sensor BMP085 which calculates pressure and temperature with great accuracy. The BMP085 is based on piezo-resistive technology for EMC robustness, high accuracy and linearity as well as long term stability. Robert Bosch is world market leader for pressure sensors in automotive applications. Based on experience of over 200 million pressure sensors in the field, the BMP085 continues a new generation of micro-machined pressure sensors.[10]

BMP180

Bmp180 sensor is used to measure the atmospheric pressure and the temperature as well. The atmospheric pressure is used to determine the relative air pressure experienced in the surrounding. This is very useful if we are using the system in high altitude environment and a calibrated value of the altitude along with other environmental readings provides a good projection of the surroundings weather pattern and we can notice changes with increase or decrease in altitude.[11]

Light Intensity

Light Dependent Resistor (LDR)

Materials used as the semiconductor substrate include, lead Sulphide (PbS), Lead Selenide (PbSe), indium antimony(InSb) which detect light in the infra-red range with the most commonly used of all photoresistive light sensors being Cadmium Sulphide (Cds). Cadmium sulphide is used in the manufacture of photoconductive cells because its spectral response curve closely matches that of the human eye and can even be controlled using a simple torch as a light source. Typically then, it has a peak sensitivity wavelength (λp) of about 560nm to 600nm in the visible spectral range. The net effect is an improvement in its conductivity with a decrease in resistance for an increase in illumination. Also, photoresistive cells have a long response time requiring many seconds to respond to a change in the light intensity.

Wind Speed and Direction

Wind speed propeller

Mechanical measurements of wind speed in the form of a propeller comprising 3 fruit bowl mounted on the radius centered on the vertical axis or all of the bowl is mounted on a vertical axis. Entire bowl facing a circumferential direction so that when the wind blows the rotor rotates on a fixed direction. Rotational speed of the rotor depends on wind speed. Plate sensor is a device used to sense the speed of rotary vane bowl. The focal point of the sensor plate and the center of the propeller bowls connected by a shaft, so that the disk rotation speed same as the rotational speed sensor vane bowl. Form of sensor plate is fitted with a propeller. Photointterupter output signal pulses which are formed photo-intterupter light emitters due to the cut due to the holes encoder disc. Optocoupler output signal of the voltage pulses will not be stabilized through the gate so that the output voltage reaches 5V TTL level. To dole 74ls04 and optocoupler IC used positive voltage regulator with input voltage of 12V 7805 generates 5V output voltage. Capacitors used for voltage stabilizer. R1 is used to limit the current to the optocoupler emitter while a pull-up resistor R2.[4]

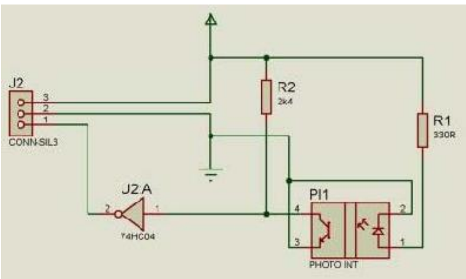

Fig 3.2 Circuit Schematic of optocoupler

Anemometer

A three cup anemometer assembly is used to calculate the wind speed by calculating the rotation per minute of the anemometer cups symmetry, with the help of a reed switch and a magnet. With each rotation the switch closes and opens for a single time. As shown in Fig.3.3 a magnet is placed on the shaft of rotating cup symmetry which rotates with the rotation of cups. As the magnet passes the reed switch while rotating, the switch toggles twice.[10]

Fig 3.3 Wind speed meter(Anemometer)

Wind vane sensor

Here we are using a potentiometer based wind vane mechanism for calculating the direction from which the wind is coming towards the station. The minimum angle of the wind vane sensor we are using here is 220 - 230, which is sufficient. We can also increase the resolution of the wind vane sensor if desired.[10]

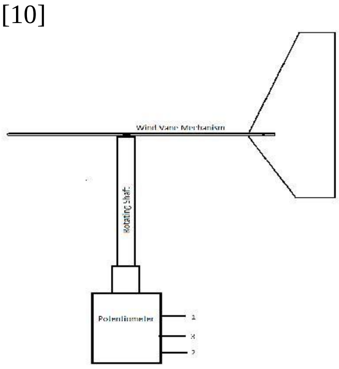

Fig 3.4 Wind vane sensor

Table 3.3 Modern Approach

Parameters	**Techniques/sensor used**		
Temperature	LM35 [1][3][4][6] [7][8][12]	RTD [5]	DHT11 [6][10]
Range	-55^0C to $+150^0$C	0^0C to 100^0C	0^0C to 80^0C
Accuracy	0.5^0C at 25^0C	+-1.5^0C	+-1^0C
Humidity	HSP15A[16]	DHT11[6][10]	
Range	20% - 80%	20% - 80%	
Accuracy	+-5%	+-2%	
Pressure	MPX4115A[16]	BMP085[10]	BMP180 [15]
Range	15kPa- 1115kPa	15kPa-1115kPa	15kPa-1115kPa
Accuracy	+-1kPa	+-1kPa	+-1kPa
Wind Speed	Anemometer[10]		
Range	1m/sec-74m/sec		
Wind Direction	Wind vane Potentiometer		
Wireless	GSM[5][6][12]	RFKYL1020 [4]	Zigbee Module [1]
Wired	USB Interface[1]		

IV. Conclusion

Wireless weather monitoring system is reliable and efficient system for efficiently monitor the weather parameters. Wireless monitoring reduces human power as well as gives accurate changes in it. It is cheaper in cost compare to wired system. The digital sensors are more accurate and reliable than analog sensor. Wireless system has benefits over the wired system. This system is less power and less time consuming.

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