HANDHELD MEASURING DEVICE FOR MULTIPLE PARAMETERS, IN WOOD AND CERAMIC INDUSTRIES

Godavarthi.SS Prasad[1], Dr. I. Santi Prabha[2], M. Venkateswara Rao[3].

[1]ECE, JNTUK, A.P, INDIA, ***prasadgss.eie@gmail.com***
[2]Professor, ECE, JNTUK, A.P, INDIA, ***santiprabha@yahoo.com***
[3]Associate Professor, BME, OU, A.P, INDIA, ***mekavrao@gmail.com***

Abstract

Development, testing, Validation of a battery operated low power consumption, highly reliable hand held device for measuring various important parameters such as Temperature, humidity, Due point, Equilibrium moisture content(EMC), Depth measurement, and finally hazardous gas alarm for wood and ceramic industry is addressed in this paper. To measure the basic parameters (Temperature, Humidity, and depth measurement) different independent sensors are considered. To measure due point and EMC values the temperature and humidity values are considered and by using the standard set of equations these values are deduced. In wood and ceramic industries, highly inflammable gases can be presented in the environment, due to pigments and process itself, which need to be identified and if the levels are above the tolerable limits an alarm need to be provided to take necessary precautions, to avoid major accidents. In the developed model a gas sensor is provided to monitor the inflammable/ methane gas concentration. The design includes a micro controller with built in ADC and the developed program obtains these values and by performing necessary calculations the specified parameters are displayed on the LCD.

Keywords: *PIC micro controller and display system, IC temperature sensor, Humidity sensor, MEMS based gas sensor, due point, EMC value, Doppler based distance measurement, prototype testing/validation.*

----------***----------

1. INTRODUCTION

The highly demanding and complex measuring tasks of today can only be mastered with high-precision devices. The special requirements placed on hand-held measuring devices are the result of the spectrum of physical measurements that are to be measured, as well as the decisions that are based on this measured data. In the present work, only the timber and ceramic industry requirements are considered. The parameters that are considered for measurement include temperature, humidity, due point and EMC values. The distance measurements are necessary in all the industries, and thus the distance measurement is considered. In industries, frequent fire accidents can take place, these fire accidents can be averted by monitoring the inflammable gases. In the present project a gas sensor is used to provide an alarm, if the concentration exceeds the permissible limits.

2. TEMPERATURE

Temperature is the most often-measured environmental quantity. This might be expected since timber quality and the ceramic quality are affected by temperature, greatly. Some processes work well only within a narrow range of temperatures and certain chemical reactions are efficient at specified temperatures. In industries also it is required to monitor the temperature of the environment and also the processing temperature of ceramic products. Several temperature sensing techniques are currently in widespread usage. The most common of these are RTDs, thermocouples, thermistors, and sensor ICs. The right one for the specified application depends on the required temperature range, linearity, accuracy, cost, features, and ease of designing the necessary support circuitry. The hand held device is able to measure the temperature in the range of 0^0C to 100^0C, which can cover most of the specified applications. The RTDs, thermocouples and thermistors require a special calibration circuit and need to be tuned accurately. The IC temperature sensors are having a range of advantages and thus considered for the present application. Though several manufacturers are providing IC temperature sensors, the National semiconductors LM35 is considered for this application.

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. 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. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. 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 positive and negative supplies. As it draws only 60 μA 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).

3. HUMIDITY

Humidity is the water vapor contained in the air at a particular temperature. The measurement of the quantity of water vapor is made using different types of devices such as wet and dry bulb, hair or cellulose hygrometers, thin-film capacitance hygrometers, and relative-humidity (RH) sensors.

Humidity sensors have gained increasing applications in industrial processing and environmental control. For manufacturing highly sophisticated integrated circuits in semiconductor industry, humidity or moisture levels are constantly monitored. In medical field, humidity sensors are used in respiratory equipment, sterilizers, incubators, pharmaceutical processing, and biological products. In timber and ceramic industries, the final product quality is dependent on environmental humidity. The humidity sensors are used for humidity control in dryers, ovens, film desiccation, wood and ceramic production.

The humidity can be measured using different type of transducers and each one is having its own advantages and disadvantages. In the present work a humidity sensor using hygroscopic crystal is used, which provides a resistance variation at its terminals. This resistance variation is converted into voltage variation and is applied to the microcontroller as an analog signal.

4. DEW POINT

Dew point is the point at which the atmosphere can no longer hold the water vapor in it and is converted into droplets of water. Humidity records 100% at the dew point. The temperature at this point is called dew point temperature. It can never be higher than the atmospheric temperature. When these two quantities are equal, the atmosphere, which gets saturated, holds higher amounts of water vapor than in the normal case.

Most common methods to measure dew point are chilled mirror, metal oxide and polymer sensors. Chilled mirror method will offer highest accuracy. It will mostly used where the absolute accuracy is needed and frequent maintenance can be done. And it is more expensive. Metal oxide measurement is used in industries where low dew point measurement is a criterion. Metal oxide sensors, designed for low dew points can be damaged if they are exposed to high humidity. Polymer sensors are widely used in industries and meteorology. It has long time stability.

But, all these methods are not required to measure it. One can also calculate it by using temperature and relative humidity. So, to reduce the complexity in the device circuitry, we used temperature and humidity sensors to calculate dew point without incorporating a separate sensor to calculate it.

Formula to calculate Dew Point (T_p):

$$T_d = \frac{b\left[\ln\left(\frac{RH}{100}\right) + \frac{aT}{b+T}\right]}{a - \ln\left(\frac{RH}{100}\right) - \frac{aT}{b+T}}$$

Where:
a = 17.271; b = 237.7
T is in ºC; Td is in ºC; RH is in %

Based on the August-Roche-Magnus approximation, considered valid for:

0 ºC < T < 60 ºC; 1% < RH < 100%; 0 ºC < Td < 50 ºC

5. EQUILIBRIUM MOISTURE CONTENT (EMC)

This measurement is mainly meant for timber industry. The moisture content of wood below the fiber saturation point depends on the relative humidity and temperature of the surrounding air. If wood remains long enough in air where the temperature and relative humidity are constant, the moisture content also becomes constant at a value known as Equilibrium Moisture Constant (EMC). The number of water molecules (bound water) increase or decrease so that the vapor pressure of the wood is in equilibrium with that of the air surrounding it. The particular value of moisture content which is in equilibrium with a given relative humidity/temperature combination is EMC. The EMC at a constant temperature will increase as the relative humidity of the surrounding air increases and decreases with decreasing relative humidity. The relationship between EMC, relative humidity and temperature is shown in the equation:

$$EMC = \frac{1800}{W}\left[\frac{Kh}{1-Kh} + \frac{K_1Kh+2K_1K_2K^2h^2}{1+K_1Kh+K_1K_2K^2h^2}\right]$$

EMC is moisture content in percent, and *h* is the fractional relative humidity.
For temperature *T* in Celsius degrees

$W = 349 + 1.29\ T + 0.0135\ T^2$
$K = 0.805 + 0.000736\ T - 0.0000073\ T^2$
$K_1 = 6.27 - 0.00938\ T - 0.000303\ T^2$
$K_2 = 1.91 + 0.0407\ T - 0.00093\ T^2$

6. DISTANCE MEASUREMENT

In industry it is required to measure the distance between two points or the depth of tank, etc. In all these cases it may not be possible to use sensors which can be in contact with the environment. In such cases an ultrasonic or IR echo based sensors are preferred. In the present application an ultrasonic sensor is used for this purpose.

In the sensor circuit there is a pulse generation circuit, which is applied to a piezo electric horn, which transmits the ultrasonic waves. When these waves encounter any obstruction, the waves are reflected back and are received by another piezoelectric sensor mounted adjacent to the transmitting sensor. The received signal is processed and applied to the micro controller. The time gap between the transmitting and the reflected echo is proportional to the distance of the obstructing object.

The micro controller receives both the transmitted pulse and the reflected echo and the time gap between the two pulses is measured. This time gap is converted into distance by processing the time gap, as one knows the velocity of sound waves in the air. This result is displayed on the LCD.

7. COMPLETE UNIT

The total block diagram of the system is shown in the Fig. 1. The Temperature sensor, i.e., LM35 and the humidity sensor outputs are fed to the micro controller as analog signals. The ultrasonic distance pulses are also applied to the micro controller as inputs. A selection switch is provided to select the desired parameter to be measured. The measured quantity is displayed on the LCD. The entire system is built around the PIC micro controller 18F452. Even the Dew point and the EMC values are calculated from the readings taken from the temperature and humidity sensors.

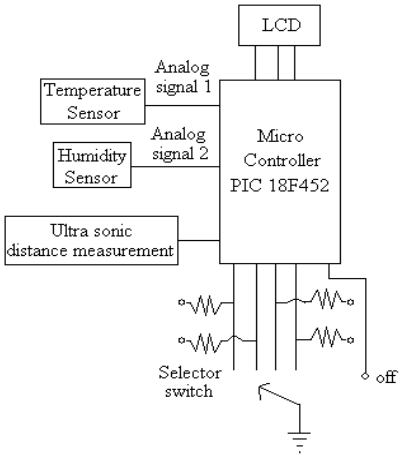

Fig.1. Block Diagram of the hand held device

From these parameters in industry it is required to monitor the environment for combustible gases, if any. This happens due to accidental apart leakages. It is potentially hazardous because explosion accidents might be caused when it leak out accidentally or by mistake. So the detection of it in industrial environment is needed. At present, more attention have been focused on the detecting of LPG, such as Fe_2O_3 gas sensor by doping with Ag_2O and modifying with the Al_2O_3 surface-coat doping with Pt; $ZnGa_2O_4$ based sensing element; $MgFe_2O_4$ and $CdFe_2O_4$; tin film with composition of ruthenium in the tin oxide matrix showed unusual high sensitivity for LPG; Ni1-xCoxMnxFe_2-xO_4 nano-particles with 10-15nm size showed highly sensitive and selective to LPG, etc.

Such sensors are readily available in the market, and in the present application, one such sensor is used, to make the hand held device a complete unit. This sensor output is directly applied to the comparator driving a piezo electric buzzer. The circuit diagram of the gas sensor setup is shown in fig2. The comparator reference voltage can be adjusted to suit the individual requirements of the industry. The gas sensor is always ON and is no way connected to the micro controller circuit and is fully independent.

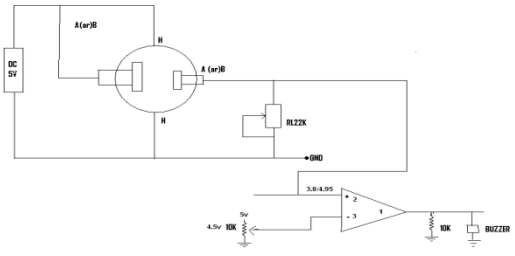

Fig.2. Gas sensor circuit

CONCLUSIONS

The developed product is a customized application, which can be used in timber, Paper and Porcelain tile industries. The unit can be further improvised by adding other applications specific to these industries.

REFERENCES

[1] M. Kunze, H. Glosch, B. Ehrbrecht, S. Billat, S. Messner, M. Ashauer and R. Zengerle "THERMAL DEWPOINT SENSING: A NEW APPROACH FOR DEWPOINT DETECTION AND HUMIDITY SENSING" MEMS 2007, Kobe, Japan, 21-25 January 2007.
[2] Liu Xuanchao, Liu Xiaolong "The Research on Intelligent Humidity Measurement System" 2010 Second International Conference on Information Technology and Computer Science, IEEE Computer society.
[3] Kalyan Phani Tangirala, J. Robert Heath, and Arthur Radun "A Handheld Programmable-Logic-Device-Based Temperature and Relative-Humidity Sensor, Processor, and Display System Platform for Automation and Control of Industry Processes" IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 46, NO. 4, JULY/AUGUST 2010.

BIOGRAPHIES

Godavarthi S S Prasad was born in andhrapradesh, india, in 1989. He received the bachelor degree from poundicherry university, Pondicherry, india, in 2010. He is currently working towards the masters degree from JNTUK University, andhrapradesh, india.

Dr.I.Santi Prabha was born in india. She received Ph.D degree. In 1985, she joined JNTUK, AP. India, where she is currently professor in the Electronics and communication department and also working as a director of center for empowerment of women and grievances.

M.venkateswara Rao M.Tech, Assoc. prof. Department of BME, UCE(A), Osmania University, Hyderabad.