ISSN : 2230-7109 (Online) | ISSN : 2230-9543 (Print)

Soil Testing and Analyzing using AVR Microcontroller

[1]Mohammad Junaid Khan, [2]Rashid Mustafa
[1]Dept. of ECE, SIET, Bilaspur, HP, India
[2]Dept. of ECE, SDDIE, Barwala, KU, Haryana, India

Abstract
In this paper, Agriculture refers to the production of food and goods through farming. In India has a very long history dating back to ten thousand years. Presently, about two-third of the Indian population depends directly on agriculture for its livelihood. Agriculture productivity mainly depends on quality of soil which is dependent on the plentiful factors like soil texture, soil water holding capacity, soil pH value, soil conductivity and soil mineral contents. Soil pH, Fertilizer and conductivity give a lot of information about the physical and chemical properties of soil. In this work, a microcontroller based system is developed to measure these three properties of soil (soil pH and Fertilizer and Conductivity/ Salinity) which in turn effect the plant's growth. The signals from the sensors are conditioned with the help signal conditioning cards and interfaced to microcontroller through inbuilt ADC. Digital readout is used to display the computed results in LCD.

Keywords
Soil pH and Fertilizer, Soil Conductivity, Soil Salinity

I. Introduction

The detection of the fertilizer (Nitrate and Chlorine), soil pH, soil conductivity and soil salinity content in soils is important because it can provide information about Fertilization by Soil testing and pollution by nitrate Fertilizers. It is faced with a crucial challenge of excessive Fertilization in decreasing cultivated lands. An important solution excessive Fertilization is to soil testing for formulated fertilization. Soil nutrient testing is the basis for nutrient commendation and site-specific fertilization. Conventional soil nutrient detection methods are time consuming and expensive. Rapid lower-cost detection methods for soil nutrient are urgently needed. The ion selective e1ectrode is a new and active branch in the potentiometry field in recent thirty years. Because of its special advantages, such as easy, rapid, fitful to analysis on the spot and not ruin the water sample. The technology provides efficient method for resolving some difficult problems in precision agriculture field. It is compared with a reference electrode, is linear to the change of the ionic activity (in logarithmic units) of the target ion [1-2]. discussed that soil has a very important role in the life of plants/ crops. Soil provides water and nutrients in the form of soluble salts for the growth of plants. Roots of plants absorb water and nutrients from soil and then they are passed to all the other parts of plants like stem, leaves. Different plants/crops required different types of environmental condition, soil characteristics, and nutrients e.g. some plants/crops may require the acidic soil while some may have the requirement of alkaline soil. In heavy rainfall region, the conductivity of soil may be less than in the areas of low rainfall due to the leaching of soil which may results in the leaching away of essential plant nutrients.

II. pH /Redox Electrode

In simple terms, an acid is defined as a substance that tends to releases hydrogen ions (H^+). Conversely, a base is defined as a substance that releases hydroxyl ions (OH^-). All acids cotain hydrogen ions and the strength of the acid depends on the degrees ionization (Release of hydrogen ions) of the acid. Some acids are strong acids because they are highly ionized (Release of H ions) when dissolved in solution. Examples of strong acids are HCl, H_2SO_4 and HNO_3. Other acids are weak acids because they slowly ionize (release H ions). Examples of weak acids are H_2CO_3, $H_8C_6O_7$.when clay colloids are saturated by H ions, they behave as a weak acid. Such as all bases contain hydroxyl ions and the strength of the base depends on the degrees ionizations (Release of hydroxyl ions) of the base. Some bases are strong because they are highly ionized (release hydroxyl ions). Example of strong base is NaOH. The pH of a soil is among the most important soil characteristics for crop production. The pH of the soil is a measure of the activity of hydrogen (H^+) ions in the soil solution usually obtained by shaking soil with distilled water. The pH is the unit to define the nature if aqueous solutions as acidic, neutral or alkaline on a scale of 0-14. Mathematically pH is negative logarithm of the Hydrogen ion concentration [8]. The pH values for acids and bases. pH value of 7 represents neutral solution.

Formula of measuring value of

$pH = -\log[H^+]$

Soil pH is the pH of soil solution. Soils are both acidic and alkaline. Measurement of soil pH gives information about the availability and deficiency of nutrients which in turn determine the application of fertilizers, treatment to be given to soil in order to alter the soil pH in order to favour the crop growth and activity of microorganism in soil i.e. soil life. Fig. 1, illustrates the relationship between soil ph and the availability of various soil nutrients.

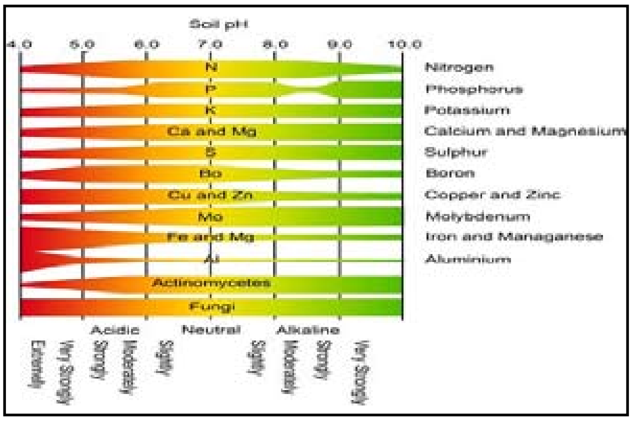

Fig. 1: Availability of nutrient with respect to soil pH

Most important range of soil pH is 6 – 7. In this range of soil pH most of the plant nutrients are easily available for plant uptake and concentration of elements which becomes toxic at higher concentration is hindered. Knowledge of soil pH helps in the application of fertilizers. Ammonium forming fertilizers like urea decreases soil pH while nitrate sources carry basic ions and are less acid forming fertilizers. Elements like Calcium Potassium cause almost no change in soil pH and no any effect in the soil. Soils contain water soluble salts. Plants absorb nutrient in the form of soluble salts. Salts are present in the soil as ions. Ions are transported to soil through decomposition of minerals in soil, irrigation water, fertilizers or they may migrate upward in the soil from underground water. But when the rainfall is insufficient to leach away the salts from soil or drainage system is poor, salts

 ISSN : 2230-7109 (Online) | ISSN : 2230-9543 (Print)

accumulates in the soil and this excessive accumulation of salts is called soil salinity. High soil salinity has negative effect on plant growth. The main affect of soil salinity is osmotic effect. This means that high salts increases the energy with which water is held in the soil. This reduces the amount of available water in the soil for plant growth. Thus the soil must be kept wetter to provide same amount of water to plant as would be without salts. Excessive accumulation of salts on the surface of soil also results in the loss of soil.

III. Measurement of Soil pH Value

[3-5] discussed the pH sensor and its characteristic. Soil pH is measured from soil solution using pH electrode. pH electrode has output in mill-volts depending upon the pH value. pH electrode basically measures the hydrogen ion [H^+] activity. Measurement of pH with pH electrode is based on the principle that potential is developed when two solutions of different ph comes in contact through a thin glass membrane.

Fig. 2, shows the main parts of pH electrode. pH electrode consists of glass electrode, reference electrode and metallic electrode [6]. pH is determined by measuring the potential between the two electrodes. At the tip of sensor there is a thin membrane capable of ion exchange. The pH sensitive glass membrane of electrodes has extremely low alkline error and low electrical resistance thus ensuring fast and accurate response. We can supply these electrode for pH range of and 0-14 and for temperature range of 0-1300C. electrode is available kcl filled versions and is supplied with one meter long cable and BNC plug. These electrode can be supplied with almost all makes of international and domestic meters. Ph electrode model CA-11 provide by toshniwal company. For neutral solutions i.e at pH of 7 the output of pH electrodes is 0mV when ideally. The sensitivity of pH electrode to the pH is 59.16mV/pH. By this Formula

mv = (7-pH) (54.2+t*0.2)

where, mv= Input voltage produced by pH probe,

pH= varing from 0-14,

t= temperature in degree Celsius

this calculation at room temperature.

Therefore giving a voltage of 414mV at pH of 0 (i.e. Strong Acids) and -414mVat pH of 14 (i.e. Strong Bases). Fig. 2, shows the output of pH electrode against the various pH values. The measurement of pH is sensitive to temperature. Fig. 3, shows the relation between pH and pH electrode output at different temperature.

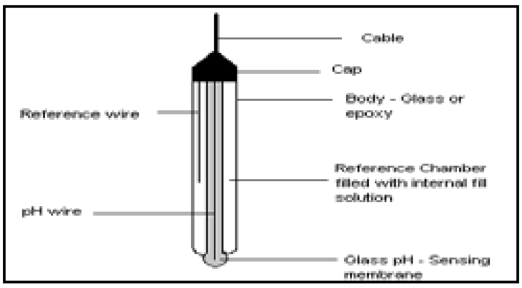

Fig. 2: Main Parts of pH Electrode

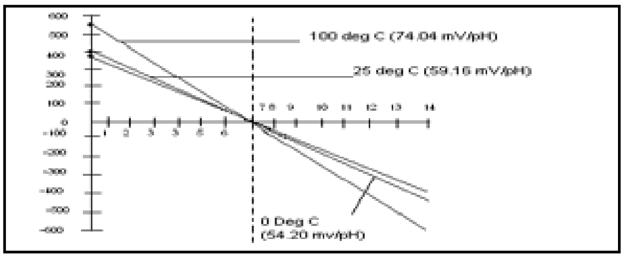

Fig. 3: pH Electrode Transfer Function

The output pH electrode is connected to microcontroller pin with BNC shoket. The signals generated by the sensors. The signals are send to adc of inbuilt AVR microcontroller. AVR microcontroller accepts the signals from computes the soil pH. AVR Microcontroller displays the three parameters of the soil on LCD .These parameters are used to interpret the properties or quality of soil, treatment to be given to soil to make it suitable for plant growth.

IV. Salinity/Conductivity of Soil

[3-7], discussed that soils contain numerous of water soluble salts. Ions are transported to soil through decomposition of minerals present in the soil, irrigation water, fertilizers or they may migrate upward in the soil from underground water. But when the rainfall is insufficient to leach away the salts from soil or drainage system is poor, the salts accumulate in the soil. If this condition prevails over a long period, the result is excessive concentration of salts in soil and this excessive concentration/accumulation of salts in soil is termed as soil salinity. High soil salinity has negative effect on plant growth. The main affect of soil salinity is osmotic effect. Different plants have different response to soil salinity. When soil salinity exceeds the plant's limit to handle salinity level, growth of plants is reduced. Excessive accumulation of salts on the surface of soil also results in the loss of soil permeability to air and water. Different plants have different response to soil salinity. Some plants are highly tolerant to soil salt concentration; some are moderately tolerant while some of the plants are very sensitive to soil salinity. They are able to absorb the water from soil with higher salt concentration in soil while salt sensitive plants have limited ability to adjust with soil salinity. The affect of salinity is less at emergence of plant as compared to mature plant. [4, 6], discussed the technique to measure the soil salinity. Salinity of soil is interpreted by measuring the conductivity of soil. In aqueous solutions the level of ionic strength varies from the low conductivity of ultra pure water to the high conductivity of concentrated chemical samples. Conductivity of soil is computed from the conductance of soil measured by the conductivity electrodes using a scale factor that reflects the ratio of length and cross-sectional area of the sampled water volume in which the electrical current actually flows. Conductance is reciprocal of resistance and basic unit of conductance is mhos or siemens(S). The other measurement units of conductivity are: deciSiemens per meter (dS/m).

MilliSiemens per centimeter (mS/cm).

millimho per centimeter (mmho/cm).

Table 1: Conversion Factors for Conductivity Units

To convert from:	To	Multiply by:
ec (µs/cm)	ds/m	0.001(divide by 1000)
ds/m	ec (µs/cm)	1000
ds/m	Ppm	640

[7] Provides the standard method of measuring the soil salinity/ conductivity. Soil extract is the solution containing water and soil in 2:1 ratio. Higher the concentration of ions higher is the conductivity. When water/soil extract in 2:1 is prepared, salt ions of soil dissolve in the water. The classification of soil as saline/ non saline with respect to the conductivity of soil extract is given in Table 2.

Table 2: Soil Salinity and its Effect

S.No.	Conductivity (mho/cm or ds/m) 2:1 Water/Soil Sample	Effect
1	<0.40	Non saline: salinity affect on plant growth is negligible.
2	0.40 – 0.80	Very slightly saline: the growth of very salt sensitive plants is reduced by 25% - 50%.
3	0.81 – 1.20	Moderately saline: the growth of salt sensitive plants is reduced by 25% - 50%.
4	1.21 – 1.60	Saline soils: the growth of salt tolerant plants possible.
5	1.61 – 3.20	Strongly saline: suitable for salt tolerant plants.
6	>3.2	Very strongly saline: only salt tolerant plants will grow.

V. Methods to Alter Soil Salinity

Excessive accumulation of salts in soil reduce the productivity of soil. In order to maintain the productivity of soil, it necessary to control the salinity of soil and maintaining it within limit such that it does not hamper the plant growth. The salt concentration in the soil is managed through leaching. Leaching is the process of applying the sufficient amount of water is applied to field such that it penetrates through the soil carrying with it a portion of accumulated salts. The frequency of leaching depends on the quality of irrigation water, Poorer the quality of irrigation water poor, the drainage system or lower the sensitivity of plants grown on field towards salinity, more frequently the leaching is to be done.

VI. Technique to Measure Conductivity

[8-10], discussed that conductivity sensor is well known as conductivity cell (fig. 4). Conductivity cell consists of two rectangular electrodes of well defined dimensions placed 1 cm distance apart. Fig. 5, shows the different parameters of conductivity cell. The parameter cell constant of conductivity cell is the used to convert the conductance measured by conductivity cell and shows fig. 6.

$$K = d/A$$

K = Cell constant or Cell factor.
d = Distance between the electrodes
A = Area of the electrodes

conductivity cell with cell constant of 1.155. Optimum conductivity ranges for cells of three different cell constants

Fig. 4: Conductivity Cell (K=1.155)

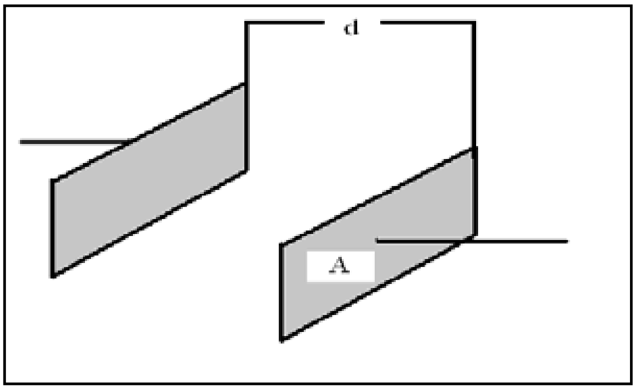

Fig. 5: Parameters of Conductivity Cell

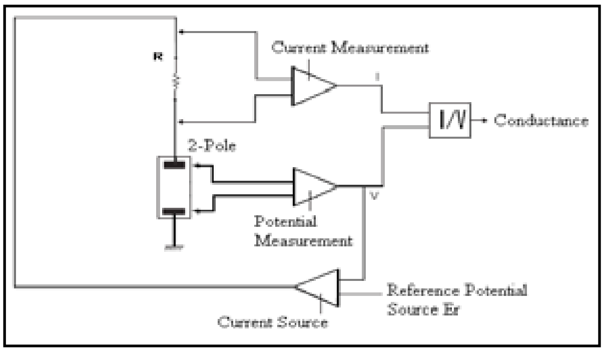

Fig. 6: Simplified Conductivity Meter

Conductivity of solutions cannot be measured by applying a D.C. signal to conductivity cell. Only sinusoidal ac or pulse signal is to be used be used. Because if the D.C signal is passed through the conductivity cell and dipped in the aqueous solution, it will rip the ions apart and a constant changing reading will be obtained. In the product conductivity sensor is interfaced to the microcontroller through the standard interfacing card with provides the ac excitation to the cell and generate a signal proportional to the conductivity of the solution. Measurement of Soil pH. The pH sensor is to be calibrated each time before measuring the pH of unknown solution. The pH 4, 7 and 9.2 are used. Most of the pH measuring systems are calibrated using the buffer solutions having pH of 7 and 9.2.

VII. Calibration of pH Sensor

For calibrating the pH sensor, two knobs are provided on the front panel. One marked as SET and other marked as SLOPE. After setting the system for the pH measurement by pressing the pH push button on the panel, the pH sensor is first place in the buffer solution of pH 7 and the displayed valued on the digital readout is set to 7 by rotating the SET knob clockwise or anticlockwise.

ISSN : 2230-7109 (Online) | ISSN : 2230-9543 (Print)

After that, sensor is placed in the buffer solution of pH 9.2 and the value displayed on digital readout is set to approximately 9.2 by rotating the SLOPE knob clockwise or anticlockwise. Now the system is ready to measure the pH of unknown solution.

VIII. pH Measurement of Soil Sample

After calibrating the pH sensor, the sensor is placed in the soil extract of each sample. The results of measurement for pH. The pH of tested soil samples lies between 8.0 and 8.6. The results of the measurement show that the pH of the selected field lies in the strongly alkaline region. pH characteristic of tested soil samples.

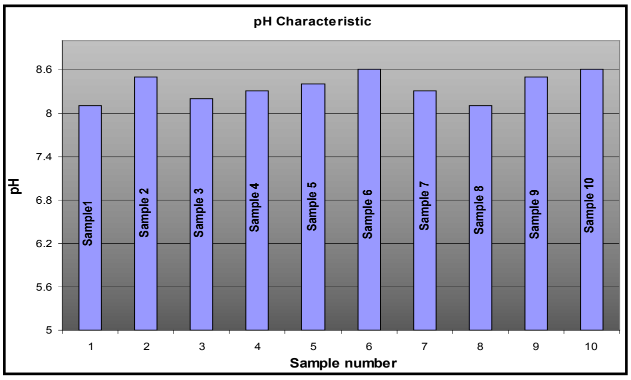

Fig. 7:

IX. Measurement of Soil Conductivity

Measurement of conductivity does not require any calibration before measurement. The conductivity cell is placed in the soil extract and the obtained reading on the digital readout is noted down. The results of measurement for conductivity. The pH of tested soil samples lies between 0.69 mS/cm and 0.76.mS/cm. The results of the measurement show that the conductivity of the selected field lies in the strongly alkaline region. Conductivity characteristic of tested soil samples.

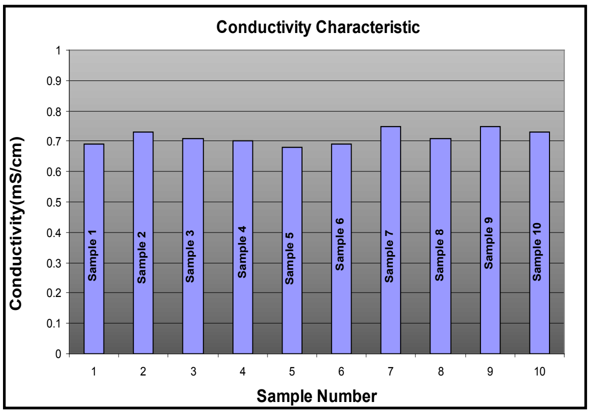

Fig. 8:

The system is build using Atmel's AVR series microcontroller ATmega16. ATmega16 microcontroller has in build ADC, the most important component used to interface any sensor to microcontroller because most of the sensors have analog output. Inbuilt ADC in ATmega16 reduces the hardware and makes the design compact.

X. Main Block Diagram

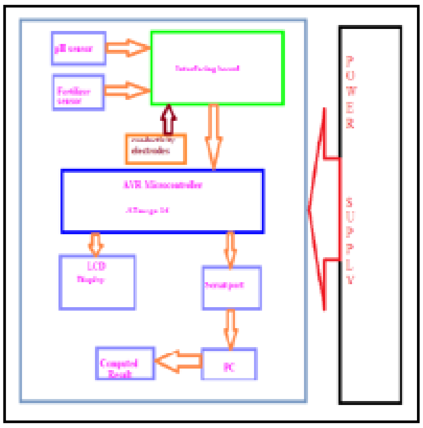

Fig. 9:

References

[1] B. Scott Jones, Shenai Krishna,"Subsurface Measurement Needs for Ecological, Hydrological and Agricultural Applications", 50th Midwest Symposium on Circuits and Systems, August 2007, pp. 754-757.

[2] K.F. Golson,"Spatial Distribution of Soil Physical Properties under Various Forested and Agricultural Land Use management Practices", IEEE International Geoscience and Remote Sensing Symposium, 2001, Vol. 5, pp. 2088-2090.

[3] J. John Barron, Colin, Ashton, Leo Geary,"Care maintenance and Fault Diagnosis of pH Electrode", Technical Service Department, Reagecon Diagnostics Limited, Ireland, TSP–02, Issue 2, 21 April 2005.

[4] Robert Bobby Grissco, Mark Alley, David Holshouser Wade Thomason,"Precision Farming Tools: Soil Electrical Conductivity", Virginia Tech, Virginia Cooperative Extension, September 2007, pp. 442–508.

[5] J. Nikos Warrence, W. James Bauder, Krista E. Pearson, "The Basics of Salinity and Sodicity Effects on Soil Physical Properties", Water Quality and Irrigation Management, Montana State University, June 2000.

[6] Tom Doerge,"Fitting Soil Electrical Conductivity Measurement into the Precision Farming Toolbox", Conference on Aglime and Pest Management, Madison, Wisconsin Fertilizer, WI, pp. 16-18, 2001.

[7] A. Robert Patterson,"Consideration of soil salinity when assessing the land application of effluent or greywater", Lanfax Laboratories, Technical Sheet Reference 1/6, 2006.

[8] National Instruments,"pH measurement tutorial", [Online] Avalable: http://www.zone.ni.com/devzone/cda/tut/p/id/2870

[9] J. John Barron, Colin Ashton,"The selection and Use of Instrument for Accurate Conductivity Measurement", Technical Service Department, Reagecon Diagnostics Limited, Ireland, TSP 04, Issue 1.

[10] Xiujun Li, C.M. Gerard Meijer,"A Low – Cost and Accurate Interface for Four Electrode Conductivity Sensor", IEEE Transactions on Instrumentation and Measurement, Vol. 54 Issue 6, December 2005, pp. 2433-2437.

Mohammad Junaid Khan wasborn in Madhay Pradesh, India, in 1987. I got 289 rank in PET in M.P. He earned B.E. Degree of Electronics and Communication Engineering From Govt. Engineering College Ujjain, Madhay pradesh, India in 2009. He is Qualified of GATE in 2009. He has been completed M.E. in Electronics & Communication Engineering from PEC, University of Technology chandigarh, India in 2011. Two research papers published in NCFAEE-11. He is currently working with Shiva Institute of Engineering and Technology, Chandpur, Distt. Bilaspur, Himachal Pradesh, India as Assistant Professor.

Rashid Mustafa received his B.Sc. degree in physics from B.N.D. College, C.S.J.M. University, Kanpur (U.P.), India in 2001, the M.Sc. Degree in Electronics from C.S.J.M. University, Kanpur (U.P.), India in 2004, and the M.Tech. degree in Instrumentation from PU, Chandigarh,India 2010. He is working as assistant professor, with Department of ECE, SDDIE, Barwala, Kurukshetra University. His research interests include digital signal processing, electronic measurement techniques,Embedded System.