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Determination of Moisture Content of Soil Using Microwaves

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Abstract: **This paper presents a compact and low cost rectangular patch antenna that was used as a sensor for real time agriculture measurements, industry. The microstrip patch antenna is designed to operate at microwave frequency 2.45GHz on FR4 substrate with 1.57mm thickness. The radiation loss due to water molecules in the soil sample will be proportional to the moisture content in it. Many types of moisture measurement methods are used such as oven drying method, neutron probe method etc. These methods are very cheap and easy to use but there are some drawbacks they are more time consuming as well as energy consuming . To resolve these problems microstrip patch antenna is used to determine the moisture content of soil. In this method microwaves are incident on soil sample on one side and received signal is measured at other side. if the moisture content in the soil is more then signal will be attenuated As we increased water, the received voltage will be decreases. This shows that the electromagnetic radiation gets affected by the water molecules and hence this principle can be used for many applications. One of them is measuring moisture content in soil.**

Keywords: **Soil Moisture Content, Patch Antenna, Printed Circuit Board, voltage controlled oscillator Microcontroller , Display.**

I. INTRODUCTION

Water contained in soil is called soil moisture. The water is held within the soil pores. Soil water is the major component of the soil in relation to plant growth. Hence, soil moisture content has quite significant influence on engineering [1], soil science,[2,3], geological, biological, industrial quality monitoring[4-6]. This paper aims to develop a sensor system which measures the amount of moisture in the given soil.

Furthermore, it has a major role to play as far as the plant growth, organization of the natural ecosystems and biodiversity [7] is concerned. Generally, the sensors used in monitoring the soil quality are based on the physical and chemical properties of the soil. The physical properties include color, texture, structure and moisture content in the soil [8]. Moisture content is a measure of the quantity of water in a product. Moisture content provides information about texture since increasing level of moisture provides water mobility[9].

Fig 1. Soil moisture measurement system using antenna

The determination of soil water content is important to improve growth and water efficiency in agriculture . Soil moisture content is also used as an important parameter for water balance studies, slope stability analysis and performance evaluation of various geotechnical structures such as pavements, foundations, earthen dams, retaining walls, compacted clay liners. [4,6, 10-12]. It plays a major role in casting industries also known as foundries. The sand casting method also known as molded casting, is used to produce the required objects. Here the sand is used as molding material. In this casting method sand is mixed with bonding agent usually clay is mixed. The mixture is moistened typically with water to develop strength and plasticity for molding. Maintaining the proper moisture levels when producing sand molds guarantees bonding takes place between materials to create the right cohesiveness, permeability, refractoriness, surface finish, flow ability, and chemical inertness. Without achieving these properties, the quality of castings becomes compromised [19].In this context, earlier researchers have developed several techniques for measuring the soil moisture viz., gravimetric [5,7,13], neutron scattering, oven drying method etc. However, these techniques are quite intricate, expensive, extensive calibration needed.

So in order to overcome all these hurdles the system uses microwave sensors. Microwave sensors emerged as effective tools for real-time, nondestructive, and continuous sensing of moisture content in a variety of materials [14–17]. Two rectangular patch sensors have been fabricated using micro strip feeding method and both patches were printed on low cost FR4 board. This two rectangular patch antenna are developed of which one is used as transmitter and another as receiver [18]. To measure the moisture content in the soil, given soil sample is placed between the Antennas. Transmitter antenna transmits the signal. The dielectric constant of water is higher than other materials, the power of transmitted signal decreases in proportion to the moisture content of the sample of soil. This attenuated signal is measured by detector, the control unit can instantly convert this signal into the direct moisture content in percentage which will be displayed.

II. LITERATURE REVIEW

- **Prof. Krishna Reddy:**

This paper presents oven drying method of moisture measurement, moisture content is expressed by ratio of weight of original sample to the weight of dry soil. Different soil samples are taken. This samples put into container. Measure weight of this sample and heated into oven. Heated sample are remove from the oven , so that no more water content are present. Then measure weight of these soil sample. By using formula , calculate moisture content. This is tedious method and it takes too much time.[8]

- **D. S. Chanas Yk and M. A. Naeth:**

Soil moisture measurements are critical to all field studies of soil-plant-water relationships. Dependable and reliable techniques are required to provide such measurements. Neutron probe technology was developed more than forty years ago (Belcher et al. 1950). Neutron probes consist of a probe and an electronic counting scale which are connected together by an electric cable , is made up of aluminum or steel radioactivelement source. Neutrons with a high energy are emitted by a radioactive source into the soil and are slowed by elastic collisions with nuclei of atoms. The average energy loss is much greater with neutrons colliding with atoms of low atomic weight than from collisions with heavier atoms. In soils, this is primarily hydrogen and, as a result, hydrogen can slow fast neutrons much more effectively than can any other element present in the soils. The density of the resultant cloud of slow neutrons is a function of the soil moisture content. Slow neutrons returning to the detector per unit time are counted. Results will be displayed. this method required extensive calibration and it has high cost.[9]

III. CONCEPT

Two rectangular patch antenna are designed at 2.45 GHz frequency using micro strip feeding method and both patches were fabricated on FR4 board. This two rectangular patch antenna are developed ,one is used as transmitter and another as receiver [18]. To measure the moisture content in the soil, given soil sample is placed between the antennas. Transmitter antenna transmits the signal After receiving signal at receiver it is measured by detector ,the control unit can instantly convert this signal into the direct moisture content in percentage which will be displayed.

In First step ,take dry soil sample put it on the device, then using touchpad give the START command. transmitting signal will be start and the signals will pass through the soil sample. after that signals will be received at the receiver end here

the received signal will be detected by the detector circuit. Then we can measure the weight of dry soil sample . In second step certain amount water will be mixed in dry soil. Now again we have to measure total weight of given sample. In third step, we make some calculations for determine the moisture content of soil, then moisture content will be displayed. The moisture will be displayed in proportion to the loss of the signal which is received .

Moisture content in soil sample, in terms of percentage was calculated by this formula,

$$\% \text{ m.c } = \frac{\text{Total wt.} - \text{weight of dry soil}}{\text{Total weight}} * 100$$

Where, m.c is moisture content in terms of percentage.

IV. BLOCK DIAGRAM

There are various components are used to determine moisture content of soil using microstrip patch antenna.

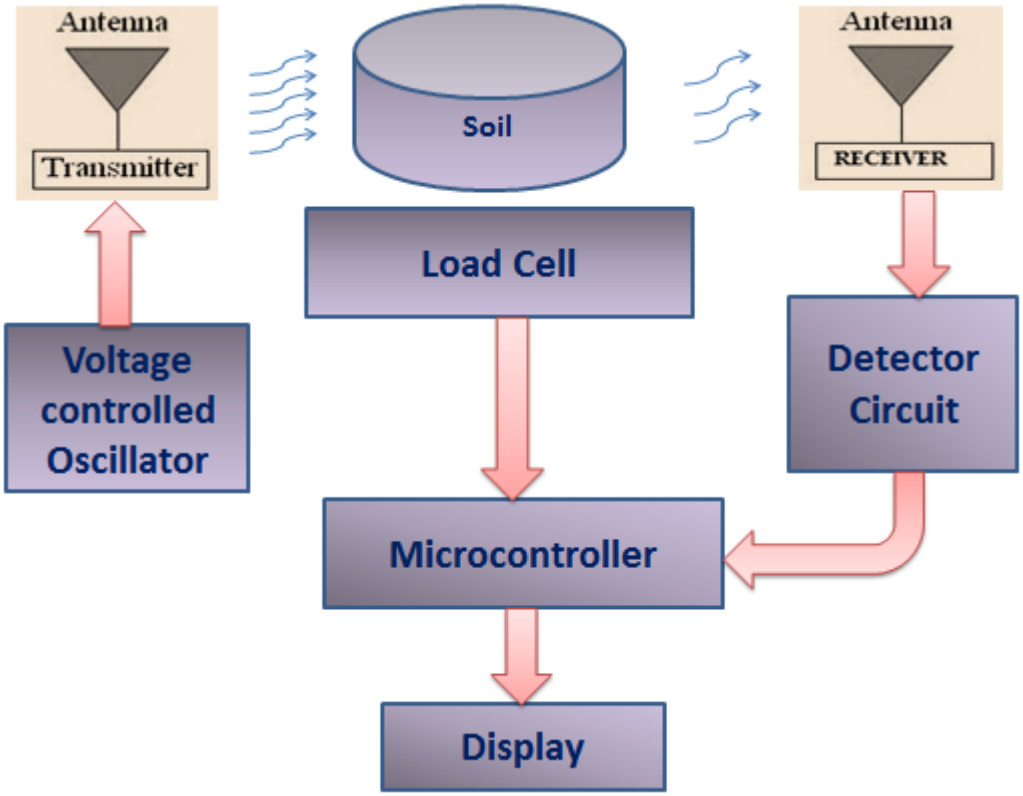


Figure 2: block diagram

The working of this circuit is as follows

Here design a transmitter circuitry which will radiate signals of 2.4GHz frequency. It will consist of a transmitting antenna and VCO. The radiated signal will be passed through soil to be examined. The results of system that whether soil is moist or dry, will depend on the power loss of input radiated signal. If there will be loss in power it means that attenuation of signal strength has taken place resulting in presence of moisture contents in that soil sample. Signal will pass through soil if there will be no moisture contents . The signals coming out from sample soil will be received at receiver. At receiver side there will be :

- Detector: will be made up of schottky diode which acts as half wave rectifier. Detector circuit also contains low pass filter whose cut-off frequency will be 15.9Hz. Output (V) of detector circuit will be given to microcontroller.
- Percentage of Moisture content will be calculated in microcontroller as well as measure the weight of soil from load cell placed below the sample soil.
- Display will show the results.

V. RESULTS

First case, take soil sample without adding water and measured weight and moisture. Due to dry soil voltage we get at output will be near about 520mv without any attenuation. Percentage of moisture content will be near about 0.

Fig 3. dry soil result

Second case Some amount of water will be mixed in dry soil. As we increase water content, percentage of moisture will be goes on increasing and voltage will be decreases due to attenuation.

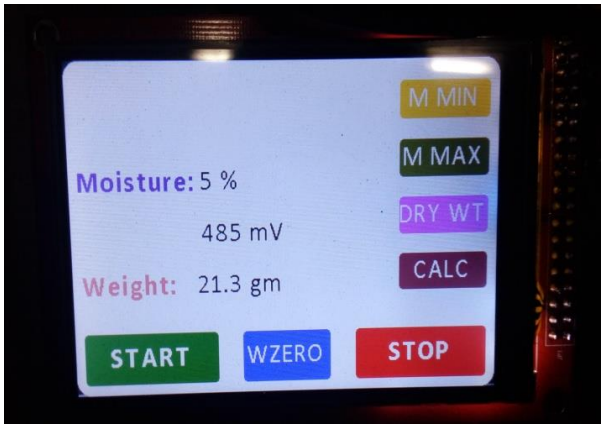


Fig 4. Result after 2mili water mixed in dry soil

Various samples are taken to measure the moisture content of soil.

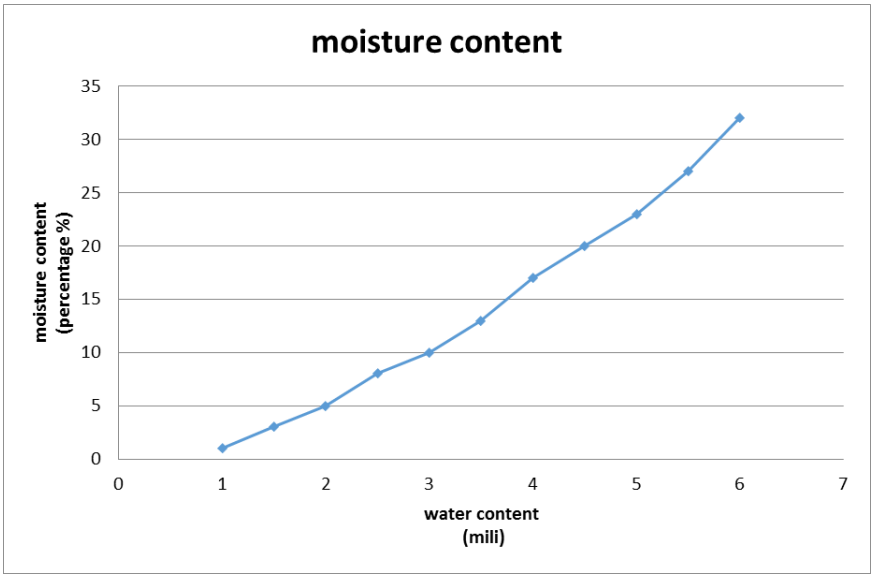
$$\%\ \text{m.c} = \frac{\text{Total wt.} - \text{weight of dry soil}}{\text{Total weight}} * 100$$

Where, m.c is moisture content in terms of percentage.

By using this formula, determined moisture content of soil for various samples which are shown in following table:

Table 1. various sample of soil

Sample no.	Water content (mili)	Dry soil weight (kg)	Total weight (kg)	Moisture content (percentage %)
1	1 ml	20.6	20.9	1
2	1.5 ml	20.5	21.2	3
3	2 ml	20.5	21.8	5
4	2.5 ml	20.5	22.3	8
5	3 ml	20.4	22.6	10
6	3.5 ml	20.5	23.5	13
7	4 ml	20.5	24.9	17
8	4.5 ml	20.5	25.6	20
9	5 ml	20.4	26.4	23
10	5.5 ml	20.4	28.2	27
11	6 ml	20.5	30.2	32



Above graph shows moisture content of soil. In this graph , X-axis indicates the water content in terms of mili (ml) and Y-axis indicates moisture content in terms percentage (%) When increase the water content into soil , also percentage of moisture will be increases.

VI. CONCLUSION

Irrigation is the biggest consumer of water, So farmers need to use water very carefully. Field can neither be under irrigated nor over irrigated. Accurate and appropriate moisture of soil is required for proper growth of plants and crops. Also, water is essential for survival of mankind, so this is required to be used with utter care and intelligence.

For this purpose the soil moisture measuring techniques can help them a lot. All the techniques have their own advantages and disadvantages. Comparing all techniques, it can be concluded that when one has to make a soil moisture system using antenna and embedded system, the soil moisture sensor is easy to interface. The microstrip patch antenna has been designed, tested and fabricated at desired frequency. comparing another techniques to determine moisture content of soil, optimum size of antenna is main parameters also durability ,low cost and accuracy are considerable parameters. So use of microstrip patch antenna is best method to give more accurate results. This system will overcome problems arriving in other moisture content measurement system as this method gives result in minimum fraction of time also this method is accurate and non-destructive.

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