

A Rectangular Microstrip Moisture Sensor Based on Microwave Measurement Technique

Sweety Jain¹, Pankaj Kumar Mishra², Vandana Vikas Thakare³

¹Department of Electronics, ²Department of Applied Physics, ³Department of Electronics

^{1,2}ASET, Amity University Gwalior M.P., ³MITS Gwalior M.P.

Email: ¹1502sweety@gmail.com

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Abstract: This paper propose a microstrip moisture sensor based on microwave measurement technique. Sensors with low insertion loss were developed to operate with a frequency range from 1 GHz to 3 GHz. The variations in percentage of moisture with magnitude and phase of transmission coefficient were investigated by using the different techniques.

Keywords: Moisture sensor, CST, Vector network analyzer, reflection coefficient, rectangular antenna.

1. INTRODUCTION

Because the moisture (water) content of cereal grains is the most important factor determining safe storage potential, and because it is important in determining market value, suitability for processing, and the quality of processed products, much effort has been devoted to development of rapid methods for moisture content determination. The electrical properties of grain are highly correlated with moisture content and have, therefore, provided the most practical means for sensing moisture with electrical instruments in the grain trade for more than seventy years. Early instruments were based on measurements of the dc conductivity of grain as it passed between crushing rollers, but for at least the past 50 years, electronic instruments that sense the dielectric properties of grain have been the dominant type of moisture meters used at the grain elevators and grading stations in the United States and many other countries [1].

In the last few decades, microstrip antennas have become very important in microwave areas as well as useful for moisture sensor which is detect of soil moisture, fruit moisture etc [2].

The microstrip moisture sensor also find the dielectric properties, which is useful for dielectric properties of the material, The principle of the sensor is based on measuring reflection of the mature fields in the far field region from the sample interface. The design controlled dual frequency moisture meter is developed for special applications, where the water content of various lossy liquids and food products is an important process parameter.

The different types of the techniques have been used such as Transmission/ Reflection techniques, Cavity resonator techniques, Slotted line techniques, Free-space techniques etc.

In all the method, the preparation of the sample usually take much more time than the actual process of measurement but in the free space technique will eliminate the primary step of preparing the sample before measurements. It results in saving the time for measurements besides this increase in speed and simplicity the advantages were that there are no errors. It was used for measure the dielectric properties of moist popular materials at microwave frequencies. It was very useful in terms of non-destructive and non-contact measurement of the moisture content [3-4].

Microstrip antennas have used widespread application in recent years due to their compact, adaptable size, inexpensive printed circuited board technology, and ease of integration with related electronics.

The quality of rice, moisture content & broken rice percent can be determined by microstrip patch sensor. The moisture levels were measured by the sensors based on resonance frequency & discussed the moisture content and relative complex permittivity measurements. In addition, applications in present-day mobile communication systems usually require smaller antenna size in order to meet the miniaturization requirements of mobile units.

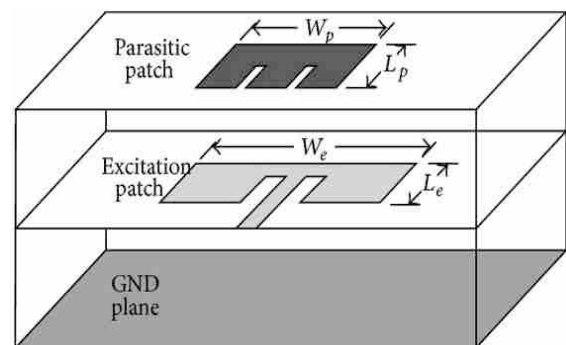


Figure 1: Microstrip Patch Antenna

2. PRINCIPLE OF OPERATION

Feeding techniques is used to supply the signal sources to microstrip patch sensor. Two types of the feed techniques are

contacting method and non-contacting method. Firstly if we talk about the contacting method, The RF Power is fed directly to the radiating patch using a connecting element such as micro strip lines. Contacting method is of two types microstrip feed line and co- axial probe feed In the other hand if we talk about the non contacting method, In the non-contacting method Electromagnetic field coupling is done to transfer power between the microstrip line & the radiating patch. Non-contacting methods are of two type's aperture coupled feed and Proximity coupled feed [5-6].

There are various factors that affect the performances of the micro strip patch antenna e.g. size of patch, feed point location and shapes of patch. The resonance frequency of the microstrip patches antenna change with dimension of microstrip patch. Thus the optimum dimension of patch and location of feeding point location must be first determined, in order to maintain its optimum performance using CST Microwave studio. [7-8]

• **For a rectangular microstrip patch antenna,**

The resonance frequency for any TMMN mode is given by:

$$f_0 = c/2(\epsilon_{\text{reff}})^{1/2}[(m/L)^2 + (n/W)^2]$$

Where, m and n are modes along L and W respectively.

• **For Effective Radiation,**

The width W is given by,

$$W = c/2f_0(\epsilon_r + 1/2)^{1/2}$$

The T- shape rectangular microstrip moisture sensor is designed for moisture measurement at design frequency between 1 GHz to 3 GHz. The sensor is etched using the substrate RT 5880 loss free with the dielectric constant ϵ_r . The other parameters patch are 15mm and 10mm, substrate thickness (h) the rectangular shape slotted on the patch 14mm and 6mm as shown in figure 2 and define the all parameters which is related to rectangular moisture sensor as well as define the different parameters. [9-20]

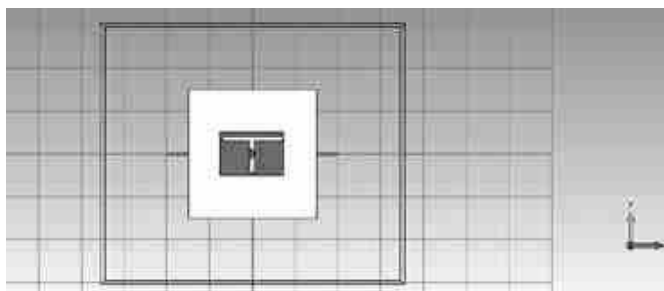


Figure 2: Rectangular microstrip moisture sensor at 2.8 GHz

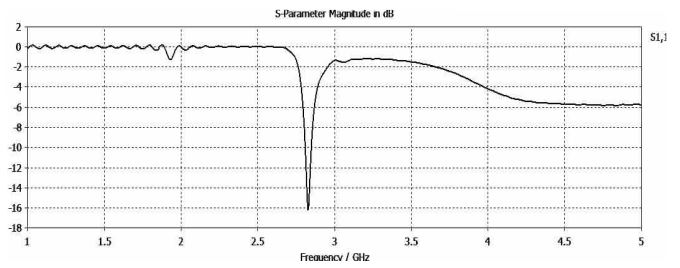


Figure 3: S parameter of Rectangular microstrip moisture sensor at 2.8 GHz

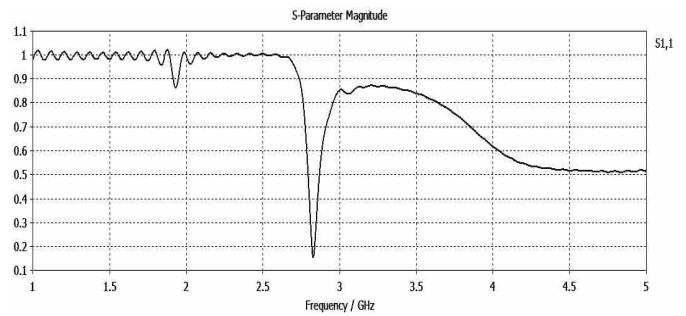


Figure 4: Magnitude of Rectangular microstrip moisture sensor at 2.8 GHz

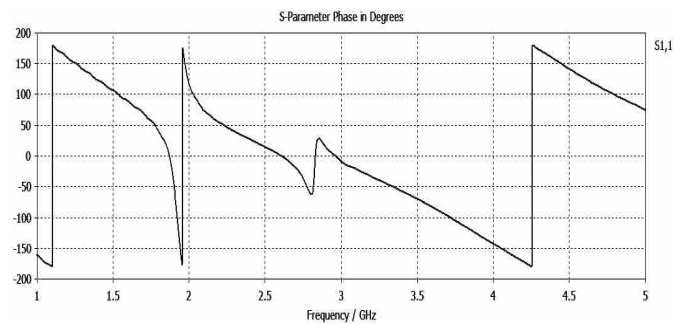


Figure 5: Phase of Rectangular microstrip moisture sensor at 2.8 GHz

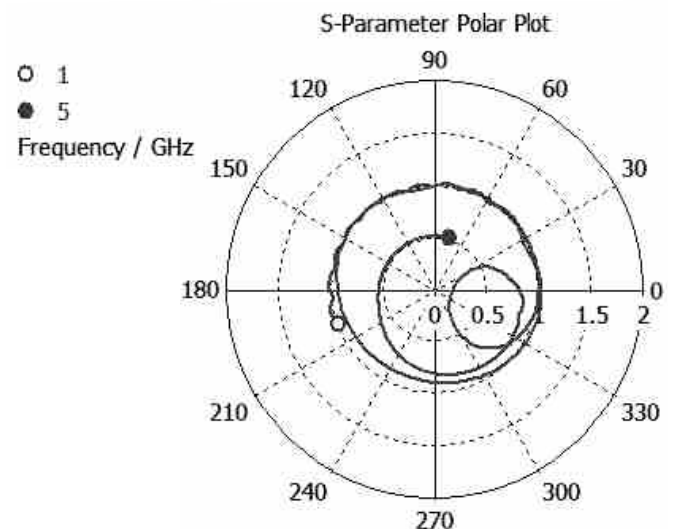


Figure 6: Polar plot of Rectangular microstrip moisture sensor at 2.8 GHz

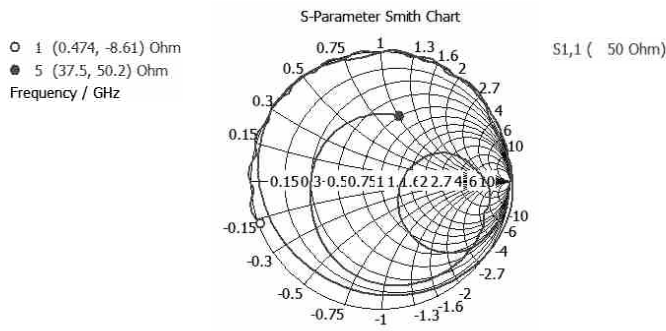


Figure 7: Smith chart of Rectangular microstrip moisture sensor at 2.8 GHz

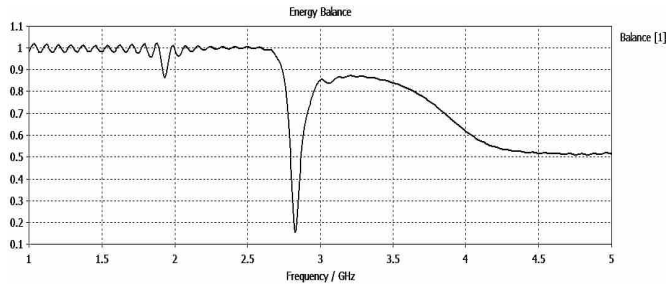


Figure 8: Energy Balance of Rectangular microstrip moisture sensor at 2.8 GHz

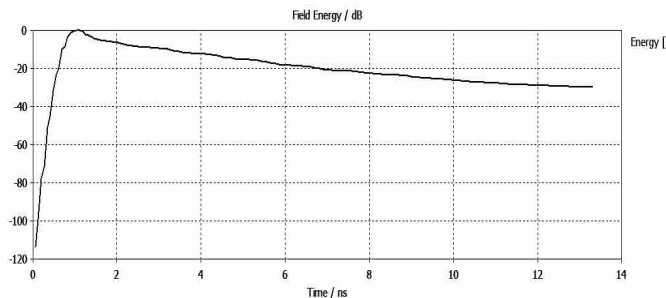


Figure 9: Field Energy of Rectangular microstrip moisture sensor at 2.8 GHz

The rectangular microstrip moisture sensor without T shape in the patch is designed for moisture measurement at design frequency between 1 GHz to 3 GHz. The sensor is etched using the substrate RT 5880 loss free with the dielectric constant ϵ_r . The other parameters patch are 15mm and 10mm, substrate thickness (h) the rectangular shape slotted on the patch 14mm and 6mm as shown in figure 2 and define the all parameters which is related to rectangular moisture sensor as well as define the different parameters.

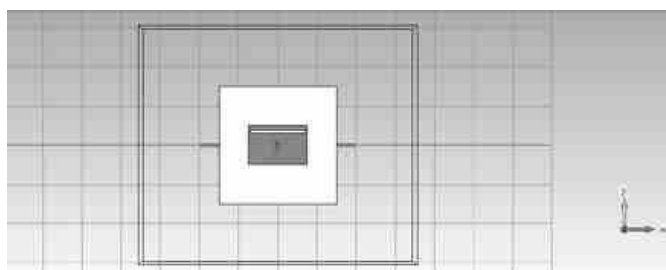


Figure 10: Rectangular microstrip moisture sensor at 2.8 GHz

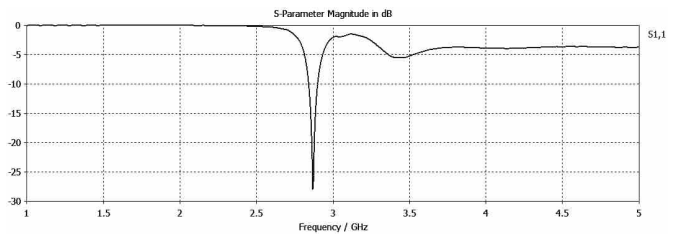


Figure 11: S-Parameter Rectangular microstrip moisture sensor at 2.8 GHz

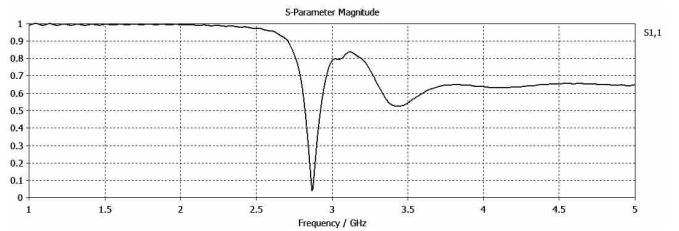


Figure 12: Magnitude of Rectangular microstrip moisture sensor at 2.8 GHz

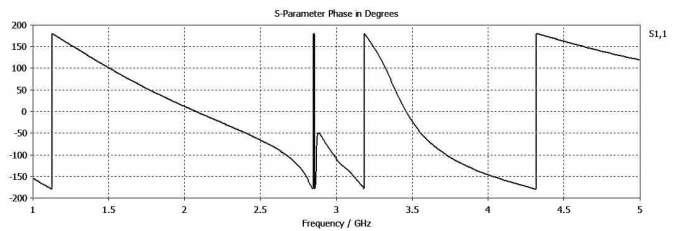


Figure 13: Phase of Rectangular microstrip moisture sensor at 2.8 GHz

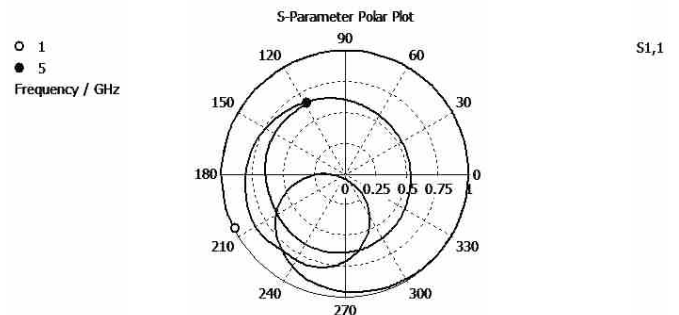


Figure 14: Polar Plot of Rectangular microstrip moisture sensor at 2.8 GHz

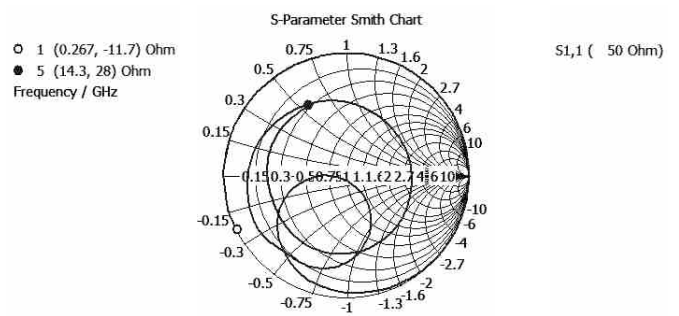


Figure 15: Smith Chart of Rectangular microstrip moisture sensor at 2.8 GHz

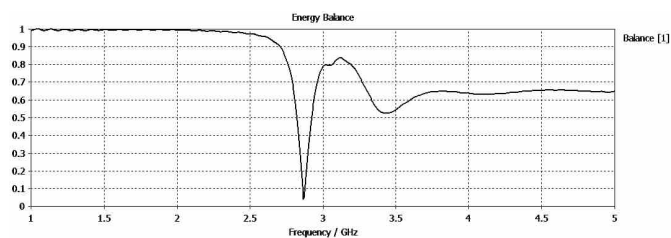


Figure 16: Energy Balance of Rectangular microstrip moisture sensor at 2.8 GHz

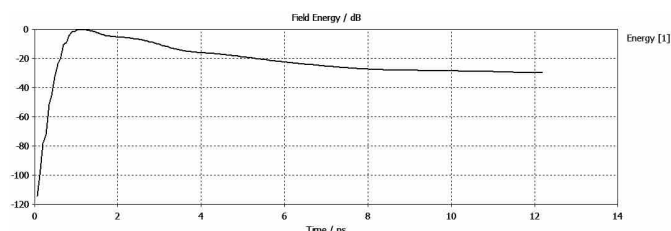


Figure 17: Field Energy of Rectangular microstrip moisture sensor at 2.8 GHz

3. CONCLUSION

In this paper, the microstrip moisture sensor as a rectangular shape by using the free space technique, it will be very useful for soil moisture and detect with a less time by using the vector network analyzer as well as sensitivity will be increase with operate the frequency 1GHz to 3GHz. This design size will be compact, fast speed, accuracy, compatibility, etc.

Moisture content measurements for soil can be done rapidly and effectively using the rectangular microstrip moisture sensor. A close agreement has been obtained between computed and simulation results of the insertion loss as a function of moisture content in soil. A sensor is designed and analyzed with low cost, high sensitivity, easy design as well as high accuracy for measurement the rice grains and for larger volume of material under the test can be designed which will be used for more accurate and rapid measurement.

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