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Design and Analysis of Triangular Microstrip Sensor Patch Antenna Using DGS

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ABSTRACT

Nowadays microstrip antenna is an important tool for wireless networks. Frequency sensitive antenna by using DGS at 2.39GHz and by using non DGS at 1.96 GHz is being proposed. This study represents microstrip sensor by using a triangular patch antenna using defected ground structure (DGS). It is used for high quality rice measurement. By using DGS and without DGS a percentage of minimum and maximum moisture content is determined at different frequencies. It is designed on FR4 substrate which is simulated in CST software after that hardware has been fabricated on Printed circuit board and the return loss is measured by using spectrum analyzer.

Key words Computer Simulation Technology (CST), Printed Circuitry Board (PCB), Spectrum Analyzer, Triangular patch antenna

INTRODUCTION

The microstrip sensor was used for fish meat processing in 1970 [1]. After that it was used for ripening of fruits. Later this technique has been improved over the years, gradually [2]. Basically the use of sensors is to change the physical and chemical properties [3]. A patch which is a very thin metallic strip in microstrip antenna and the function is to create a flat radiating structure on the ground plane [4]. Here the measurement of the minimum and maximum moisture content percentage at different frequency has been presented by using the triangular patch antenna on the rice. The moisture content of rice characterization is an important concern for the storage purpose. Microstrip antenna is an effective tool for various purposes because of low cost, light weight, easy fabrication and it is used for wireless networks also. A triangular patch antenna is designed with and without DGS and measurement has been taken on the spectrum analyzer. This method is very convenient as well as less time consuming as compared to others. There are so many methods like gas evaporation method, chemical reaction method, distillation method, these are laboratory methods, but these methods are very time consuming in which the material is first dried in an oven for 24 hours after that when it becomes cool it is tested. They contain other disadvantages like low gain, narrow bandwidth, less efficiency and high return loss. In the microstrip line sensor the bandwidth can be improved by using different ways like by taking thick substrate, slots, and defected ground structure. Non-destructive methods have different low frequency laboratory measurements which take very less amount of time in comparison to destructive methods. It is based on reflection principle in which with the help of reflection method a percentage change has been determined for moisture percentage [5].

ANTENNA DESIGN AND ANALYSIS

On same dielectric substrate patch antenna is designed with two layers. On FR4 substrate patch antenna is realised on the first layer and microstrip feed line is realised on the second layer. Firstly, a microstrip triangular patch antenna is designed by using DGS at 2.39 GHz and non-DGS at 1.8 GHz.

Design Calculation

From [5] -

Width of Patch (W) $W = \frac{1}{2fr\sqrt{\mu o \varepsilon o}}\sqrt{\frac{2}{\varepsilon r+1}}$, Where f_r = resonant frequency (1)

Effective Dielectric Constant of the Substrate (ε_r) $\varepsilon_{reff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[1+12\frac{h}{W}\right]^{\frac{1}{2}}$ (2)

Where, h = height of substrate and $\mathcal{E}r$ = dielectric constant of substrate

Extension in Length $$\frac{\Delta L}{h} = 0.412\frac{(\mathcal{E}reff+0.3)(\frac{W}{h}+0.264)}{(\mathcal{E}reff-0.258)(\frac{W}{h}+0.8)} \quad (3)$$

Length of Patch (L) $$L = \frac{1}{2fr\sqrt{\mathcal{E}reff\sqrt{\mu o\mathcal{E}o}}} - 2\Delta L \quad (4)$$

Length of Patch $$L_e = L+2\Delta L \quad (5)$$

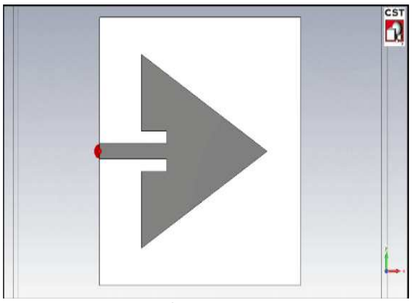

Fig. 1 Front view of triangular patch antenna

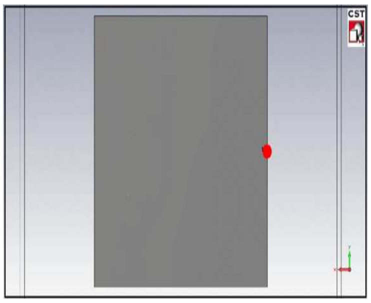

Fig.2 Back view

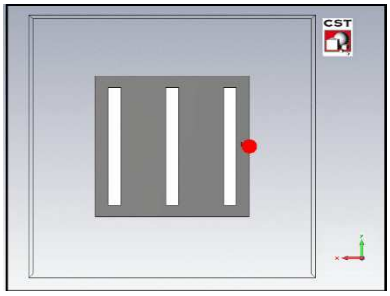

Fig. 3 Back view with DGS

Software Simulation and Result

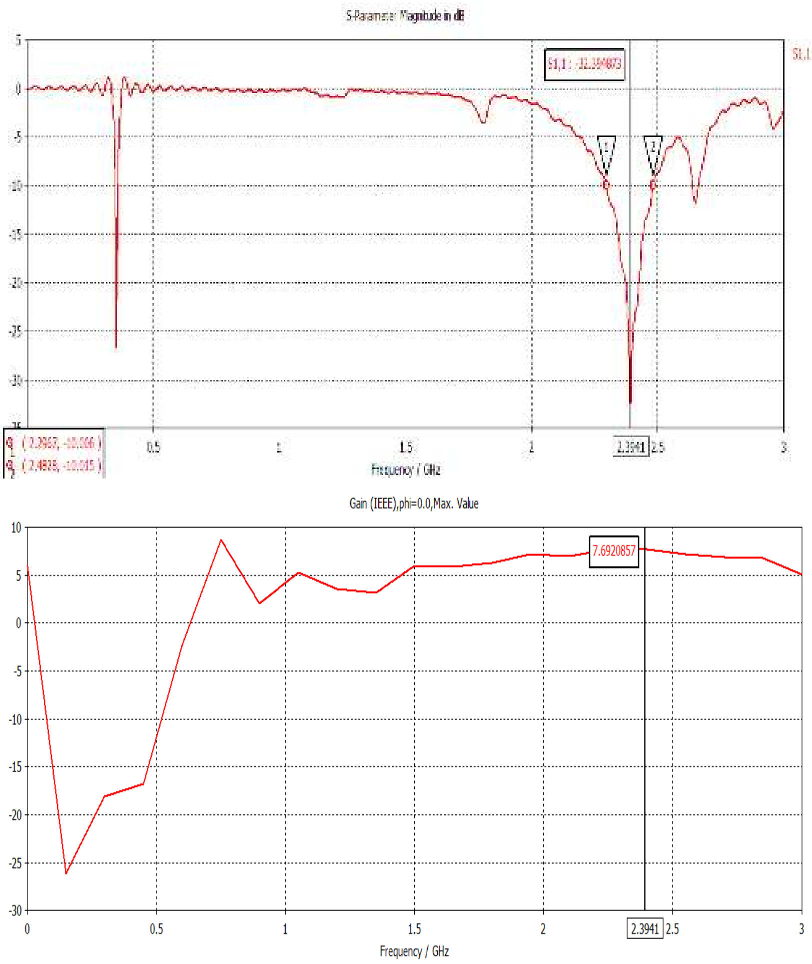

Fig. 4 Graph of return loss and gain triangular patch antenna by using DGS

Design	Frequency(GHz)	Return Loss (dB)	Gain (dB)	Bandwidth (MHz)
Without DGS	1.96	-20.57	-2.8	20.7
With DGS	2.39	-32.39	7.69	186

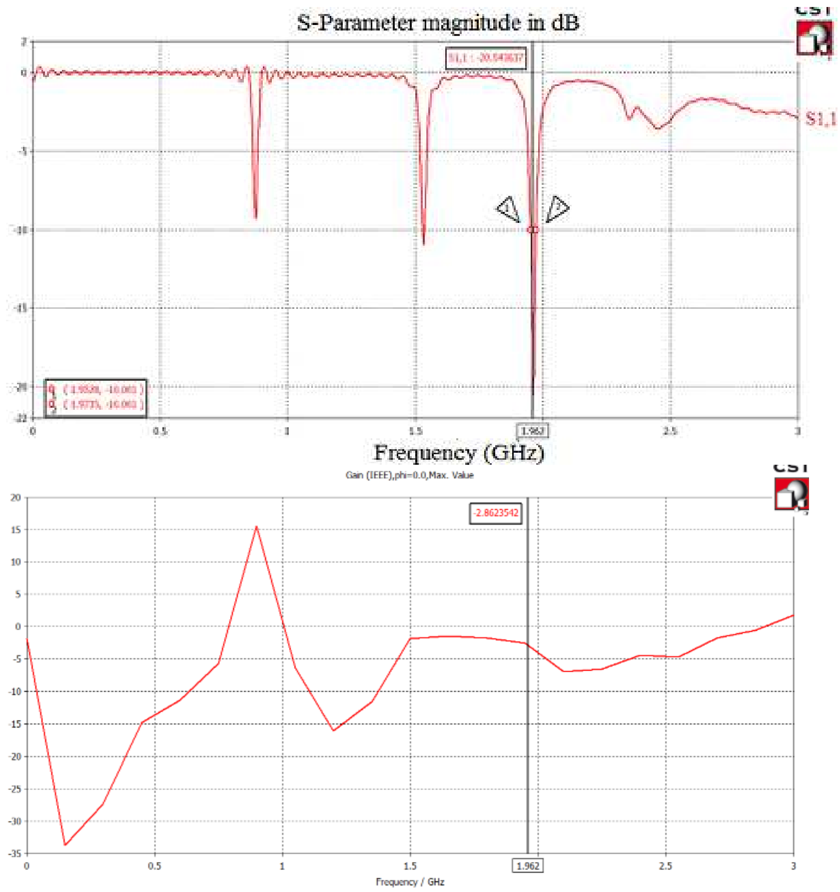

Fig. 5 Graph of return loss and gain triangular patch antenna without DGS

Fabrication Process

After the simulation technique the antenna is designed on the FR4 substrate PCB with h=1.6, $\mathcal{E}_r$= 4.3, tanδ = 0.02. Then by using AutoCAD software the design has been converted and printed on the act paper and finally then etched on the PCB, and then by using $FeCl_3$ the remaining copper is etched out and the return loss is measured by using spectrum analyser. Structure of the Sensor is shown in fig. 6.

Fig. 6 Front view and back view of sensor

RESULTS AND DISCUSSION

Defected ground structure (DGS) plays an important role in the microstrip antenna. This is frequency sensitive antenna because of defining different frequencies at same dimension triangular patch antenna. With the help of DGS the effective inductance and capacitance has been increased therefore, the return loss, gain and bandwidth show better results as compared to non-DGS. Fig. 7 shows the graph between the reflection coefficient and frequency as well as the measured return loss and frequency on spectrum analyser. In this process a triangular patch antenna sensor using non-DGS has been placed and dry rice is taken up to the height of 6mm. After that the relation has been formed. The reflection coefficient is minimum at 1.8GHz and maximum at 2.6GHz. Fig. 8 shows the graph between the reflection coefficient and frequency as well as the measured return loss and frequency on spectrum analyser. In this process a triangular patch antenna sensor using non-DGS has been placed and wet rice is taken to a height of

6mm. After that the relation has been formed. The reflection coefficient is minimum at 2.2GHz and maximum at 2.6GHz. Fig. 9 shows the maximum and minimum moisture content (%) at different frequencies. By using the above results of measuring the dry and wet rice the percentage change has been taken in reflection coefficient. In microstrip triangular patch antenna using non-DGS minimum moisture content is 8% at 2.6GHz and maximum moisture content is 79% at 2GHz.

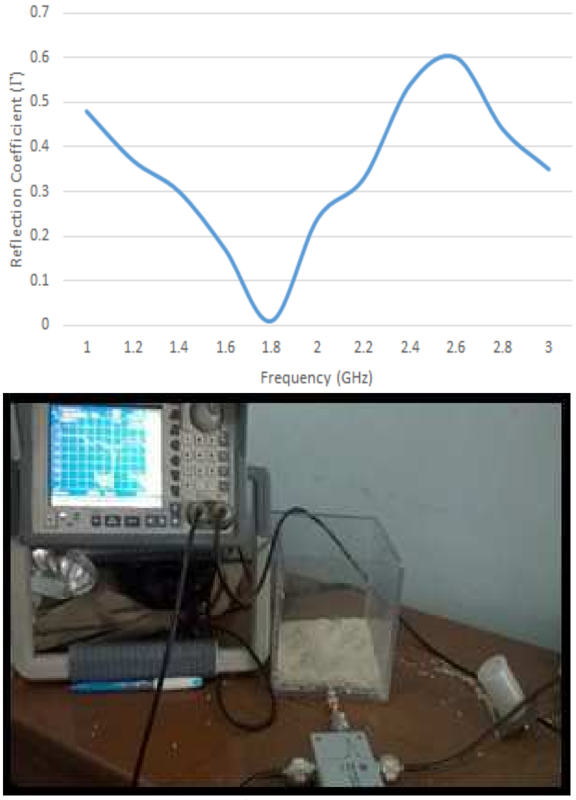

Fig. 7 Sample of dry rice using non-DGS

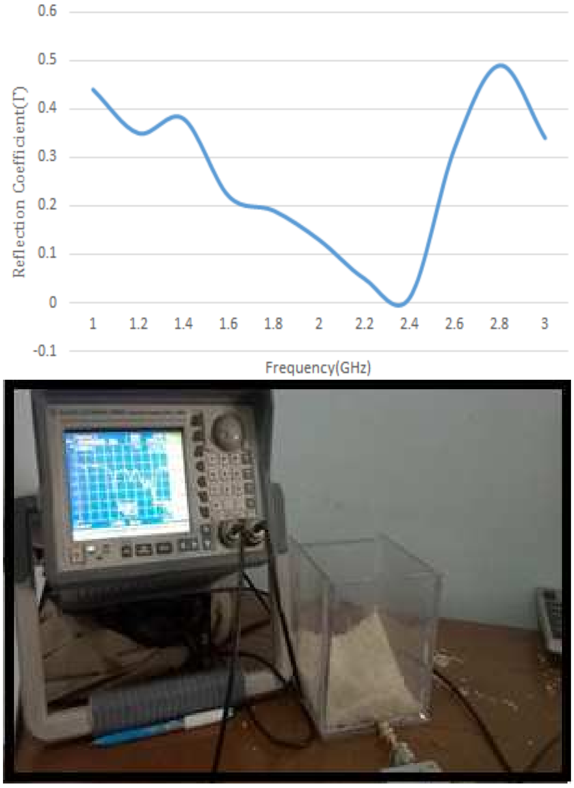

Fig. 10 Sample of dry rice using DGS

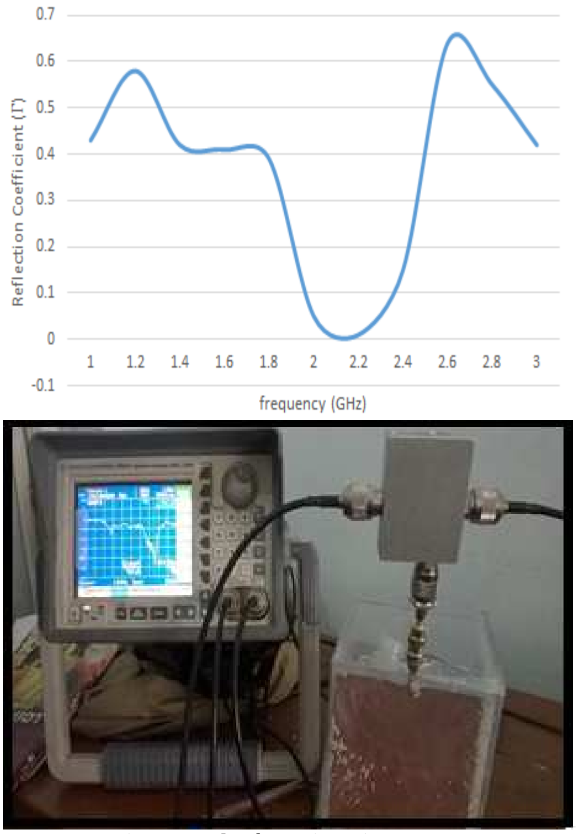

Fig. 8 Sample of wet rice using non-DGS

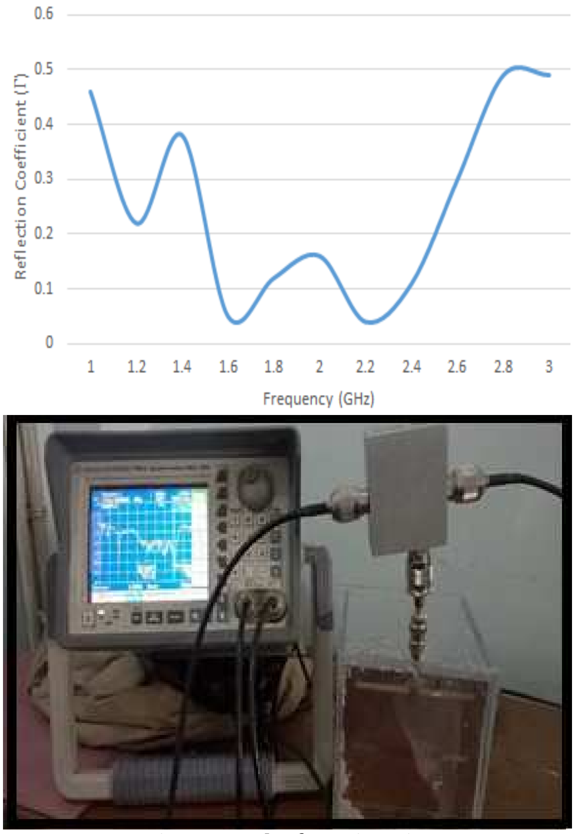

Fig. 11 Sample of wet rice using DGS

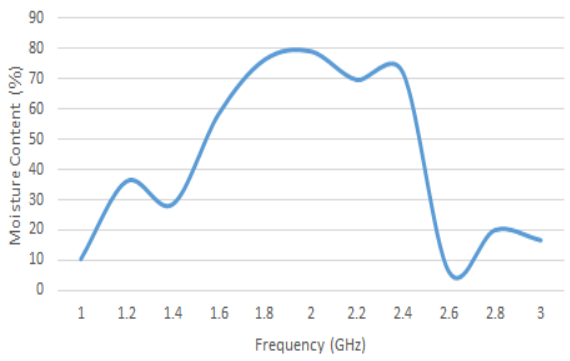

Fig. 9 Measurement of moisture content without DGS

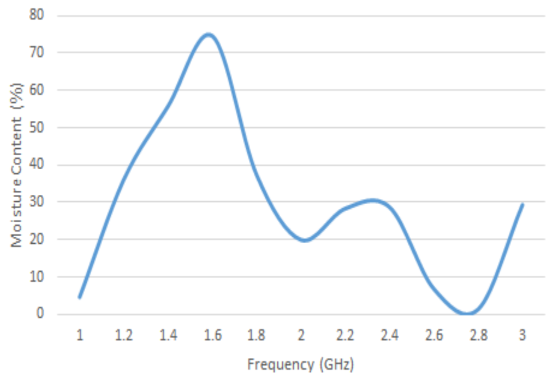

Fig. 12 Measurement of moisture content using DGS

Fig. 10 shows the graph between the reflection coefficient and frequency as well as the measured return loss and frequency on spectrum analyser. In this process a triangular patch antenna sensor using DGS has been placed and dry rice is taken to a height of 6mm. After that the relation is formed. The reflection coefficient is minimum at 2.4GHz and maximum at 2.8GHz. Fig. 11 shows the graph between the reflection coefficient and frequency as well as the measured return loss and frequency on spectrum analyser. In this process a triangular patch antenna sensor using DGS has been placed and wet rice is taken to a height of 6mm. After that the relation has been formed. The reflection coefficient is minimum at 2.2GHz and maximum at 2.8GHz. Fig. 12 shows the maximum and minimum moisture content (%) at different frequencies. By using the above result of measuring the dry and wet rice the percentage change has been taken in reflection coefficient. In microstrip triangular patch antenna using DGS minimum moisture content is 1.5% at 2.8GHz and maximum moisture content is 75% at 1.6GHz.

CONCLUSION

In this paper minimum and maximum moisture content (%) has been obtained at different frequencies by using DGS and non-DGS. Defected ground structure at the back of the printed circuit board improves the result as compared to non-DGS. The above analysis shows that the moisture content is minimum and maximum at different frequencies and that can be considered for the better implementation of the approach. The whole approach has been implemented considering the moisture content of the rice.

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