Effect of Different Space Dielectrics on the Performance of the Rectangular Microstrip Patch Antenna

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***Abstract*— In this paper, we have studied the effect of space dielectrics on the microstrip patch antenna. The Resonant frequency used in this design is 2.4 GHz. Three basic parameters as resonant frequency, bandwidth and Insertion loss showed negligible effect against the variation in space dielectric. Resonant frequency and band width showed ±2% tolerance and Insertion loss below -30dB. Thus a dielectric covers of optimized thickness of 0.8mm of LTCC material is placed on the patch. The results are predicted using commercial HFSS finite element method software.**

***Keywords*— Rectangular Microstrip, Resonant Frequency, LTCC, Space Dielectrics, Bandwidth.**

I. INTRODUCTION

Microstrip antennas are becoming a popular choice for portable wireless system since they are light weight, low cost and easily manufacture. In several applications, microstrip antennas require a dielectric cover over the radiating elements to provide protection against environmental changes and to protect from heat, rain, physical damage during flight or severe condition [1-2]. The antennas are usually placed in plastic covers or protective dielectric superstrate. Such dielectric cover over microstrip antenna changes the parameters of antenna such as resonant frequency, bandwidth and insertion loss with the change in space dielectric constant and its basic performance causes serious degradation of system performance. Several researchers have studied the effect of dielectric covers on resonant frequency [1-6] with rigorous numerical method. All these method are complex, time consuming and not useful for the computational –aided design. Additionally, none of these method account for any intentional or unintentional air-gap between the antenna and superstrate of microstrip patch antenna.

The basic properties of radiation in such an environment have been discussed in their paper. One significant result in their work was that a superstrate with dielectric constant higher than that of the substrate may, at the proper thickness, reduce to a minimum the surface-wave excitation and increase the radiation efficiency. In this paper we study the design of microstrip patch antenna with dielectric cover of optimized thickness and spaced dielectric superstrate of different dielectric environment

II. DESIGN OF RECTANGULAR MICROSTRIP ANTENNA

The proposed antenna based on the rectangular patch was designed first. The antenna is planner rectangular patch antenna fed by microstrip line on the LTCC substrate with dielectric constant ε_r =9.4 and 1.6mm.of thickness (h). This antenna is designed at frequency 2.4GHz. Width of microstrip line is 2.6 mm. for match impedance with 50 Ω of transmission line. The Structure of a simple rectangular patch antenna is shown in fig. 1. The dimension in width (w) =28mm. and Length (L) =20mm. These dimensions are calculated by well known formulas

$$W = c/2f\,[(\epsilon r + 1)/2]^{-1/2} \ldots\ldots\ldots\ldots\ldots (1)$$

$$L = c / 2f\sqrt{\epsilon e} - 2\Delta l \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The estimated resonant frequency of rectangular microstrip patch can be calculated by the expression given below:

$$fr,nm = \frac{\alpha_{nm}\, c}{2\pi a_{eff}\left(\varepsilon_{eff}\right)1/2} \ldots\ldots\ldots\ldots (3)$$

Where α_{nm} is the m^{th} zero of the derivate of Bessel function of order n, c is the velocity of light in free space, ε_{eff} is the effective relative permittivity of the medium below the patch and a_{eff} is the effective radius of the patch in presence of a dielectric superstrate.

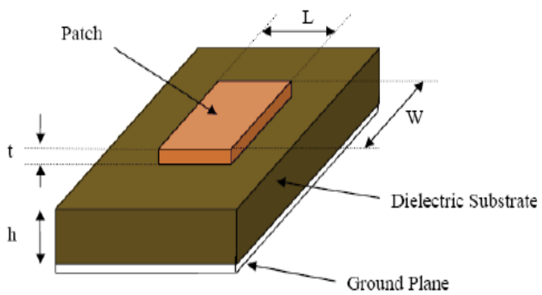

Fig. 1: Structure of a Microstrip patch antenna

When the microstrip patch antenna was covered by a dielectric layer the resonant frequency, Insertion loss and Bandwidth of the patch antenna was varied with different dielectric materials. The design is shown in fig. 2. In fig. 2

the ε_{r1}, ε_{r2}, ε_{r3} corresponds to the substrate, the dielectric cover and space dielectric respectively.

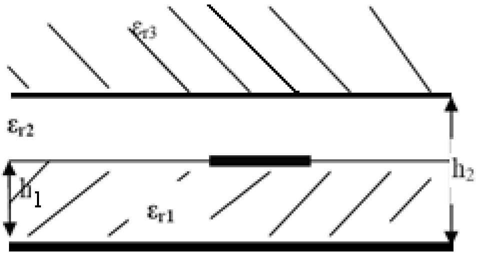

Fig. 2: Rectangular microstrip patch with spaced superstrate

III. Discussion On Result

A superstrate layer of LTCC material of optimized thickness was placed on microstrip patch as shown in fig. 2. Then another layer was placed on the superstrate layer for the study of effect of different dielectric materials (spaced dielectric environments). Different dielectric materials were considered in this study. The range of dielectric constant is from ε_r =2 to 10. An air gap of 0.7mm thickness exists in between superstrate layer and spaced dielectric layer.

Fig. 3 shows the effect of space dielectric on the Insertion loss of antenna, fig. 4 shows the effect of space dielectric on the % Bandwidth of antenna and fig. 5 shows the effect of space dielectric on the resonant frequency of antenna

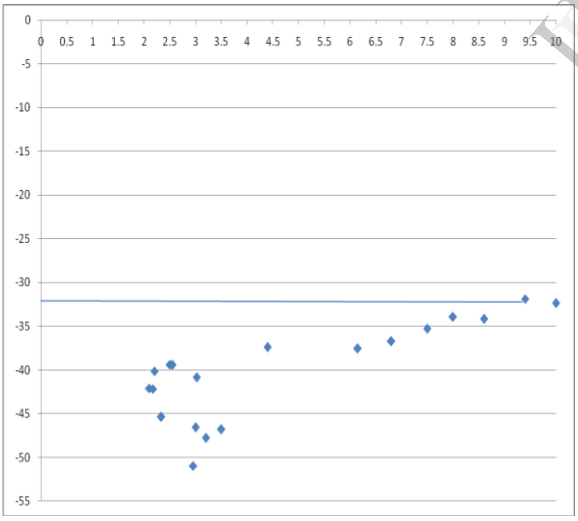

Fig. 3: Curve between Dielectric Constant (ε_r) and Insertion Loss (dB)

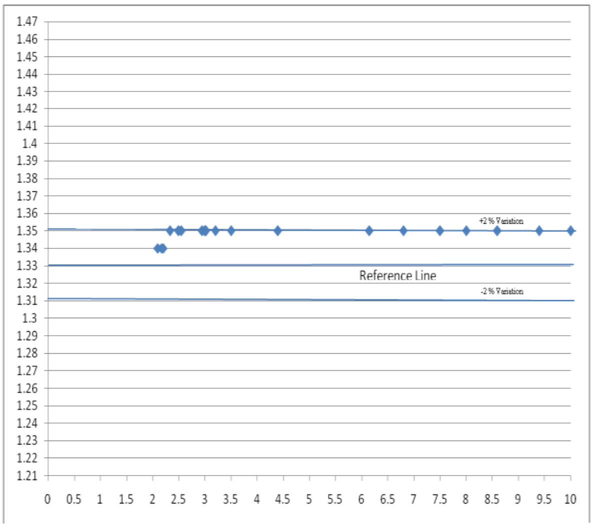

Fig. 4: Curve between Dielectric Constant (ε_r) and % Bandwidth.

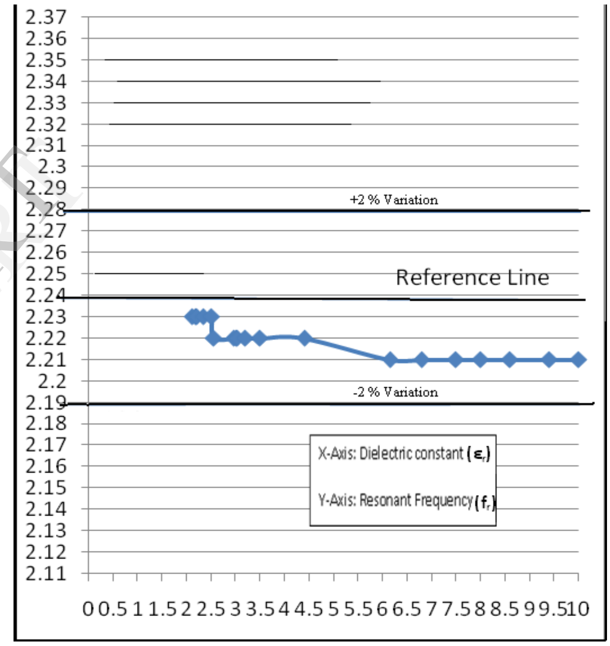

Fig. 5: Curve between Dielectric Constant (ε_r) and Resonant frequency (f_r).

IV. CONCLUSION

This paper presents the analysis of a rectangular microstrip patch antenna covered with a dielectric layer (superstrate) of optimized Thickness of 0.8mm of LTCC material.

A superstrate of proper thickness reduces the surface-wave excitation and increase the radiation efficiency. After placing the superstrate layer of optimized thickness on the patch the environmental effects on surface waves becomes negligible. In this paper the figure3, figure4 and figure5 shows the negligible effects of space dielectrics on different parameters of antenna such as Insertion loss, % Bandwidth and resonant frequency. In fig. 4 the Reference line shows the %Bandwidth without space dielectric (1.33%) and it varies in the Tolerance limit of ± 2% with the variation of space dielectric. In fig. 5 the Reference line shows the Resonant frequency without space dielectric (2.24GHz) and it varies in the Tolerance limit of ± 2% with the variation of space dielectric This tolerance limit is negligible we can say. Therefore the manufacturer can design the antenna in to the package of the system with space dielectric ranging from ε_r =2 to 10 with 0.7mm.air gap between superstrate (dielectric cover) and space dielectric layer without affecting the characteristics of antenna.

REFERENCES

[1] I.J. Bahl et al "*Design of microstrip antennas covered with a dielectric layer,"* IEEE AP-30 pp314-18, Mar. 1982.

[2] N.G.Alexopoulos and D.R.Jackson, "*Fundamental dielectric cover effects on printed circuit antennas,"* IEEE Trans.Antennas prop. Vol. AP-37,pp 802-16,1986.

[3] A.K.Verma et al,"*Analysis of Rectangular patch antennas with dielectric cover"*, IEICE Trans.Vol.E74, pp.1270-76, May 1991.

[4] O.M.Ramadhi and Y.T.Lo.,*"Superstrate effect on the resonant frequency of microstrip antennas",* microwave Opt.Technol.Lett.Vol.5, pp.254-57, June 1992.

[5] R.Shavit,"*Dielectric cover effect on rectangular microstrip antenna array,"*IEEE AP-42, pp.1180-84, Aug.1994.

[6] J.T.Bemhard et.al.*"Resonant frequencies of Rectangular microstrip antennas with flush and spaced dielectric Superstrates"*, IEEE MTT-47, No.2, Feb.1999.

[7] Debatosh Guba and Jawad Y.Siddiqui,*"Resonant Frequency of Circular Microstrip Antenna Covered with Dielectric Substrate "*, IEEE Trans. AP-51, No.7, July2003.