Analysis of Microstrip Patch Antenna For Three Different Substrates At 2.4GHz.

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Abstract- *This paper presents a method to improve the size reduction of microstrip patch antenna in addition to various mobile services. The microstrip patch antenna also can be utilized in Bluetooth, WLAN, WI-FI, and frequency ranges from 2.4GHZ to 2.5GHZ which is convenient for Bluetooth application. Analysis of antenna using the ie3d software scheme and reducing the size of the microstrip antenna is investigated both theoretically and experimentally.*

Keywords- Patch antenna, microstrip antenna, fr4, bakelite, rt duroid 6010 LM laminate.

I. INTRODUCTION

Nowadays in wireless communication it is convenient to use microstrip patch antenna for many applications. There is so much demand for antenna design due to a large increase in wireless communication. The size of the microstrip patch antenna is small but has a large bandwidth.

The three common methods of reducing patch size are [3]

1. The use of microwave substrate with high permittivity.
2. Use of shorting pins
3. Use of shorting walls.

From above we are focusing on 1st point. i.e. the use of microwave substrate with high permittivity. A scheme to cut back the size of the microstrip patch antenna is investigated theoretically and experimentally. The reason behind that we design microstrip antenna is these antennas are widely used than conventional antennas . Microstrip antennas are light weighted, compact, and cost-effective.

The operating frequency and the length of patch both are inversely proportional to each other, so the antenna size becomes large when the operating frequency is low, similarly antenna size becomes low when operating frequency is high. The purpose of this is to investigate Size reduction theoretically. For increasing the permittivity we need to reduce the length of the antennas and for this analysis of reducing the size of antenna we are using microstrip patch antenna to design.

1.1. microstrip antenna

Microstrip antennas are one of the most popular antennas in the wireless communication market. One can find the application of Microstrip antennas in various safe fields of high-tech technology like in mobile communication the paper presents the analysis of microwave substrate with a high permittivity method to reduce the size of the microstrip patch antenna is investigated by both theoretically and experimentally. We design the microstrip antenna that is widely used, lightweight, compact, and cost-effective. The operating frequency is inversely proportional to the antenna size. Antenna size becomes large when the operating frequency is low similarly antenna size becomes low when operating frequency is high. Apart from frequency the size of antenna also depends on permittivity, increasing permittivity reduces the size of the antenna. Microstrip antennas are one of the most popular antennas in the wireless communication market. Microstrip antenna geometry as given below in fig 1.

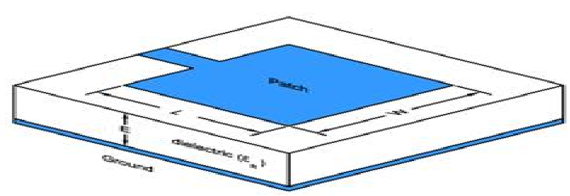

Fig.1.Microstrip antenna geometry

Some different feeding technique is used to design the microstrip patch antenna to improve the antenna parameters.

Sections (1.2), Different microstrip patch antenna feeding techniques are detailed below.

1.2. microstrip antenna feeding methods

A microstrip antenna is a few kind of resonator so designers need some feeding methods to excite a field into this resonator. There are various ways to feed the antenna. The foremost common way is essentially to use a coaxial probe during which the probe penetrates the bottom ground plane and shorted to the upper conductive of the antenna. By the way the upper conductive antenna is also called patch, because it can have many shapes. During this paper report, rectangular shape has been discussed, but essentially it may be of any shape. The second way of feeding a resonator over the cavity domain under the patch is using some kind of inset a microstrip into the cavity. The third way is using a strip which is penetrating the cavity domain under the patch without touching anything and by electromagnetic coupling is excite the cavity domain under the patch. The fourth way which is used also for a feeding microstrip antenna is using microstrip lines which excite a slot and this slot excites the cavity domain under a patch antenna. This feeding has appropriate for multilayer applications while in which don't want to use from one layer to another layer and therefore is popular especially for multilayer applications in which one can integrate an arc section with the antenna for different substrate that are listed below.

1.2.1. Bakelite

Bakelite is an early plastic, is one in all the commonly available dielectric substrate. Bakelite may be molded easily. It may retain their shape easily and are immune to heat. This used for its electrical non-conductivity and heat-resistant properties in electrical insulators etc. Microstrip Antenna (MSA) applications using a thicker substrate with a low dielectric constant is preferred to enhance the fringing fields and hence the radiation effect. Another important parameter is that the loss tangent (tan δ). The tan δ indicates the dielectric loss which increases with the frequency.

1.2.2. Fr4

This dielectric substrate could be a material composed of fiber glass cloth with an epoxy resin binder and might be used as flame resistant. In both dry and humid conditions material is assumed to retain its high mechanical values and its electrical insulating qualities.

1.2.3. Rt duroid 6010

Loss tangent for RT duroid 6010 is LOW. It is also an excellent chemical resistance. Fabrication process for RT duroid 6010 is very easy, it can be done easily. This is a very environment friendly material. Section (2), Analysis of size w.r.t frequency, and permittivity is detailed in the following section.

II. METHODOLOGY OR MATHEMATICAL ANALYSIS

The relation between the dimensions of the antenna and resonant frequency are given using the following formulas.

1) Frequency of operation-

$$Fc=\frac{c}{2L\sqrt{\varepsilon r}}$$

2) Calculation of width of a patch(W)-

$$W=\frac{c}{2f0\sqrt{\frac{\varepsilon r+1}{2}}}$$

3) Calculation of the effective dielectric constant-

$$\varepsilon ef = \frac{\varepsilon r+1}{2}+\frac{\varepsilon r-1}{2}\left[1+12\frac{h}{w}\right]^{\frac{-1}{2}}$$

4) Calculation of the effective length of patch-

$$Leff=\frac{c}{2f0\sqrt{\varepsilon eff}}$$

5) Calculate the length of extension-

$$\Delta L = 0.412h\,\frac{(\varepsilon eff+0.3)(\frac{W}{h}+0.264)}{(\varepsilon eff-0.258)(\frac{W}{h}+0.8)}$$

6) Calculate the actual length of patch

$$L=Leff-2\Delta L$$

III. THEORETICAL ANALYSIS

Here permittivity of the substrate is inversely proportional to the width of a patch and operating frequency as permittivity increases the size of microstrip patch reduces. The permittivity of the substrate decreases effective dielectric constant decreases. As effective dielectric constant decreases effective length of patch increases as are inversely proportional.

As the value of relative permittivity changes the result is obtained and increasing the value of the substrate gives better results, but after the Ɛr=5, return loss goes above

-10db, which is not acceptable for a standard antenna [2].The permittivity of the substrate is inversely proportional to the width of a patch and operating frequency as permittivity increases the size of the microstrip patch reduces. Permittivity of the substrate decreases effective dielectric constant decreases. As effective dielectric constant decreases effective length of patch increases as are inversely proportional.

IV. RESULTS

TABLE 1.GEOMETRY DIMENSIONS FOR SUBSTRATE (USING MATLAB CODE FOR MATHEMATICAL ANALYSIS)

Parameters	Bakelite	FR4	RT duroid
Patch Height	1.6mm	1.6mm	1.6mm
Dielectric constant	4.74	4.36	10.2
Tangent loss	0.03045	0.013	0.002
Resonating freq(fr)	2.4GHz	2.4GHz	2.4GHz
Patch length (mm)	28.38mm	29.45mm	19.36mm
Patch width(mm)	36.89mm	38.03mm	26.42mm

Bakelite-

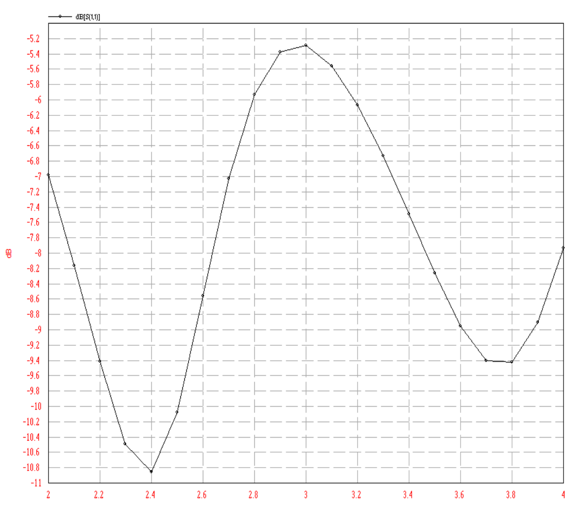

Fig.2.Return loss for the Bakelite substrate.

FR4-

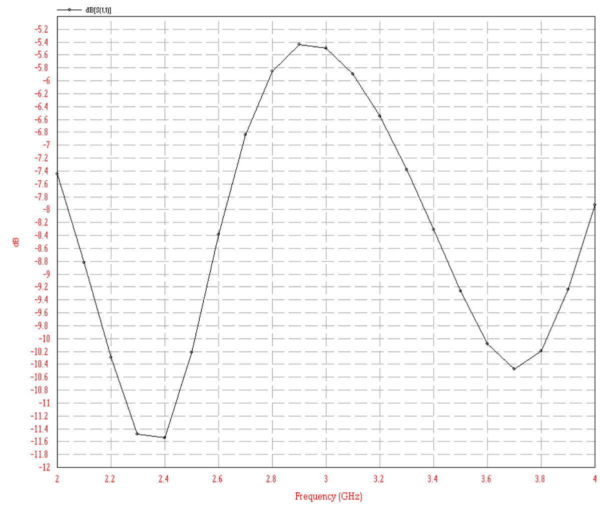

Fig.3.Return loss for the FR4 substrate.

RT duroid 6010 LM laminate-

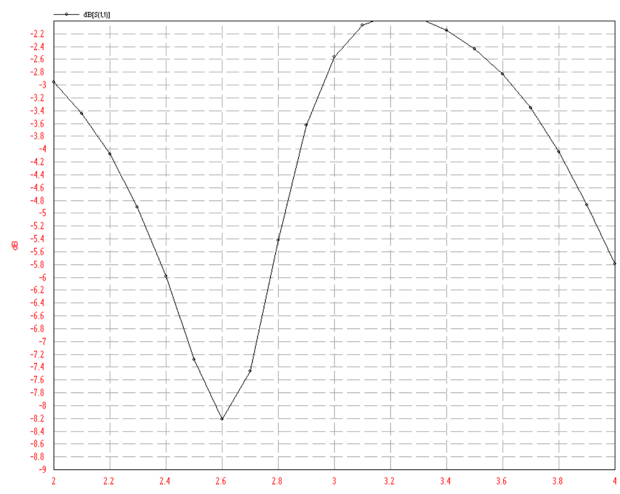

Fig.3.Return loss for RT the duroid 6010 substrate.

As the dimension of the patch and tangent loss listed above are low and from the return loss curve for Bakelite it is moderate and nearly the same for fr4 and bakelite so the bakelite is more efficient.

V. CONCLUSION

This Research paper brings the mathematical and theoretical analysis for an antenna design parameter such as length of a patch, the width of patch, and the length of extension and performance of the antenna can be improved by inserting slot on patch. From our assumption bakelite is the best substrate. The HFSS, ie3d simulation tool was used for the designing and simulation of antenna structures considered for the study and it is noticed that return loss for fr4 and

Bakelite is less than -10db but for RT duroid (10.2) return loss is greater than -10db which is not acceptable.

VI. ACKNOWLEDGMENT

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