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Design of Rectangular gap coupled Patch Antenna

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Abstract--- This paper focuses on the designs of a two and three rectangular Gap coupled patch antennas using High Frequency Structure Simulator(HFSS).They are useful to enhance the bandwidth when compared with a single rectangular patch antenna. It is used with TEFLON TLT(tm) as a substrate whose dielectric constant is 2.55. In Gap coupling patch, one patch is fed and the remaining are the parasitic patches separated with a small distance. The fringing fields from the fed antenna cause the excitation to the parasitic patch antennas.

Key words—Gap Coupled patch Antenna, Parasitic patch, Fringing field, Bandwidth, HFSS.

I. Introduction

The essential requirement for communication is to have a large Gain and Bandwidth. It is known that Band width is proportional to substrate thickness and inversely proportional to square root of relative permittivity of substrate. The Bandwidth provided by a Single Rectangular microstrip antenna cannot be increased more than 5-10%. If we increase further the efficiency decreases, and that is the reason we go for a gap coupled patch Antenna. Hence these are used in the applications where gain and bandwidth requirement.

In gap coupled microstrip antenna, only one patch is fed and the remaining are parasitic patches which are radiated by the fringing fields. The fringing fields are due to the patch that is fed, which cause parasitic patch to excite and resonate. Due to parasitic patches in gap coupled antenna, input impedance reduces close to half compared to normal Rectangular Microstrip Antenna. The length of parasitic patch is slightly less than the patch that is fed, so that parasitic patches resonate at higher frequency. The gap between the parasitic patches and fed patch must be low, otherwise it behaves like a normal Rectangular Microstrip Antenna.

In recent times, several techniques are introduced to enhance the bandwidth of a microstrip antenna. Yang et al. [1] introduced a single layer wideband rectangular patch antenna with required impedance bandwidth greater than 20%. Abdelaziz [2] introduced a microstrip antenna comprises of two different radiating elements together which is embedded on a single layer structure and connected together though the matched section to give wide bandwidth. Another technique which includes the parasitic patches with multilayer structures like E, V, and H shapes, which is responsible to excite multiple resonant modes [3]. V. Sharma M. M. Sharma [4] introduced gap coupled assembly of rectangular microstrip patches for a wide band which is applicable to both lower band and upper band of Wi-Max applications by using six patches connected to fed called radiated patches and remaining are parasitically coupled patches.

II. Antenna Geometry

The proposed gap coupled microstrip patch antenna is as shown in fig.1 and fig.2. The length and width of the two rectangular gap coupled patch is 99.08 X 78.08 mm^2. The length and width of the three rectangular gap coupled patch is 139.08 X 107.08 $mm^{2.}$

The design specifications of this Gap coupled patch antennas are as follows. TEFLON TLT(tm) is used as a substrate material having a Dielectric constant of 2.55 and a substrate thickness (h) is of 1.6 mm. The design steps of proposed antenna are as follows.

- A Substrate with a Dielectric constant ε_r = 2.55
- The values for the Width and Length of Patch can be evaluated using the following formulae

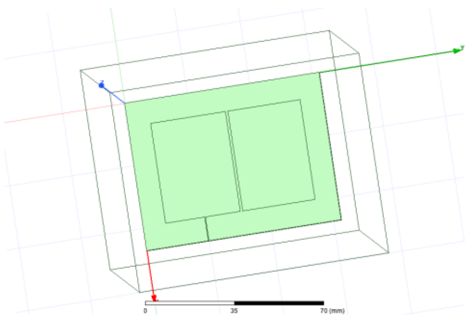

Figure : 1. Design of two rectangular gap coupled patches using TEFLON TLT(tm) Substrate

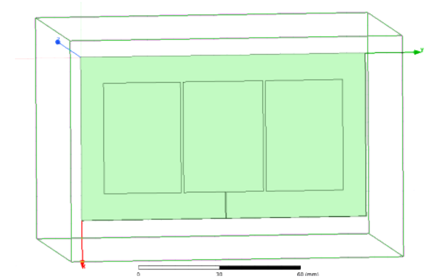

Figure: 2. Design of three rectangular gap coupled Coupled patches using TEFLON TLT(tm) Substrate

Width of Ground:

$$W_g = Width\ of\ Substrate(Ws) = Wrp + (Wpp * n) + 6h + 6h$$

Length of Ground:

$$L_g = Length\ of\ Substrate(Ls) = Lrp + (Lpp * n) + 6h + 6h$$

Where Wrp = Width of a radiating patch

Lrp = Length of a radiating patch

Wpp = Width of a parasitic patch

Lpp = Length of a parasitic patch

h = Substrate thickness

The Parasitic Patches are separated by the distance of s=0.1cm

The position of feed = radiating patch length/2+0.7c.m

III. Results and Discussion

Two Rectangular gap coupled patch Antenna:

The simulated plot of reflection coefficient is shown in Figure 3. The antenna is resonated at multiple frequencies 6.4 GHz and 7.44 GHz. At resonant frequencies the observed reflection coefficients (S_{11}) are –16.996 dB and -10.6978 dB. The plot of VSWR is shown in Figure 4. The observed VSWR at resonant frequencies are 1.3292 and 1.8241. At resonant frequency the observed gain is 6.4 dB as shown in Figure 5 and at resonant frequency the observed directivity is 6.7 dB as shown in Figure 6.

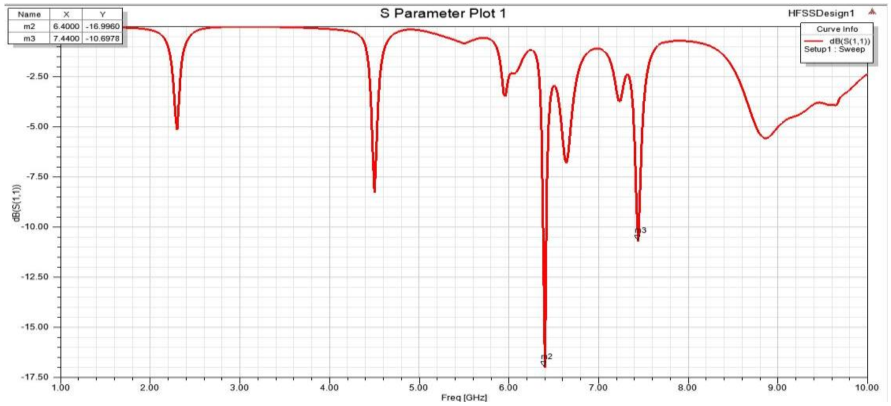

Figure: 3. Reflection Coefficient plot using Two Rectangular gap coupled Microstrip patch Antenna

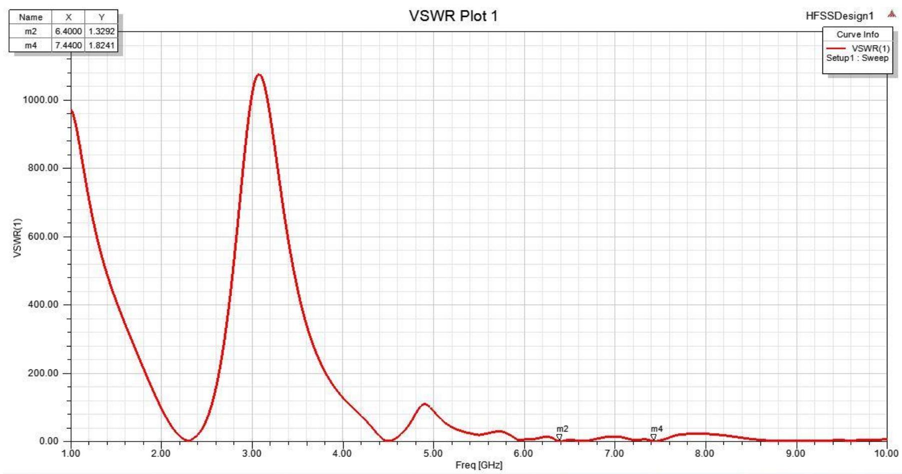

Figure : 4. VSWR of Two Rectangular gap coupled Microstrip patch Antenna

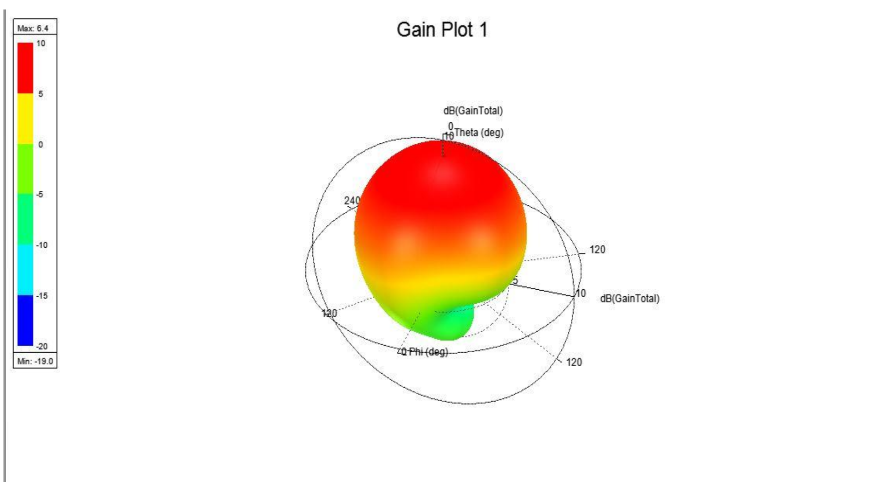

Figure: 5. Gain of Two Rectangular gap coupled Microstrip patch Antenna

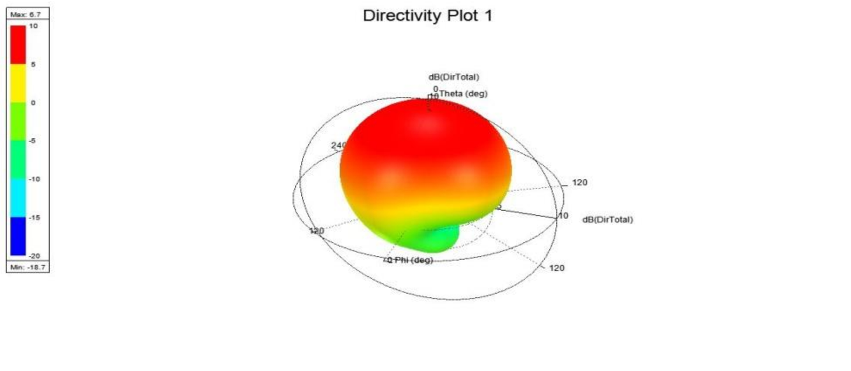

Figure: 6. Directivity of Two Rectangular Gap coupled Microstrip Patch Antenna

Table 1: Results of two Rectangular gap coupled patch Antenna:

S.no	Patch type	Resonant Frequency (GHz)	Reflection-coefficient (dB)	VSWR	Gain(dB)	Directivity (dB)	Band Width(GHz)
2	Two Rectangular Gap coupled Patches	6.40 7.44	-16.996 -10.6978	1.3292 1.8241	6.4	6.7	0.0656

Three Rectangular Gap Coupled Patch Antenna:

The simulated plot of reflection coefficient is shown in Figure 7. The antenna is resonated at multiple frequencies 4.46 GHz, 6.42 GHz, 7.16 GHz, 7.38GHz and 8.8 GHz. At resonant frequencies the observed reflection coefficients (S_{11}) are – 10.3489 dB, -15.8253 dB, -10.7613 dB, -11.5495 dB and -9.9355 dB. The plot of VSWR is shown in Figure 8. The observed VSWR at resonant frequencies are 1.8726, 1.385, 1.7195 and 1.9351. At resonant frequency the observed gain is 7.1 dB as shown in Figure 9 and at resonant frequency the observed directivity is 7.5 dB as shown in Figure 10.

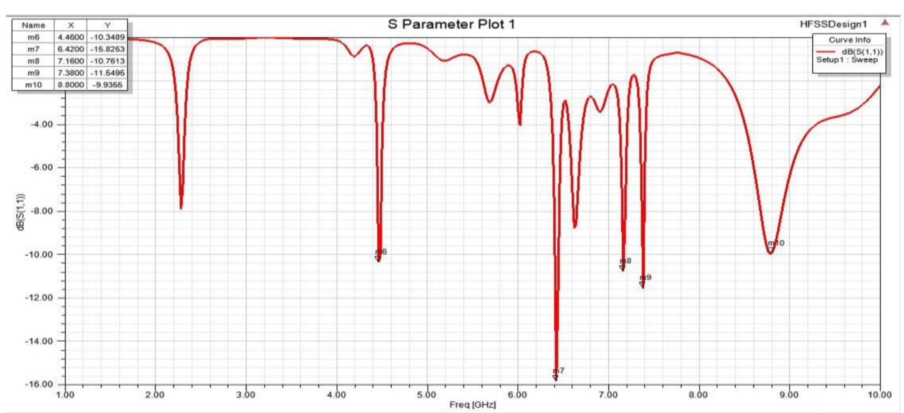

Figure: 7. Reflection Coefficient plot for Three rectangular gap coupled Microstrip Patch Antenna

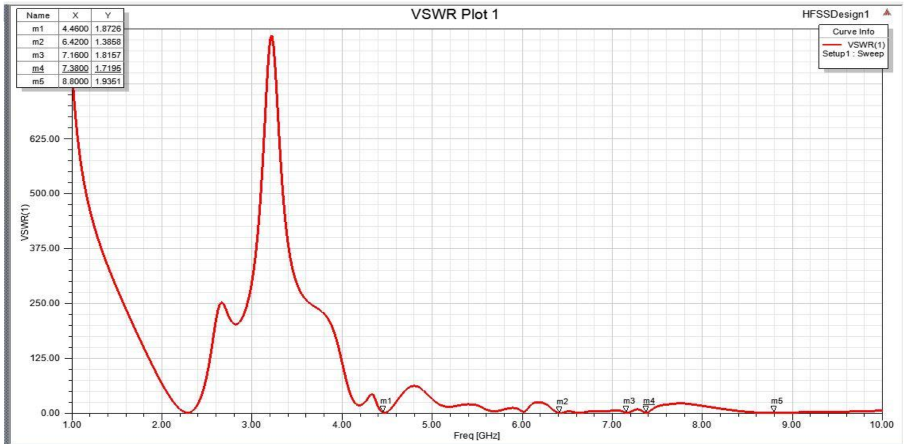

Figure: 8. VSWR of Three rectangular gap coupled Microstrip Patch Antenna

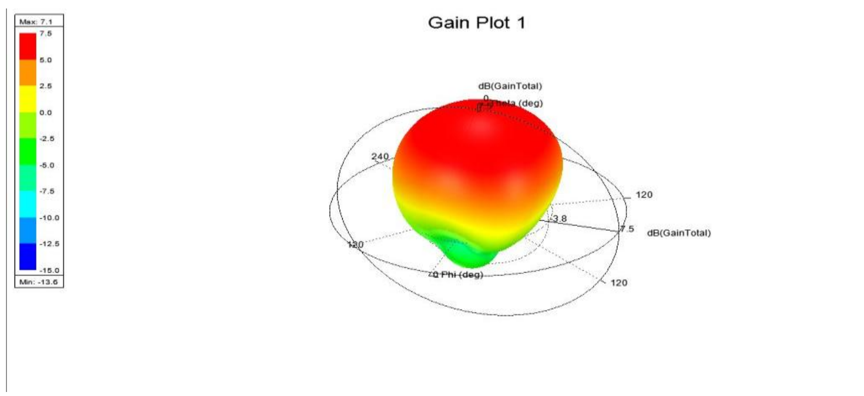

Figure: 9. Gainof Three rectangular gap coupled Microstrip Patch Antenna

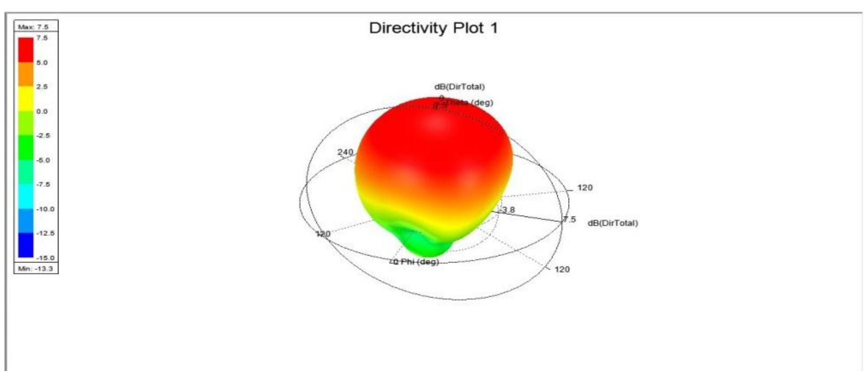

Figure: 10. Directivity of Three rectangular gap coupled Microstrip Patch Antenna

S.no	Patch Type	Resonant Frequency (GHz)	Reflection-coefficient (dB)	VSWR	Gain(dB)	Directivity (dB)	Band Width(GHz)
3	Three Rectangular Gap coupled Patches	4.46 6.42 7.16 7.38	-10.3489 -15.8253 -10.7613 -11.5495	1.8726 1.3858 1.8157 1.7195	7.1	7.5	0.886

		8.8	-9.9355	1.9351			

Table 2: Results of Three Rectangular gap coupled Patch Antenna

IV . Conclusion

From the above work it is concluded with the help of Gap Coupled type of antennas can be designed which are low cost and easily integrated into fashion garments. Lesser values of substrate dielectric constant is useful as it minimizes the surface wave losses and it is also helpful to guide propagation wave inside substrate also low loss substrate material is basic requirement to increase the efficiency is basic requirement to increase the efficiency.

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