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Compact Dual Band Hexagonal Patched Antenna for Ku-band Applications

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Abstract - *A hexagonal patched antenna is proposed in this paper with a split ring resonator in its ground plane. The antenna results in appreciable miniaturized in terms of its overall dimensions and shows a dual band response in terms of its resonant frequencies. The antenna resonates in the Ku-band of the EM spectrum at 8.5GHz and 11.5GHz and finds its application in satellite communication. The overall miniaturization resulted is 45%. The dimensions of the antenna are 15mm×13mm×1.6mm. The peak gain obtained by the antenna is 4.72dB where as the peak directivity is 6.04dB. The resulted antenna efficiency is 78.14%. The antenna also shows an improvement in terms of its bandwidth. The resulted fractional bandwidth of the antenna is 5.45% and 2.22% with the center frequencies of 11.5GHz and 8.5GHz respectively.*

***Key Words*: Hexagonal patched antenna, Split ring resonator, EM spectrum, Ku-band.**

1.INTRODUCTION

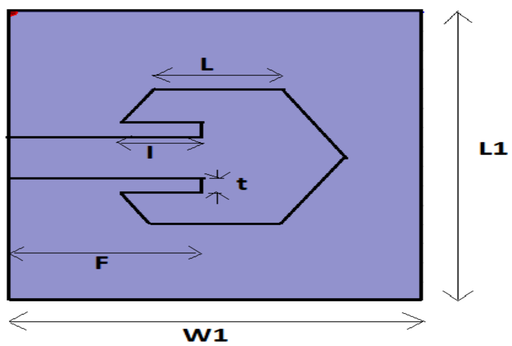
From the last few decades, microstrip antennas attracted number of researchers. The expectations from the antennas got changed as the size of the antenna becomes one of the primary factor for its applicability in any particular application. The antenna employed in any communication device must be compact in its dimensions whereas no compromise has been done in terms of its characteristics. The antenna should be compact as well as has high gain and efficiency. Also it should has a significant bandwidth. The dual, triple or multi band antennas are now also available for particular communication application.

There are multiple approaches that were used in past for compactness in antenna dimensions are inducing irregularities in the ground plane [1]. However, these irregularities may also worsen the antenna fundamental characteristics. The need is to introduce such kind of structures in the antenna configuration that may result in miniaturization of the antenna dimensions as well as do not affect the antenna characteristics[2-4]. These structures can be slots having some specific shapes or resonators that may resonate at specific resonant frequency to decrease the electrical dimensions of the antenna. If these resonating structures are properly deployed either in the patch or in the ground plane of the antenna, these can also increase the fractional bandwidth of antenna at great extent [5-8].

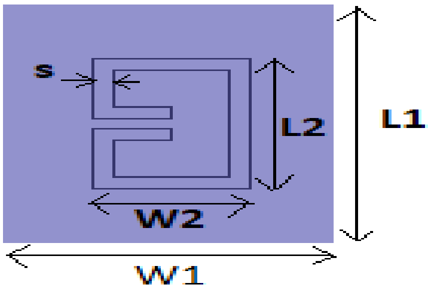
An antenna with hexagonal shaped patch is introduced in this paper. The antenna consists of a split ring resonator in its ground plane. The suggested antenna results in dual band characteristic with sufficient fractional bandwidth. Due to the deployment of split ring resonator in the antenna ground plane, an appreciable percentage of miniaturization is also resulted. The compact antenna is showing good response in terms of antenna gain and efficiency. The antenna finds its application in the Ku-band of the electromagnetic spectrum. The Ku-band of the electromagnetic spectrum is specifically reserved for satellite communication.

2. ANTENNA GEOMETRY

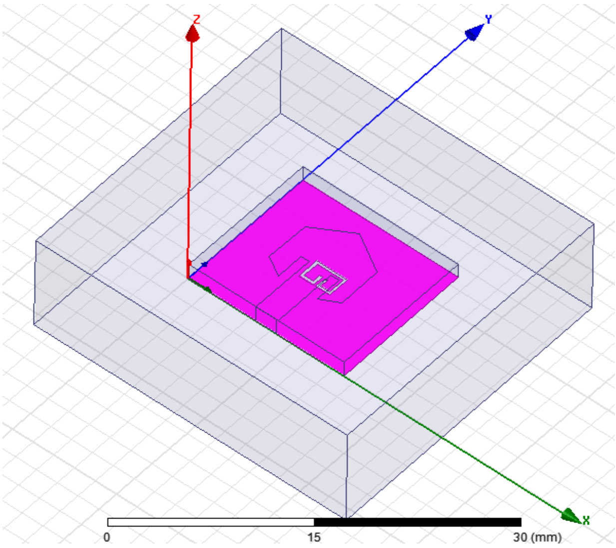
The basic geometry of the antenna is same as that of the fundamental patch antenna in which a substrate is sand witched between the patch and a conducting ground plane. The shape of the patch is chosen to be regular hexagon. The patch is fed with microstrip line which is connected using inset feed method to avoid stray fields. The substrate used is FR4 epoxy substrate having a dielectric constant of 4.4 and loss tangent of 0.04. The height of the substrate is taken to be 1.6mm. A split ring resonator is deployed in the ground plane of the microstrip antenna. The antenna resonate at two frequencies, one due to the hexagonal patch and other one is introduced due to split ring resonator. The top and bottom view of the proposed antenna are shown in the figure 1.



(a) Top view



(b) **Ground plane**



(c) **hfss view**

Fig.1. Proposed Antenna Geometry

The detailed dimensions of the antenna are indicated in the following table:

Table -1: Antenna Dimensions

Parameter	Unit (mm)	Parameter	Unit (mm)
L1	15	L2	3
W1	13	W2	2
F	4	s	0.25
L	4	t	0.5
I	3		

3. MODIFIED GROUND STRUCTURE

The ground plane of the proposed antenna is introduced with a split ring resonator. The split ring resonator is of modified rectangular shaped. The splits in the resonator are of 0.25mm. These splits are equivalent to a capacitance in which the substrate behave like a dielectric material whereas conducting ground behave like conducting strips. Also, the rectangular resonator ring behaves like an inductance. The combination of inductance and capacitance resonates at particular resonant frequency when excited by the fields generated by the patch. The fields from the patch reaches ground plane by travelling through the substrate.

This resonating structure either absorb the reached electromagnetic fields or reflect them back towards the patch and hence, it also reduce the surface wave losses in the antenna. The standard for the return loss of any antenna is -10dB which is considered as the reference line. The suggested hexagonal patched antenna results in the return loss of -13.29dB at the resonant frequency of 8.5GHz and -16.74dB at the resonant frequency of 11.5GHz. The plot for the return loss is shown in fig.

4. RESULTS AND DISCUSSIONS

4.1. RETURN LOSS

The standard for the return loss of any antenna is -10dB which is considered as the reference line. The suggested hexagonal patched antenna results in the return loss of -13.29dB at the resonant frequency of 8.5GHz and -16.74dB at the resonant frequency of 11.5GHz. The plot for the return loss is shown in figure 2.

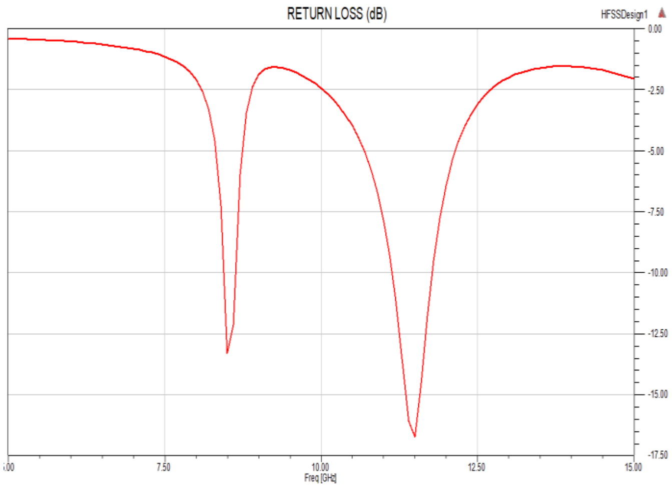


Fig.2. Return loss (dB) vs frequency plot

4.2. FRACTIONAL BANDWIDTH

The fractional bandwidth of the antenna is calculated around the resonating frequencies which is called as the center frequencies. The fractional bandwidth for this antenna is 2.22% with the center frequency of 8.5GHz and 5.45% with the center frequency of 11.5GHz.

4.3. ANTENNA GAIN

The hexagonal patched antenna shows an improvement in terms of antenna gain. The gain resulted for this antenna is 0.11dB and 4.72dB at 8.5GHz and 11.5GHz respectively. The antenna characteristic depicting antenna gain with respect to frequency are shown in the figure 3.

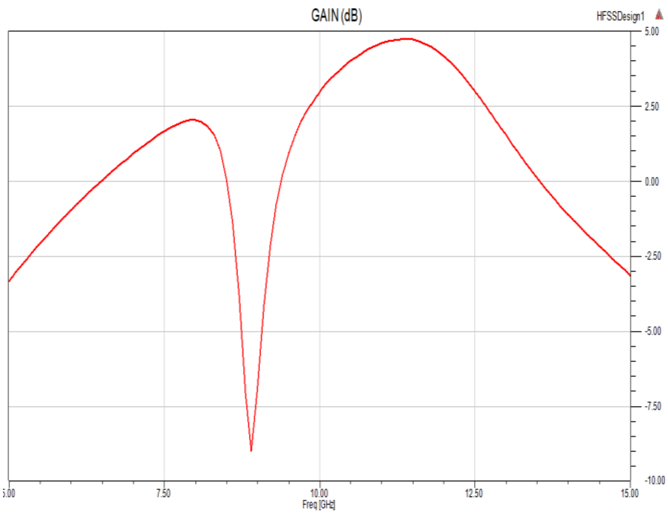


Fig.3. Antenna gain (dB) vs frequency

4.4. DIRECTIVITY

The antenna directivity for the given antenna is 4.14dB and 6.04dB at 8.5GHz and 11.5GHz respectively. The antenna characteristics depicting antenna directivity with respect to the frequency is shown in the figure 4.

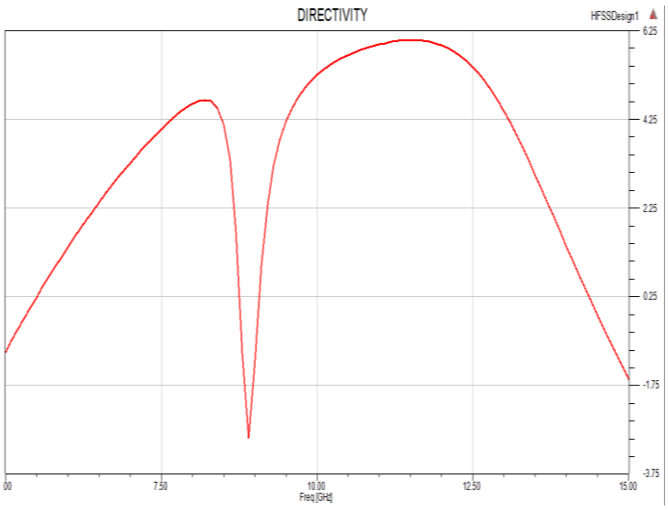


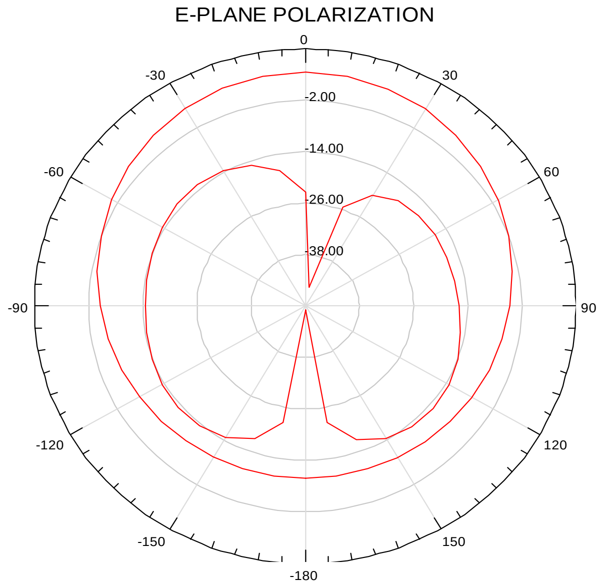
Fig.4. Directivity (dB) vs frequency plot

4.5. POWER EFFICIENCY

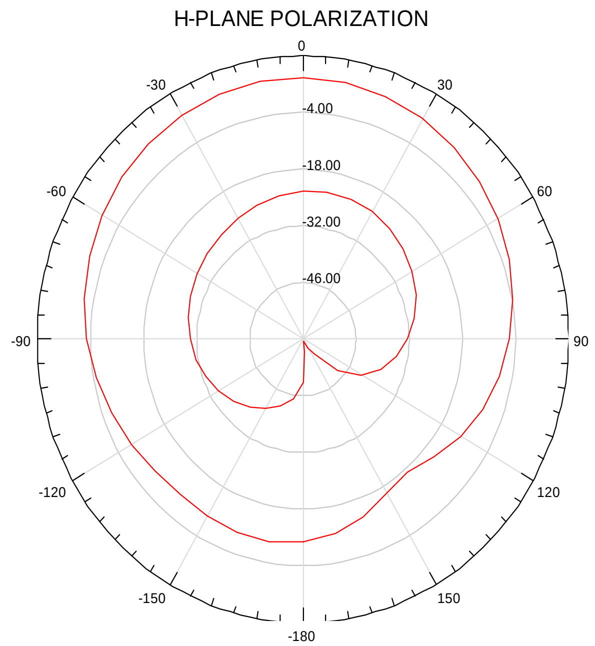
The power efficiency of a microstrip antenna is calculated with the help of antenna's gain and directivity. The proposed antenna results in an efficiency of 78.14% with respect to peak gain and peak directivity.

4.6. POLARIZATION CHARACTERISTICS

Antenna polarization characteristics are drawn by taking phi=0° for E-plane and phi=90° for H-plane polarization. Co and cross polarization for the proposed antenna for both E and H-plane are shown in the figure 5.



(a)



(b)

Fig.5. Antenna Polarization Characteristics

4.7. RADIATION PATTERN

The proposed hexagonal patched antenna results in an semi-omnidirectional radiation pattern. The radiation pattern of the suggested antenna in terms of angles theta and phi is depicted in the figure 6.

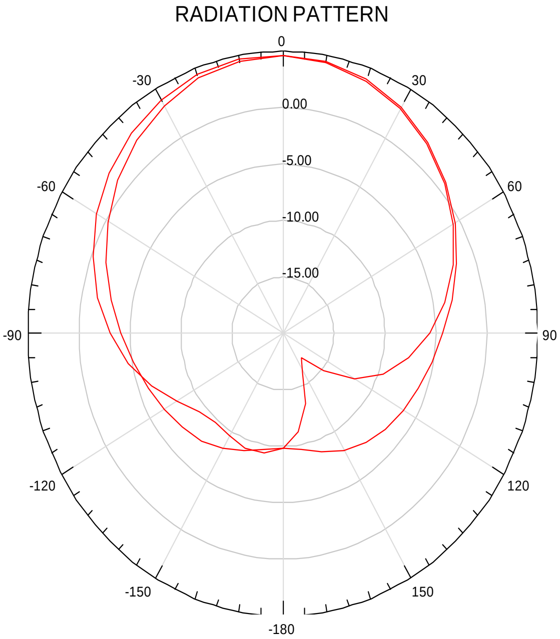


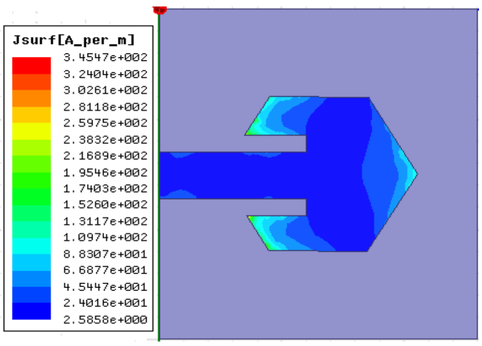
Fig.6. Radiation Pattern of proposed antenna

4.8. MINIATURIZATION

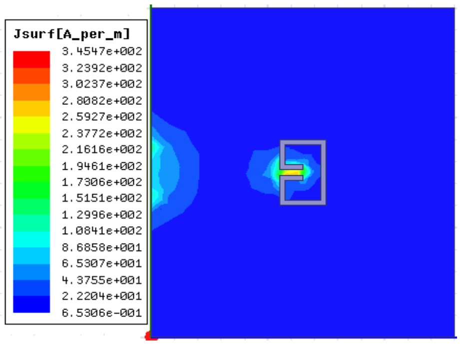
A comparison of the dimensions of the proposed antenna with that of the standard antenna at same resonant frequency is conducted at both the resonant frequencies of the antenna. At 8.5GHz, the standard antenna dimensions should be 20.3mm×17.3mm×1.6mm i.e. the overall area of the antenna will be 351.2mm^2 where the area of the proposed antenna is 195mm^2. Hence at 8.5GHz, the proposed antenna results in the miniaturization of 45%. Whereas, at 11.5GHz, the standard antenna dimension should be 17.6mm×15.1mm×1.6mm. The area required at 11.5GHz is 265.8mm^2. Hence, the miniaturization resulted at this frequency is 27%.

4.9. CURRENT DISTRIBUTION

The current distribution patterns are drawn for both patch and ground surface and depicted in the figure7.



(a)

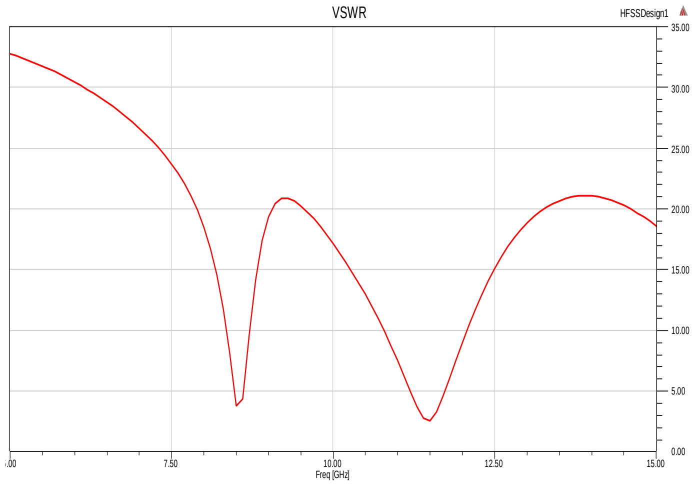


(b)

Fig.7. Current distribution in patch and ground

4.10. VOLTAGE STANDING WAVE RATIO

The impedance matching characteristics of the hexagonal patched antenna is depicted through its voltage standing wave ratio. The VSWR resulted for the proposed antenna is 3.81 at 8.5GHz and 2.54 at 11.5GHz. The plot for the VSWR is shown in the figure 8.



5. CONCLUSION

In the proposed, a microstrip patch antenna is modified to improve its characteristics as well as getting an appreciable amount of miniaturization in the antenna dimensions. The proposed antenna succeeded in enhancing the fractional bandwidth of antenna to 5.45%. The results also shows an appreciable value of gain at 11.5GHz. The antenna is dual band resonating and a notch window exists between the two bands. Both the bands lies in the Ku-band of the electromagnetic spectrum. Ku band is specifically used in the direct satellite communication in case of televisions. The antenna finds its application in the satellite communication.

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