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New slotting technique of making compact octagonal patch for four band applications

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ABSTRACT: An improved but simple four band octagonal patch with new slotting technique of making a compact patch antenna is presented, which is suitable for C-band, X-band, Ku-band and K-band applications. This compact microstrip antenna realized by changing the geometric shape, obtained by inserting small circular slots in a new way. The simulation has been performed by simulation software GEMS version 7.71.01 and using Taconic TLY-5 dielectric substrate with relative permittivity 2.2 and height 1.588mm. The simulated return losses are obtained -16.50dB, -17.25dB, -39.22dB and -30.75dB at 7.49GHz, 10.89GHz, 15.70GHz and 20.10GHz respectively. Therefore, this antenna can be applicable for C-band, X-band, Ku-band and K-band applications respectively.

KEYWORDS: Octagonal patch, Four band patch antenna, Novel patch, Circular slots, Compact patch, Multi-band patch.

1 INTRODUCTION

Microstrip antennas are also referred to as patch antennas. The radiating elements and the feed lines are usually photo etched on the dielectric substrate. The radiating patch may be square, rectangular, thin strip, circular, elliptical, triangular etc. [1]. Here a new octagonal patch antenna is presented which operate in multi-band applications.

A microstrip antenna could be made compact through a number of methods. Some of the methods involve the use of a shorting pin, while others involve geometrical modification [2]. Here the compact patch is achieved by involving geometric modification.

With the rapid growth of the wireless communication system the future technologies need a very small and multiband antenna. Nowadays, people demand multiband wireless phone supporting more than one network, having different frequencies and simultaneous transmission of audio, video and data. These services are possible with the help of microstrip patch antenna having multiband characteristics. Modern wireless communication system also requires low profile, light weight, high gain, ease of installation, high efficiency, simple in structure to assure reliability and mobility characteristics. Microstrip antennas satisfy such requirements. The key features of a microstrip antenna are low profile, relative ease of construction, low weight, comfortable to planar and non-planar surfaces, low cost, simple and inexpensive to manufacture by using printed circuit board. These advantages of microstrip antennas make them popular in many wireless communication applications such as satellite communication, radar, medical applications, aircraft, spacecraft, and missile applications [3, 4, 5, 6, 7]. Many researchers have designed a single element patch in different way to gate multiband application such as double PIFA [8], U-slot [9], double U slot, E slot, H slot and other structures.

We know that C-band, X-band, Ku-band and K-band are worked at 4-8GHz, 8-12GHz, 12-18GHz and 18-27GHz respectively [10].

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In this paper the antenna is designed to support 7.49GHz, 10.89GHz, 15.70GHz, and 20.10GHz frequencies. So, this antenna is able to meet the demand of C-band, X-band, Ku-band and K-band applications. This frequency can be changed by varying the antenna size and geometrical modification. Here the simulation has been done by simulation software GEMS simulator version 7.71.01 with substrate height 1.588mm, Taconic TLY-5 dielectric substrate with permittivity 2.2 is used.

2 DESIGN OF PROPOSED ANTENNA

Microstrip antenna consists of a thin film. This strip of thin film placed on ground plane where the thickness of the metallic strip is restricted by $t<<\lambda_0$ and height is restricted by $0.000\lambda_0 \leq h \leq \lambda_0$ [1, 11, 12, 13]. The strip and ground plane are separated by a dielectric sheet referred to as the substrate. There are numerous substrates that can be used for the design of microstrip antennas and their dielectric constants are usually in the range of $2.2 \leq \varepsilon_r \leq 12$ [1, 11, 12, 13]. The performance of the microstrip antenna depends on its dimension. Depending on the dimension the operating frequency, radiation efficiency, directivity, return loss and other related parameter are also influenced [14, 15].

The proposed antenna consists of ground plane, dielectric substrate, and metallic octagonal patch. The patch has a simple octagonal structure fed by 50Ω microstrip line. The dielectric material selected for the design is Taconic TLY-5 which has dielectric constant of 2.2 and height of the substrate is 1.588mm. The length of the microstrip transmission line is 7.2mm and width is 1mm. The octagonal patch shown in Fig.1 has two types of arm one type has 6.4mm length and other type has 6.34mm length.

Fig. 1 shows the proposed compact microstrip patch antenna. Here the proposed antenna is obtained by inserting circular slots, like as the slots are created a circular ring into the octagonal patch. Each slot has 0.5mm radius and distance between the centre point of the patch and centre point of the slot is 5mm. After inserting slots into the patch its shape is changed and acts as a compact patch.

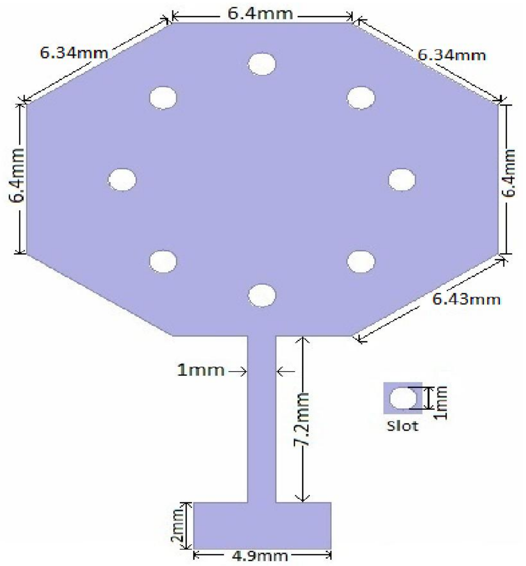

Fig. 1. Proposed compact microstrip patch antenna

3 SIMULATION RESULT AND DISCUSSION

The simulation results of return loss, directivity and radiation pattern for compact patch antenna are shown below.

The simulated compact patch antenna is operating at 7.49GHz, 10.89GHz, 15.70GHz and 20.10GHz. The corresponding return loss are -16.50dB, -17.25dB, -39.22dB and -30.75dB respectively and are shown in Fig.2. The gain at 7.49GHz, 10.89GHz, 15.70GHz and 20.10GHz are 5.654dBi, 5.0dBi, 5.35dBi and 3.47dBi respectively. Also the -10dB bandwidth is obtained 0.303GHz, 0.652GHz, 0.801GHz and 1.92GHz respectively. The directivity at 7.49GHz, 10.89GHz, 15.89GHz and 20.10GHz are 6.344dB, 5.82dB, 6.311dB and 6.46dB respectively and are shown in Fig.3. The 2D radiation pattern at 7.49GHz, 10.89GHz, 15.70GHz and 20.10GHz are shown in Fig. 4(a) and 4(b).

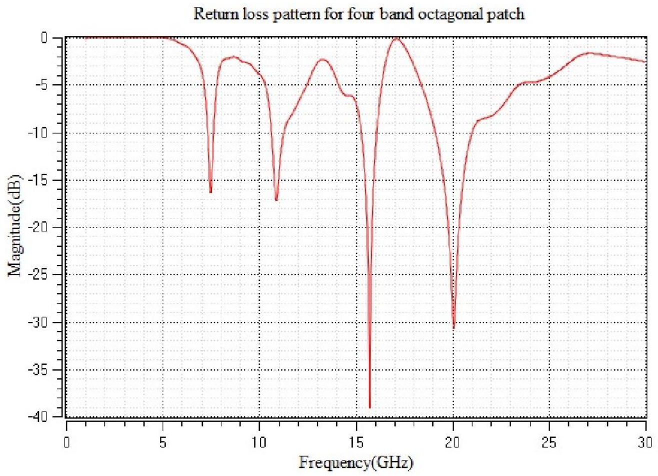

Fig. 2. Return loss pattern for octagonal compact patch.

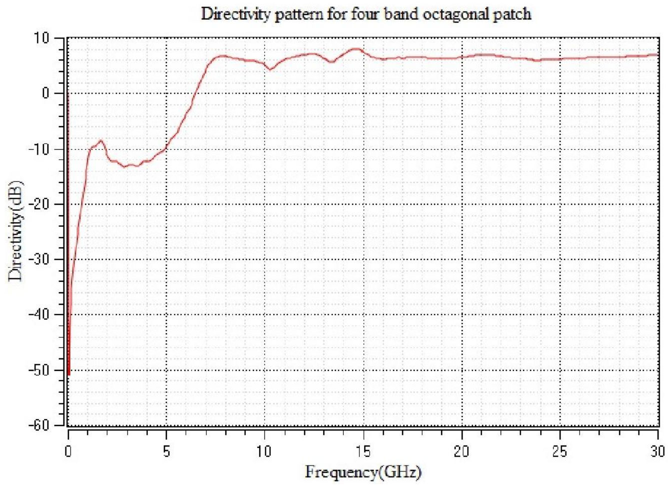

Fig. 3. Directivity pattern for octagonal compact patch.

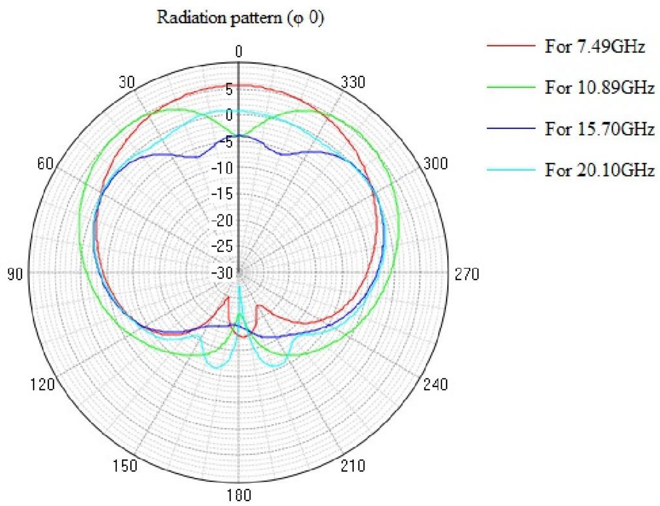

Fig. 4(a). Radiation Pattern (2D polar phi0^0) at 6.7GHz, 10.85GHz, 14.15GHz and 19.50GHz.

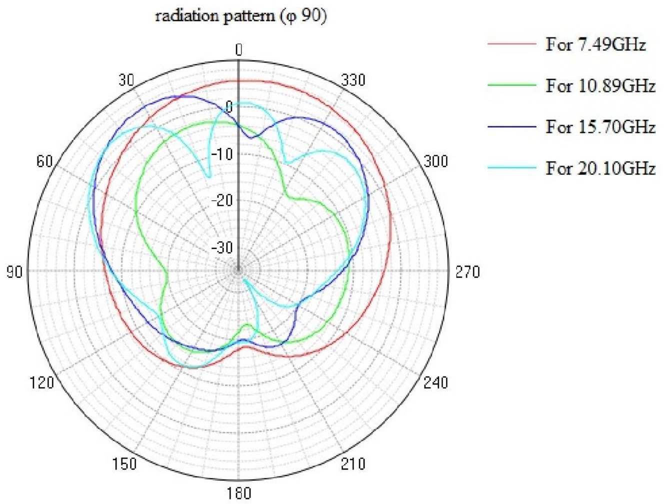

Fig. 4(b). Radiation Pattern (2D polar phi90^0) at 6.7GHz, 10.85GHz, 14.15GHz and 19.50GHz.

The far field pattern is shown in Fig.5, Fig.6, Fig.7 and Fig.8 for 7.49GHz, 10.89GHz, 15.89GHz and 20.10GHz. Here the far field is the value generated by 1V voltage at the 1 meter away from the antenna.

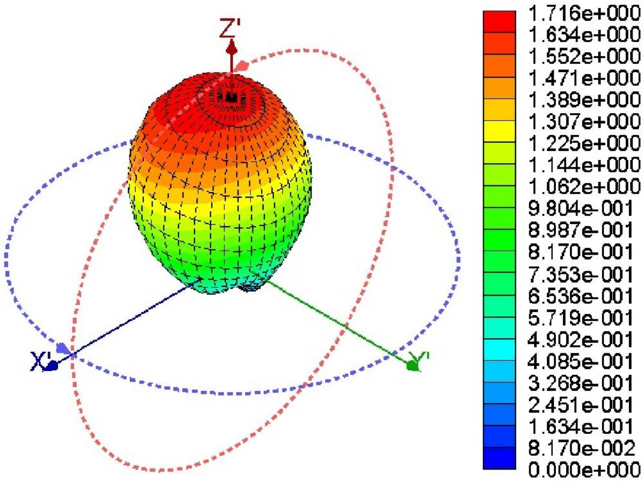

Fig. 5. Far field pattern for 7.49GHz (C-band).

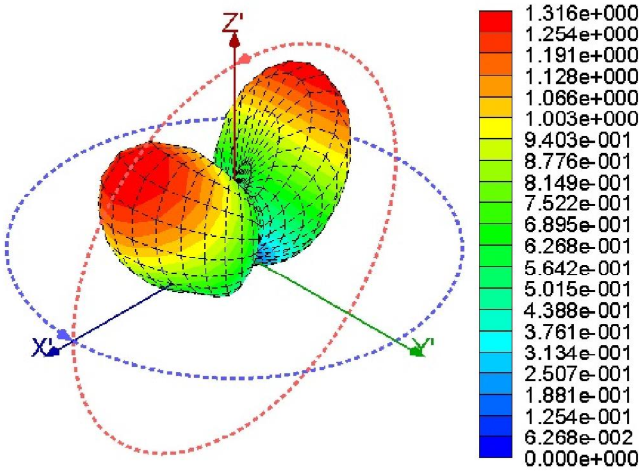

Fig. 6. Far field pattern for 10.89GHz (X-band).

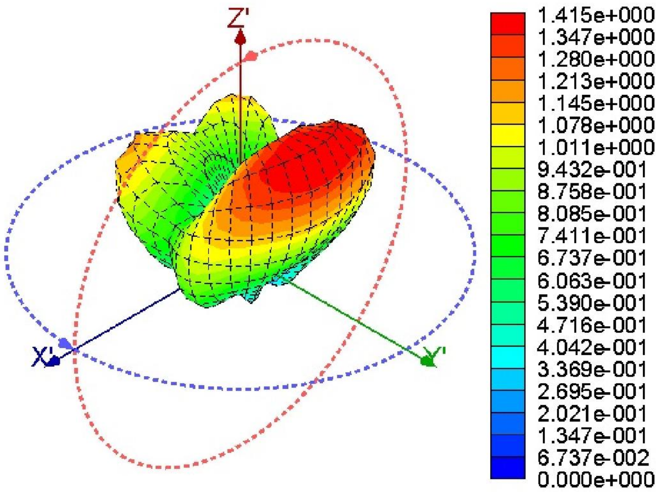

Fig. 7. Far field pattern for 15.70GHz (Ku-band).

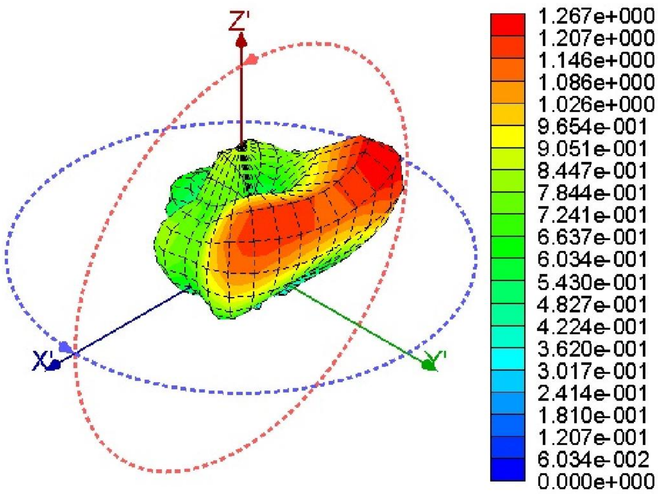

Fig. 8. Far field pattern for 20.10GHz (K-band).

After observing the performance analysis graph and pattern of octagonal compact patch antenna the obtained results are tabulated below for better analysis.

Table 1. Simulation results for compact patch at 7.49 GHz, 10.89 GHz, 15.70 GHz and 20.10 GHz.

Performance Parameter	Unit	Compact patch antenna			
		For 7.49GHz (C-band)	For 10.89GHz (X-band)	For 15.70GHz (Ku-band)	For 20.10GHz (K-band)
Simulated return loss	dB	-16.50	-17.25	-39.22	-30.75
Directivity	dB	6.344	5.82	6.311	6.46
-3dB bandwidth	GHz	1.039	3.312	2.828	7.867
-10dB bandwidth	GHz	0.303	0.652	0.801	1.92
Gain	dBi	5.654	5.00	5.35	3.47
Radiated power	mW	73.21	128.94	189.66	172.15

The corresponding graph of tabulated result is shown in figure 9. Here the x axis, y axis and z axis represent operating frequency, return loss and simulated gain respectively.

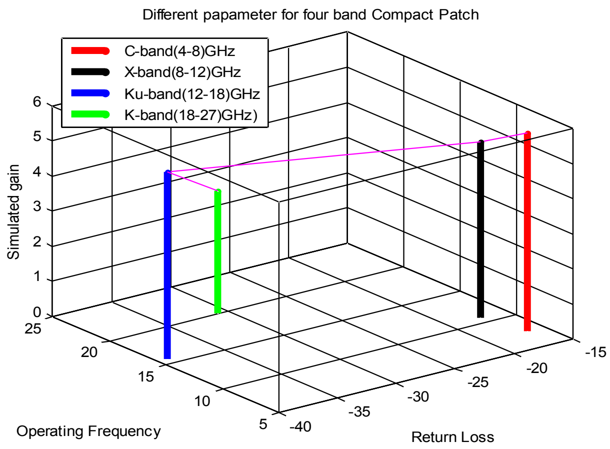

Fig. 9. Different parameter value of compact patch antenna.

After investigation of the above graphs and tabulated results we have reached the following decision-

- ✓ Here we get maximum return losses -16.50dB, -17.25dB, -39.22dB and -30.75dB at 7.49GHz, 10.89GHz, 15.70GHz and 20.10GHz respectively. We know the range for C-band is 4-8GHz; X-band is 8-12GHz, Ku-band is 12-18GHz and K-band is 18-27GHz. So, the antenna proposed in this paper can operated in C-band, X-band, Ku-band and K-band.

- ✓ -10dB bandwidth at C-band, X-band, Ku-band and K-band are 0.303GHz, 0.652GHz, 0.801GHz and 1.92GHz respectively. Here the bandwidth is not narrower for each case. The main disadvantage of any patch antenna is narrow bandwidth; this is not happening for this proposed antenna.

4 CONCLUSION

A new four band compact patch antenna with wideband is presented. This paper demonstrates a compact patch that is operated in C-band, X-band, Ku-band and K-band with corresponding return losses are -16.50dB, -17.25dB, -39.22dB and -30.75dB respectively. Using GEMS solver version 7.71.01 and Taconic TLY-5 dielectric substrate with relative permittivity 2.2 and height 1.588mm has been achieved in simulation.

This new configuration finds applications in various fields. Here the C-band is mainly used in satellite TV channel, satellite navigation etc. The X-band is primary used for medical accelerators, radar and satellite applications etc. The Ku-band is primary used for editing and broadcasting of satellite television, satellite Internet etc. The K-band is used primarily for radar, satellite communications, astronomical observations etc.

In future we will try to improve the return loss and bandwidth. Using this simple octagonal compact patch we will design different types of array such as series feed array, corporate feed array or corporate-series feed array to get higher directivity and higher gain.

Here designed antenna is covered C-band, X-band, Ku-band and K-band operating frequency, but it is possible to design for other specific system such as WLAN, WiMAX etc. applications by changing the antenna size and other parameters.

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