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Quad Band Triangular Ring Slot Antenna

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Abstract- A single layer single patch Quad band triangular ring slot antenna, with linear polarization is proposed which is most suitable for X-band, Ku-band and K-band applications. Impedance bandwidths of 5.56 %, 12.74 %, 11.11% and 3.81% were achieved at central frequencies 8.1 GHz, 15 GHz, 19.22 GHz and 22.77 GHz, with gains of 6.01 dB, 4.20 dB, 4.67 dB and 6.74 dB, respectively. This antenna is made by cutting a triangular ring slot in a triangular patch. The structure has the following advantages: (1) the feed is simple, (2) the antenna has single layer, (3) the structure of the antenna is simple, (4) the antenna is inexpensive. All the simulations are been performed by using commercial electromagnetic software HFSS.

Index Terms - Linear polarization, single layer, single patch, triangular ring slot, Quad band.

1 INTRODUCTION

With the advancements in the information services the single frequency antennas no longer meet the demand of the communication systems. Modern communication systems require multi band multi frequency antennas with low profile and low cost. Several techniques are available for such antenna, including Multi-layer stacked patch technique, shorting pin technique and introducing multiple slots. Among these the slotting technique with its advantages of high gain and simple structure is best solution.

The concept of multi band communication is useful where there is interference in one band and still the other band can work normally. Another advantage is that the user can work on both transmission and reception of signals simultaneously with these antennas.

In [1], a four band linear polarization antenna was achieved by cutting four U-slots in the printed substrate. In [2], a triple frequency antenna was proposed by cutting two semi circular slots in a circular patch antenna. In [4], Dual frequency along with ultra wide bandwidth was achieved by placing a shorting pin in between the ground and radiating element. This has also the advantage of size reduction of the radiating element. In [5], Dual frequency along with wide bandwidth was achieved by varying the position of the feed and the peak gains for the lower and higher bands are very low.

This communication presents a miniaturized, low cost four band linear polarized triangular ring slot antenna that was made by cutting a triangular ring slot in a triangular patch. The Triangular ring slot is introduced to achieve multi band operation. From the simulation studies it is found that the proposed antenna can simultaneously achieve multi-band performance, high gain, low profile and better band isolation. Details of the proposed antenna and its performance are given below.

2 ANTENNA DESIGN AND CONFIGURATION

The geometry of the proposed Quad band linear polarized triangular ring slot patch antenna is shown in the Fig. 1. The Quad frequency high gain performance is achieved by cutting a triangular ring slot in a single layer triangular patch. A square copper sheet with length 14.3 mm was used as the ground plane. A microstrip feed line of length 4 mm and width 0.9 mm was used as feed to the patch. The final optimized parameters of the antenna are listed in Table 1.

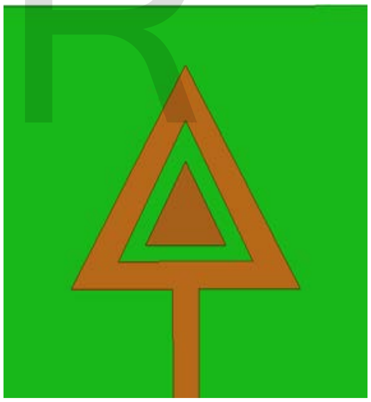

Fig. 1 Geometry of the proposed antenna

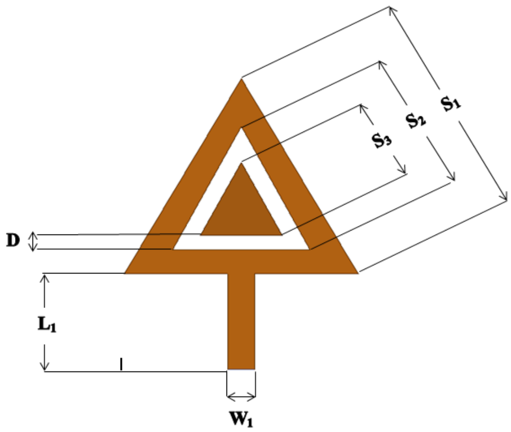

Fig. 2 Geometry of the patch

TABLE 1
OPTIMIZED DIMENSIONS OF THE ANTENNA
(Unit : mm)

Parameter	Value
S_1	8
S_2	4.7
S_3	2.8
D	0.6
L_1	4
W_1	0.9

The strategy was to first design a triangular patch for single frequency of operation, on a square FR4 substrate with a thickness of 2 mm and side length of 14 mm, and then introduce the triangular ring slot to obtain the Quad frequency. The central frequencies of the four bands are required as f_1 = 8 GHz, f_2 = 15 GHz, f_3 = 19.5 GHz and f_4 = 22.5 GHz. Against this background, guidelines for designing the antenna can be summarized as follows.

A conventional triangular patch antenna with parameters L_1, W_1, and S_1 was designed first by using the following approximate formulas [6].

$$f_r = \frac{2c}{3a\sqrt{\epsilon_r}} \tag{1}$$

$$\epsilon_{eff} = \frac{1}{2}(\epsilon_r + 1) + \frac{1}{4}\frac{(\epsilon_r - 1)}{\sqrt{1+\frac{12h}{a}}} \tag{2}$$

$$a_{eff} = a + \frac{h}{\sqrt{\epsilon_r}} \tag{3}$$

$$f_r = \frac{2c}{3a_{eff}\sqrt{\epsilon_{eff}}} \tag{4}$$

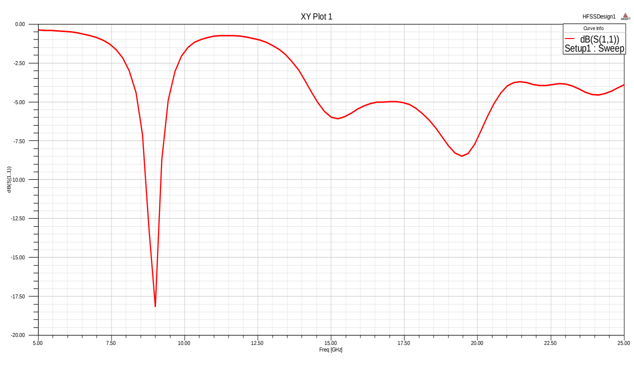

Fig. 3 Return loss for simple triangular patch with side S_1

We can observe that the antenna is radiating only for a single frequency as shown in Fig. 3, now triangular ring slot is introduced into the patch by taking the required central frequency and the 10 dB return loss bandwidth as the objectives, the optimization was carried out by fine tuning the dimensions, especially S_2, S_3 and D by using the commercial software HFSS and the quad band was achieved as shown in the Fig. 4

3 RESULTS

This antenna is designed and optimized with the aid of Ansoft HFSS ver. 14.0. The S-parameter (return loss) of the proposed antenna is shown in the Fig. 4. It can be seen that the impedance bandwidth covers (7.87 – 8.32) GHz, (14.21-16.14) GHz, (17.88 - 19.98) GHz and (22.38 – 23.25) GHz with center frequencies of 8.1 GHz, 15 GHz, 19.22 GHz and 22.77 GHz and a return loss of -15.68 dB, -28.20 dB, -22.54 dB and -10.53 dB respectively.

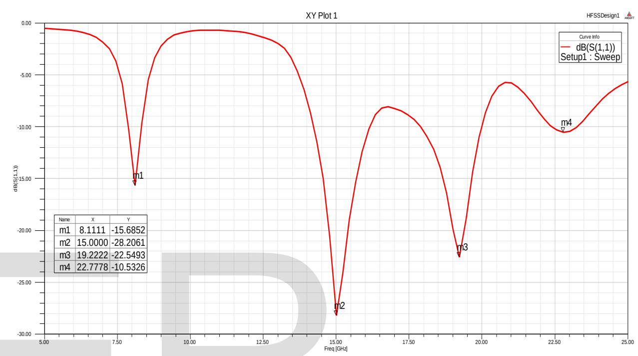

Fig. 4 Simulated reflection coefficients of triangular ring slot antenna

Reflection coefficients of conventional triangular patch antenna and triangular ring slot antenna are compared and shown in the Fig. 5. The dotted line represents the plot of triangular patch antenna and the continuous line represents the plot of triangular ring slot antenna

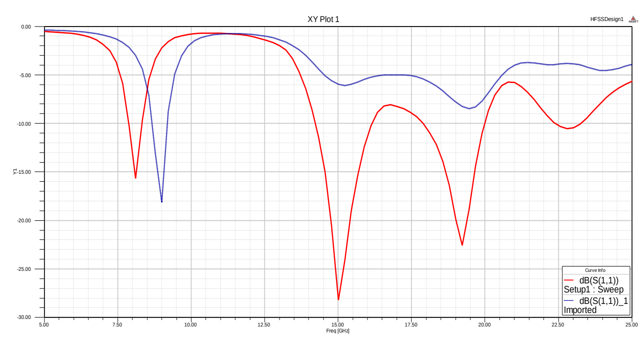

Fig. 5 Simulated reflection coefficients of triangular patch and triangular ring slot antenna

A minimum peak gain of 4.20 dB and a maximum peak gain of 6.74 dB is observed in the entire bandwidth and are shown in the Figs. 6,7,8 and 9.

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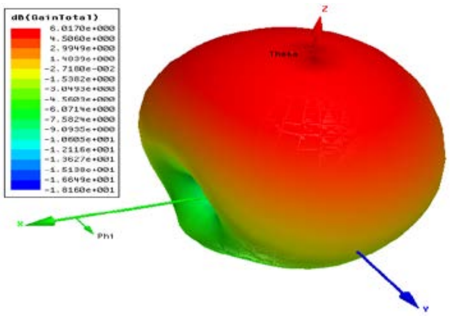

Fig. 6 Gain plot at 8.1GHz

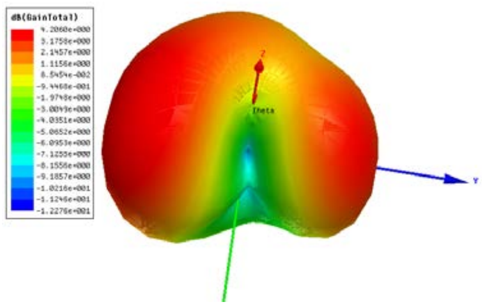

Fig. 7 Gain plot at 15 GHz

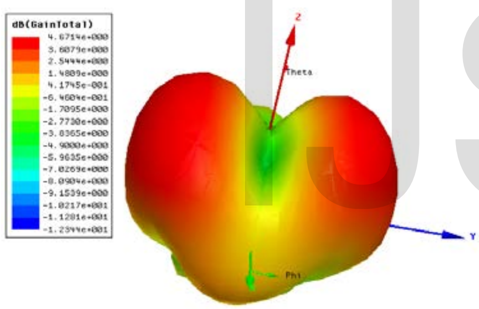

Fig. 8 Gain plot at 19.22 GHz

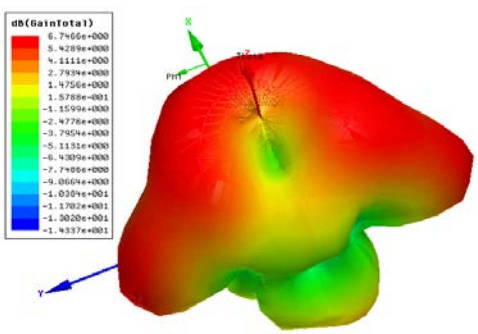

Fig. 9 Gain plot at 22.77 GHz

The radiation patterns E-Plane and H-Plane of the antenna at different resonating frequencies are shown in the Figs. 10,11,12,13 and Figs. 14,15,16,17 respectively, from this it is observed that the proposed antenna is a Omni Directional which is well suited for the wireless communication applications.

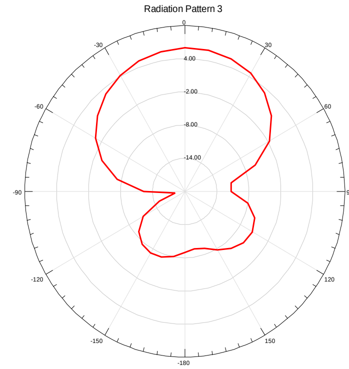

Fig. 10 E - Field at 8.1 GHz

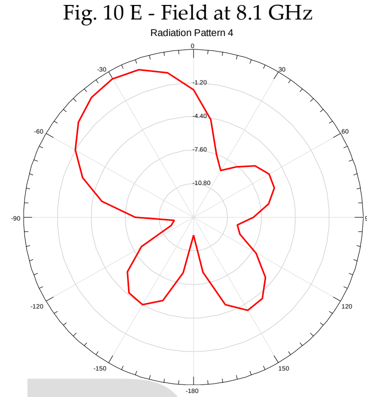

Fig. 11 E - Field at 15 GHz

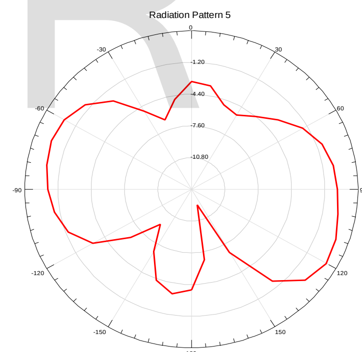

Fig. 12 E - Field at 19.22 GHz

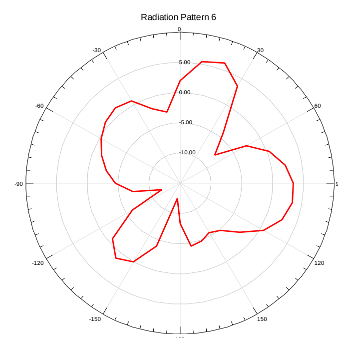

Fig. 13 E - Field at 22.77 GHz

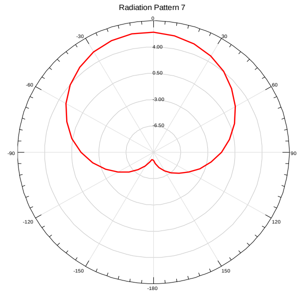

Fig. 14 H - Field at 8.1 GHz

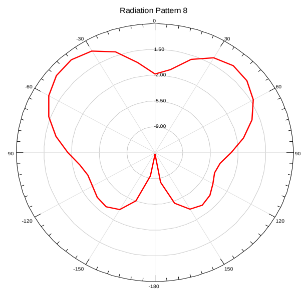

Fig. 15 H - Field at 15 GHz

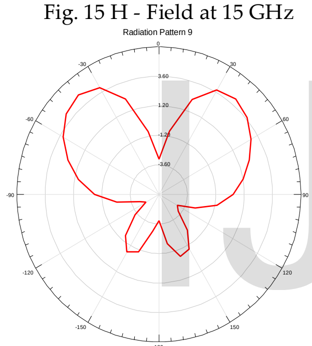

Fig. 16 H - Field at 19.22 GHz

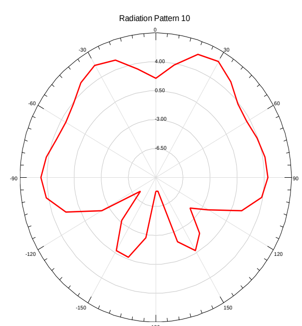

Fig. 17 H - Field at 22.77 GHz

4 CONCLUSION

This communication presents a simple geometry of a Quad Band Triangular Ring Slot Antenna. This antenna has a Triangular ring slot and is fed by strip feed. The antenna can be easily operate at 8.1 GHz, 15 GHz, 19.22 GHz and 22.77 GHz. The antenna has a impedance bandwidths of 5.56 %, 12.74 %, 11.11% and 3.81% at four different bands. The peak gains are 6.01 dB, 4.20 dB, 4.67 dB and 6.74 dB. When higher gain is required the proposed antenna can be used to form an array.

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