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Design of a Corner Cut Rectangular Microstrip Antenna Having T- Slot for Wi-fi, RADAR and Satellite Applications

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Abstract—A corner cut microstrip patch antenna having T slot with small microstrip line feed is presented here. Different design parameters with their effects are studied using v11 Ansoft HFFS. For the operational frequency of 2.35 GHz(2330-2420MHz), 3.71 GHz(3600-3758MHz), 4.12 GHz(4000-4165MHz), 4.75 GHz(4700-4834) and 9 GHz(8860-9185) VSWR bandwidth between 1.5 & 1 and maximum return loss bandwidth up to -28.75dB has been obtained. T slot at the centre and corner cut used here plays an important role in balancing resistive part and reactive part which affect the impedance matching. T slot at the centre increases radiating edges which results in improved bandwidth. The results demonstrate that the proposed antenna with T slot and corner cuts at special position can generate steady radiation patterns and is capable of wrapping the frequencies demanded by Wireless Applications.

Keywords— – Microstrip antenna, T-slot antenna, Return loss, VSWR, RADAR.

I. INTRODUCTION

In modern wireless communication systems, antennas are required to be simple in structure, compact in size, and stable in radiation patterns while retaining an extremely broad operating frequency range[1]. However, the design of a wideband antenna is not an easy task, especially for a portable device since a compromise between the size, cost, and bandwidth has to be achieved simultaneously. Recently, printed planar slot antennas have become very attractive for wireless systems due to their low profile, wide bandwidth, compact size, ease of fabrication, etc. When a slot antenna is fed by a micro strip line, it does not add weight and size to the system and is suitable for portable applications[2]. A corner cut microstrip patch antenna having T slot with small microstrip line feed is presented here. Different design parameters with their effects are studied For the operational frequency of 2.35GHz, 3.71GHz, 4.12GHz, 4.75GHz and 9 GHz VSWR bandwidth nearly 1 and return loss bandwidth up to -28.57dB has been obtained. T slot and corner cut used here plays an important role in balancing resistive part and reactive part and reactive part which affect the impedance matching T slot at the centre increases radiating edges which results in improved bandwidth. Simple rectangular antenna can be resonated frequency ranging from 1 to 9 GHz range. It can be resonated only at one frequency at a time which is not suitable for multiband operation, but with

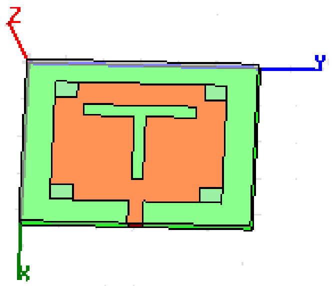

Fig. 1 Geometry of the proposed antenna

the addition of different type of slots antenna can be resonated at more than one frequency at a single time which can be used for multiple operation. These multiple tuning capabilities are used for Wireless applications . The shape of these slots may be any type which may be triangular, circular or polygonal. Slots geometry may vary or any alphabet.
Detailed Antenna design dimensions are given below.

II. ANTENNA DESIGN

The antenna substrate is placed above the ground plane, ROGERS 3210 is used as a substrate with dielectric constant=10.2, loss tangent=0.003, and thickness h=2.6mm. The design of antenna is used for the operational frequencies which are based on the formulae available from standard books which are given below in designing equations:

Step 1: Calculation of the Width (W):
The width of the Microstrip patch antenna is given as:

$$W = \frac{c}{2 f_o \sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

Step 2: Calculation of Effective dielectric constant (ε_{reff}):
The effective dielectric constant is:

$$\varepsilon_{reff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

Step 3: Calculation of the Effective length (L_{eff}):
The effective length is:

$$L_{eff} = \frac{c}{2 f_0 \sqrt{\varepsilon_{eff}}}$$

Step 4: Calculation of the length extension (ΔL):
The length extension is:

$$\Delta L = 0.412h \frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

Step 5: Calculation of actual length of patch (L):
The actual length is obtained by:

$$L = L_{eff} - 2\Delta L$$

A typical set of dimensions for antenna design is given in Table 1. The effective permittivity of the single layer configuration is found 10.2. Specification of the antenna for 2.8 GHz are length 16mm, width 23 mm, length of feed strip 3 mm, width of feed strip 2 mm . Other designing parameters are given in table 1 which is given below :

Table I

Parameter	**Size in mm**
Size of substrate (ROGERS 3210)	22×31×2.6 mm
Size of patch	16×23mm
Size of corner cut	2×3mm
Size of strip	3×2mm
Size of arms of T slot	10×1.5mm 1.5×15mm
Size of ground plane	22×31mm
Tangent loss of substrate	.003(dimensionless)
Dielectric Constant of substrate	10.2(dimensionless)

Using HFFS we make geometry of antenna which given on Previous page (fig. 1)-

III. RESULT AND DISSCUSSIONS

As discussed previously ,A corner cut microstrip patch antenna having T slot with small microstrip line feed is presented here. Different design parameters with their effects are studied. For the operational frequency of 2.35 GHz(2330-2400MHz), 3.71 GHz(3600-3758MHz), 4.12 GHz(4000-4165MHz), 4.75 GHz(4700-4834) and 9 GHz(8860-9185) VSWR bandwidth nearly 1.07 and maximum return loss bandwidth up to -28.57 dB has been obtained. T

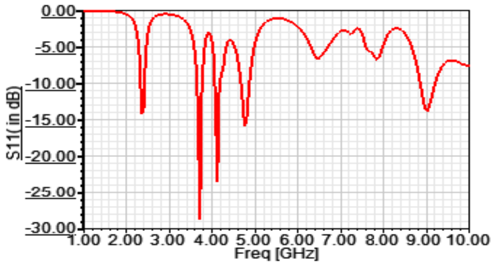

Fig. 2 s11 parameter of Proposed antenna slot and corner cut used here plays an important role in balancing resistive part and reactive part which affect the impedance matching. T slot at the centre increases radiating edges which results in improved bandwidth[4][5]. A thick dielectric substrate is helpful in increasing the bandwidth. Simple rectangular antenna can be resonated frequency ranging from 1 to 9 GHz range. It can be resonated only at one frequency at a time which is not suitable for multiband operation, but with the addition of different type of slots antenna can be resonated at more than one frequency at a single time which can be used for multiple operation. These multiple tuning capabilities are used for wireless as well as Wireless applications. The shape of these slots may be any type which may be triangular, circular or polygonal. Slots geometry may vary or any alphabet. In our antenna design s11 has value -14.20 , -28.57 , -23.41 , -15.87 and -13.82 dB at freq. of 2.35 GHz, 3.71 GHz, 4.12 GHz, 4.75 GHz and 9 GHz respectively which gives perfect matching and shown above on previous page in (fig. 2).

For above three bands range of higher frequency (f_H) and lower frequency (f_L) is given below.

- For Wi-Fi application band

  f_L (Lower freq.)= 2330 MHz
  f_H (Higher freq.)= 2420 MHz
  f_C (Centre freq.) =2353 MHz
  Bandwidth = 90 MHz

- For S band application of RADAR

  f_L (Lower freq.)= 3600 MHz
  f_H (Higher freq.)= 3758 MHz
  f_C (Centre freq.) =3713 MHz
  Bandwidth = 158 MHz

- For C band application of Satellite & RADAR

  f_L (Lower freq.)= 4000 MHz
  f_H (Higher freq.)= 4165 MHz
  f_C (Centre freq.) = 4120 MHz
  Bandwidth = 165 MHz

- For C band application of Satellite & RADAR

  f_L (Lower freq.)= 4700 MHz
  f_H (Higher freq.)= 4834 MHz
  f_C (Centre freq.) =4753 MHz
  Bandwidth = 134 MHz

- For X Band application of RADAR

  f_L (Lower freq.)= 8860 MHz
  f_H (Higher freq.)= 9185 MHz
  f_C (Centre freq.) = 9005 MHz
  Bandwidth = 325 MHz

The parameter VSWR is a measure that numerically describes how well the antenna is impedance matched to the radio or transmission line it is connected to. VSWR stands for Voltage Standing Wave Ratio, and is also referred to as Standing Wave Ratio (SWR). VSWR is a function of the reflection coefficient, which describes the power reflected from the antenna[6].

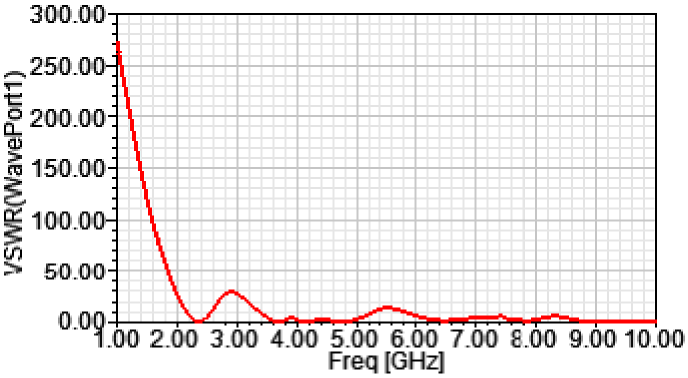

Fig. 3 VSWR of Proposed Antenna

The VSWR is always a real and positive number for antennas. The smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is delivered to the antenna. The minimum VSWR is 1.0. In this case, no power is reflected from the antenna, which is ideal. Often antennas must satisfy a bandwidth requirement that is given in terms of VSWR[7][8]. For instance, an antenna might claim to operate from 100-200 MHz with VSWR<3. This implies that the VSWR is less than 3.0 over the specified frequency range. This VSWR specifications also implies that the reflection coefficient is less than 0.5 (i.e. r <0.5) over the quoted frequency range[9][10]. The fig. 3 shows the VSWR of the proposed antenna which is given above in fig. 3 .

The radiation pattern of an antenna is a plot of the far-field radiation properties of an antenna as a function of the spatial co-ordinates which are specified by the elevation angle θ and the azimuth angle φ . More specifically it is a plot of the power radiated from an antenna per unit solid angle which is nothing but the radiation intensity [11]. Let us consider the case of an isotropic antenna. An isotropic antenna is one which radiates equally in all directions. If the total power radiated by the isotropic antenna is *P*, then the power is spread over a sphere of radius *r*. An isotropic antenna is not possible to realize in practice and is useful only for comparison purposes[12]. A more practical type is the directional antenna which radiates more power in some directions and less power in other directions. A special case of the directional antenna is the omni-directional antenna whose radiation pattern may be constant in one plane (e.g. E-plane) and varies in an orthogonal plane (e.g. H-plane). The fig. 4 shows the Radiation pattern of the proposed antenna which is given below:

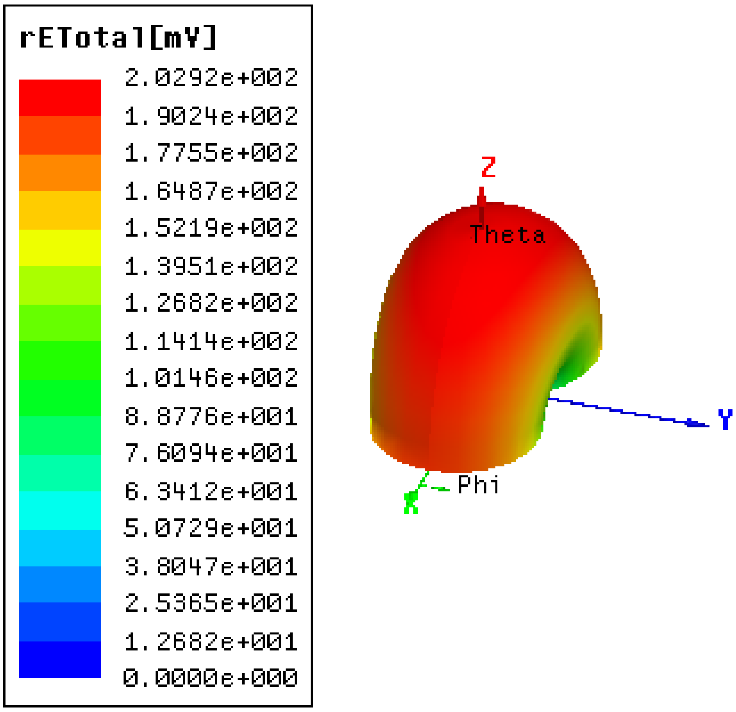

Fig 4 Radiation pattern of proposed antenna

The simulated antenna radiation pattern for the Proposed antenna has shown in figure 5 which is given below . This pattern shows the normalized directivity pattern at different values and which are adjusted according to requirement of simulated geometryThe entire pattern shows that antenna has good return loss at respective frequencies.

A compact rectangular microstrip antenna with microstrip line feed for penta narrow band wireless communications systems is designed in HFSS and fabricated on ROGERS 3210. The results demonstrate that the proposed antenna with T slot and corner cuts at special position can generate steady radiation patterns and is capable of wrapping the frequencies demanded by Wireless applications. Good agreement between the simulated and measured results further validates the utility of presented antenna for proposed applications.

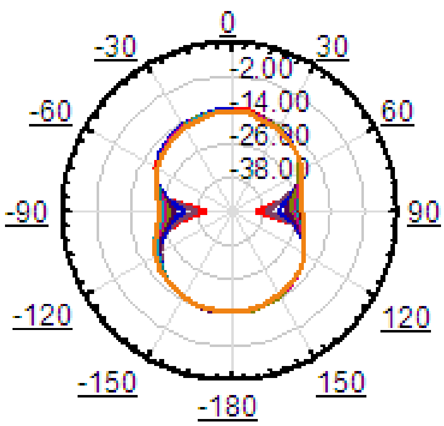

Fig. 5 Simulated antenna radiation pattern for the Proposed antenna and electric field around Proposed antenna is shown in fig .6 given on the next page.

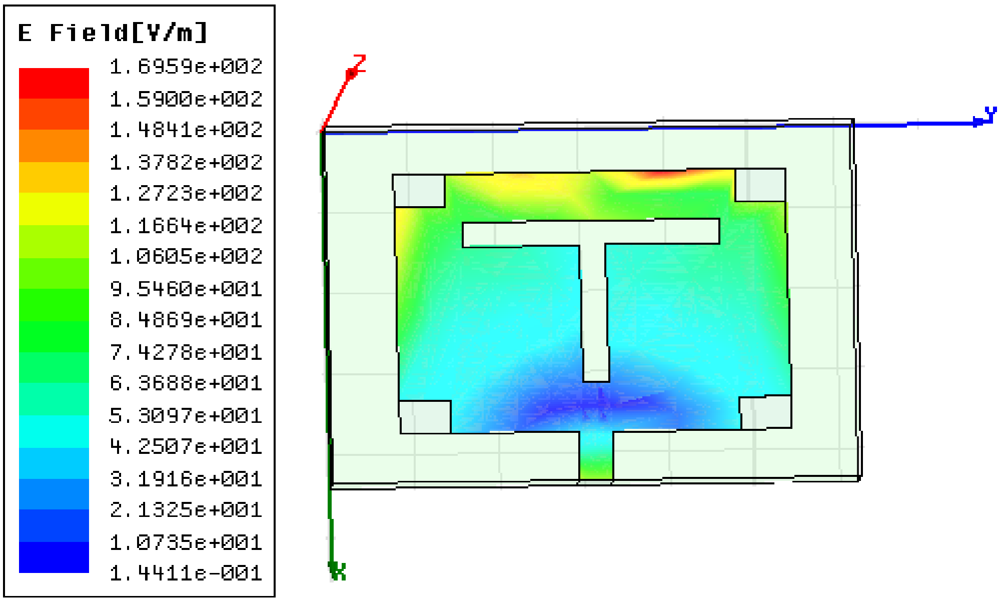

Fig. 6 E- Field of Proposed antenna

IV. CONCLUSIONS

A corner cut microstrip patch antenna having T slot with small microstrip line feed is presented here. Different design parameters with their effects are studied. For the operational frequency of 2.35 GHz, 3.71 GHz, 4.12 GHz, 4.75 GHz and 9 GHz minimum VSWR bandwidth nearly 1.07 and maximum return loss bandwidth up to -28.57dB has been obtained. T slot and corner cut used here plays an important role in balancing resistive part and reactive part which affect the impedance matching. T slot at the centre increases radiating edges which results in improved bandwidth. A thick dielectric substrate is helpful in increasing the bandwidth. The only drawback is that the feed strip causes the asymmetry in radiation characteristic at the higher frequency because of spurious radiation along the non-radiating edges of the patch. We are trying to design an antenna at various other frequencies to get similar or may be improved performance with selection of accurate patch value with other parameters.

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