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Edge truncated dual polarised antenna for wireless communication applications

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ABSTRACT

Edge truncated slot Aperture microstrip patch antenna for dual frequency operation is investigated in this paper. A simple microstrip edge fed has been used to feed the antenna and a quarter wave length transformers is used for impedance matching. The size of the antenna is reduced by 25.4% when compare to conventional square patch antenna. Design concepts with feeding methods are given along with simulated results. The antenna is showing a gain of 5.9db and a return loss of less than -10dB with VSWR<2 at both resonating frequencies.

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Introduction

There has been an increasing interest in design of dual frequency patch antennas for satellite and wireless communication applications. Here, edge truncated slot aperture patch antenna for dual frequency operation is simply fed by micro strip edge feed method. One of the original excitation methods for micro strip patch antenna is the edge fed (or) micro strip line feed technique [1-4]. Here a micro strip feed line of width W_f is indirect contact with a edge truncated slot aperture patch conductor of length L and width W edge fed patches have several advantages over other feeding techniques. One of the key features of this technology is its ease of fabrication because the feed layout and patches can be etched on one board. For this region many large planer arrays have been developed using edge fed patches. It is also very ease to control the level of the input impedance of an edge fed patch. Simply by inserting the feed into the patch conductor the impedance at resonance can be adjusted form very high 150 to 250 ohms. When the contact point of the feed line and the patch at the radiating edge of the patch, down to couple of ohms if the contact point is near the center of the patch [5-8].

Edge fed patches in their simplest form are relatively ease to model, If electrically thin material is used .Simple transmission line model can be utilized to give estimations of the input impedance performance of the antenna for cases when thicker material are used, The modeling of the performance is not too straight forward [9]. This is because of the current distribution of the discontinuities associated with the contact point between the micro strip line and the patch antenna. A quarter wavelength transformer is used in this model to attain perfect impedance matching [10].

Design of Dual Polarized Antenna

A dual polarized edge truncated slot aperture patch antenna as shown in fig1is designed to operate at 2.4 GHz and 3.1Ghz.The width of the patch is given by

$$w = \frac{c}{2 f_0 \sqrt{\frac{\in r+1}{2}}}$$

Effective dielectric constant and effective length are calculated by using the following equations.

$$\in reff = \frac{\in r+1}{2} + \frac{\in r-1}{2}\left(1+12\frac{h}{w}\right)^{-1/2}$$

$$Leff = \frac{c}{2 f_0 \sqrt{\in reff}}$$

Equation of length extinction

$$\Delta L = 0.412\frac{(\in reff + 0.3)(w/h + 0.264)}{(\in reff - 0.258)(w/h + 0.8)}$$

So the equation for the actual length of the patch

$$L = leff - 2\Delta L$$

The 50 ohm input port need to be matched with the edge impedance of the main patch to decrease the return loss and so, quarter wave transformer is used. The edge impedance is found form from the smith chart after feeding the main patch along its length and width. The values of the characteristic impedance Z_0 of the λ/4 transformer are found to be Z_0 =120ohms for the port. Finite element method based Ansoft HFSS software is used for design and simulation. A substrate material of RTduroid with dielectric constant 2.2 and height of 1.585mm is taken for simulation work. The dimensions of the proposed antenna are shown in table 1.

S.No	Length of patch	Width of patch	Substrate length	Substrate width	Substrate Height	Slot Dimensions
1	53.9 mm	45.2 mm	90 mm	99 mm	1.58 mm	L1=7.6mm, L2=5mm, L3=3mm w1=6.5mm

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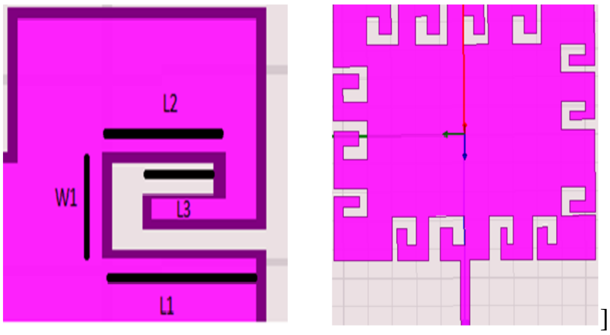

Figure (1a) Edge Truncated slot, (1b) Edge Truncated Slot aperture Antenna

Result Analysis

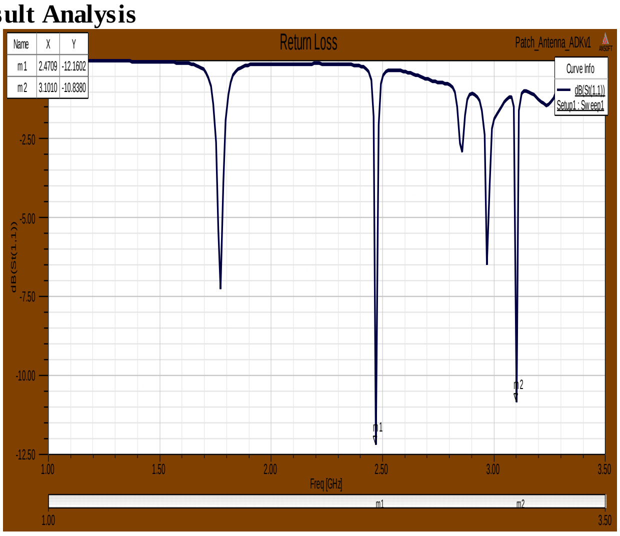

Figure 2 Return loss Vs Frequency

Return loss of -12.16 and -10.83 dB is obtained at 2.4 and 3.1 GHz. Gain of 5.9 dB is attained from this antenna.

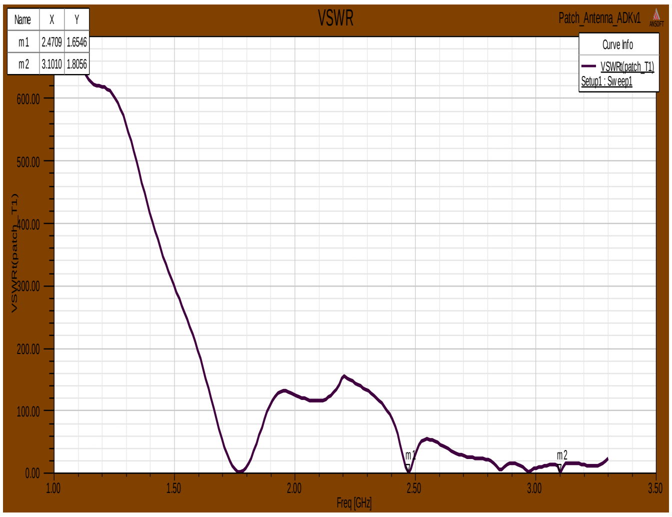

Figure 3 VSWR Vs Frequency

The band width of an antenna is the range of frequencies within which the performance of the antenna with respect to some characteristic conforms to a specified standard. If the antenna impedance is matched to the transmission line at resonance, the mismatch off resonance is related to the voltage standing wave ratio. The value of VSWR which can be tolerated then defines the bandwidth of the antenna. If this value is less than s, the usable bandwidth of the antenna is related to the total Q-factor by $B=\frac{1}{Q}\frac{S-1}{\sqrt{S}}=\frac{VSWR-1}{\sqrt{VSWR}.Q_T}$. A VSWR of 1.65 and 1.8 is obtained at both the resonating frequencies.

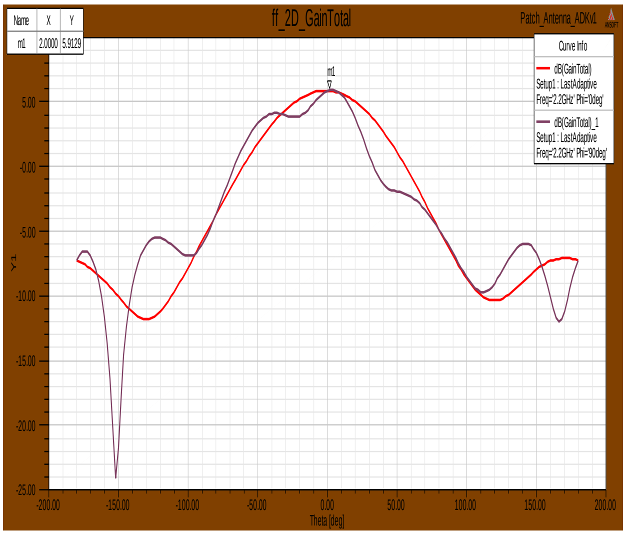

Figure 4 2-Dimensional View of Gain

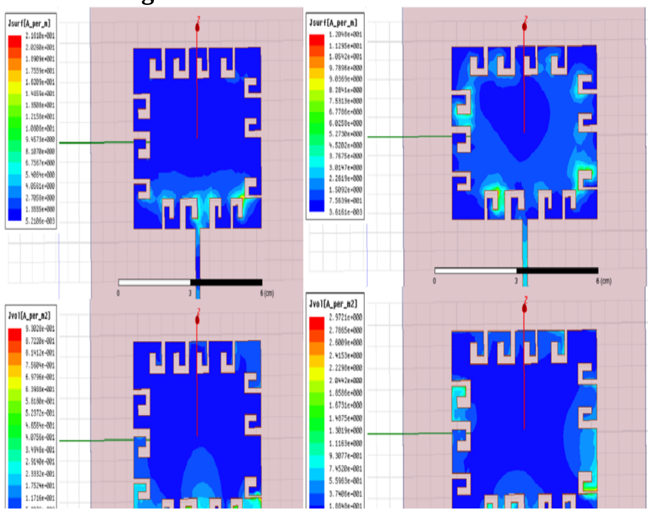

Figure 5 Surface and volume current distributions at 2.4 and 3.1 GHz

For each mode, there are two orthogonal planes in the far field region. One designated as E-plane and the other designated as H-plane. The far zone electric field lies in the E-plane and the far zone magnetic field lies in the H-plane. The patterns in these planes are referred to as the E and H plane patterns respectively.

For the TM_{01} mode, the contributions to the far fields are from the magnetic surface current densities on the side walls containing the radiating edges. The directions of the magnetic currents that the E-plane is the y-z plane (Φ=90º) and the H-plane is the x-z plane (Φ=0º). For the TM_{10} mode, the E-plane is the x-z plane (Φ=0º) and the H-plane is the y-z plane (Φ=90º)

$$E_\theta(r,\theta,\phi)=-2wh\left(\frac{E_0}{\eta_0}\right)\cos\phi(1-T^{TM}(\theta))\cos\left(k_x\frac{L}{2}\right)\mathrm{sinc}\left(k_y\frac{w}{2}\right)\mathrm{tanc}(k_{z1}h)$$

$$E_\phi(r,\theta,\phi)=2wh\left(\frac{E_0}{\eta_0}\right)(\cos\theta\sin\phi)(1-T^{TE}(\theta))\cos\left(k_x\frac{L}{2}\right)\mathrm{sinc}\left(k_y\frac{w}{2}\right)\mathrm{tanc}(k_{z1}h)$$

The directivity D of an antenna is defined as the ratio of power density in the main beam to the average power density while the gain G=eD. The directivity is not sensitive to resonant frequency.

Conclusion

Edge truncated spiral shaped slot aperture dual band antenna is designed and simulated results are presented in this paper. The antenna is resonating at 2.4 GHz and 3.1 GHz, which includes the WiMAX and Wi-Fi applications. A gain of 5.9 dB is attained from this antenna and it is showing excellent VSWR values at both the resonating frequencies, which includes values between 1.5 to 2.

The impedance bandwidth at each operating band is enhanced to a maximum value of 24.78% and 35.63% by truncating the corners by 3 mm. This enhancement of impedance bandthwidth does not affect the nature of broad side radiation characteristics. Further the use of truncating corners at the edges of this antenna reduces the overall size of antenna by 25.4% when compared to conventional Antenna.

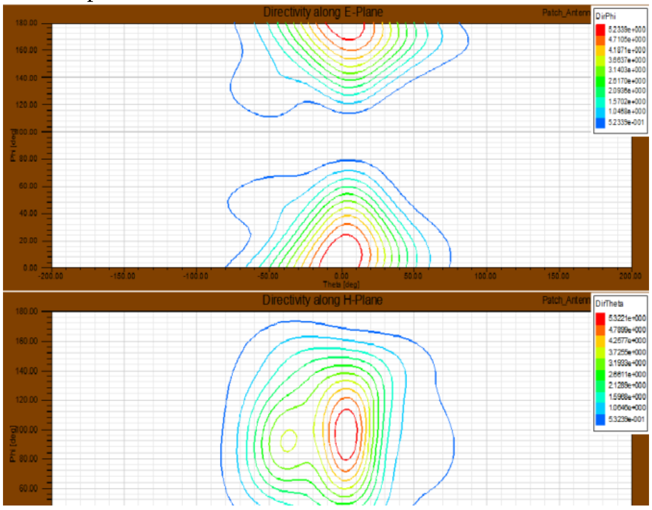

Figure 6 Directivity along E-Plane and H-Plane

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