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# Design and Analysis of Multiband Hybrid Coupled Octagonal Microstrip Antenna for Wireless Applications

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**Abstract:** A novel octagon shaped hybrid coupled microstrip antenna for multiband operation is proposed. By exciting two orthogonal modes by 90° time phase difference in hybrid coupling circular polarization is obtained. The gain is enhanced by tapering at the end of hybrid coupling. The design simulation is done using method of moment based software. The proposed antenna is resonating in the frequency range of 2-4 GHz. Hybrid coupled octagonal patch antenna is having gain of 9.11 dB and the directivity of 8.98 dB. Power radiated by this antenna is 0.038 W.

**Key words:** FR4 substrate, hybrid coupler, multiband operation, network analyzer, octagonal shape, patcho antennas

## INTRODUCTION

In wireless communication many application require multi terminal operation at various frequencies (Jin *et al*., 2006; Calmon *et al*., 2006 ). Single layer single feed dual frequency antennas are proposed by many researchers (Hsieh *et al*., 1998; Yang and Wong, 2001; Bao and Ammann, 2007; Nasimuddin *et al*., 2010; Yang and Rahmat-Samii, 2001). Octagonal shaped microstrip antenna for radar application is resonating in the frequency range of 3.1-15 GHz (Kumar and Kaur, 2011). Coplanar wave guide octagonal shaped microstrip antenna having 29×29×1.6 mm dimension ranging from 7-10.65 GHz (Natarajamani *et al*., 2009). There are vertical patch antennas (Lau *et al*., 2006) and spiral patch antennas (Zhang and Zhu, 2006) for circular polarization having very low bandwidth. To solve this problem, many techniques are introduced like proximity coupling (Tong and Huang, 2008), dual feed (Lau and Luk, 2005) and stacked structure (Herscovici and Sipus, 2003). By changing the phase difference in antennas using switched beam systems multiband operation is achieved (Denidni and Libar, 2003). The most important consideration of this reseach is requirement of multiband high gain microstrip antenna.

In this study, hybrid coupler is connected with octagonal shape antenna for multiband operation. The simulation is carried out by using ADS software and the antenna is resonating at four different frequencies and also having high gain and directivity.

## MATERIALS AND METHODS

**Basics of microstrip antenna:** In its most fundamental form, a microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Fig. 1. The patch is generally made up of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate (Grag *et al*., 2001). Number of methods are available in microstrip antenna feeding techniques. Main classifications are contacting and non contacting method. In contacting method, RF power is fed directly to the radiating patch using a connecting element such as a microstrip line (Abdallah *et al*., 2003). Other classifications are micro strip line feed, coaxial feed or probe feed, aperture coupled feed and proximity coupled feed. In micro strip line feed of feed technique, a conducting strip is connected to the edge of the microstrip patch. The conducting strip is smaller in width as compared to the patch and this kind of feed

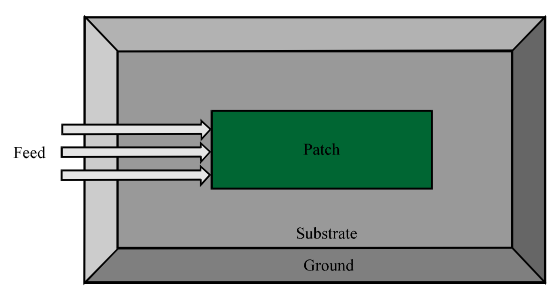


Fig. 1: Geometry of microstrip antenna

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arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure. The coaxial feed or probe feed is a very common technique used for feeding microstrip patch antennas (Pues and Van de Capelle, 1984). The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch while the outer conductor is connected to the ground plane. The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation.

In aperture coupled feed technique, the radiating patch and the microstrip feed lines are separated by the ground plane. Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane. The coupling aperture is usually centered under the patch leading to lower cross polarization due to symmetry of the configuration. The amount of coupling from the feed line to the patch is determined by the shape, size and location of the aperture. Since, the ground plane separates the patch and the feed line, spurious radiation is minimized. Generally, a high dielectric material is used for the bottom substrate and a thick, low dielectric constant material is used for the top substrate to optimize radiation from the patch. The other name of proximity coupled feed technique is electromagnetic coupling scheme. Two dielectric substrates are used such that the feed line is between the two substrates and the radiating patch is on top of the upper substrate. The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth due to overall increase in the thickness of the microstrip patch antenna. This scheme also provides choices between two different dielectric media, one for the patch and one for the feed line to optimize the individual performances (Ge *et al*., 2006). Here, researchers used probe feed because of impedance matching property. Polarization of an antenna is defined as the polarization of the wave transmitted (radiated) by the antenna whereas polarization of radiated wave is defined as property of an electromagnetic wave describing the time varying direction and relative magnitude of the electric field vector; polarization may be classified as linear and circular (Yamazaki *et al*., 1994). If the vector that describes the electrical field at a point in space as a function of time is always directed along a line, the field is said to be linearly polarized. The polarization can also be determined by the propagating antenna. Linear polarized can be horizontal or vertical. Circular polarization occurs when two signals having equal amplitude but 90° phase shifted (Li *et al*., 2005). Here, the proposed antenna is having circular polarization.

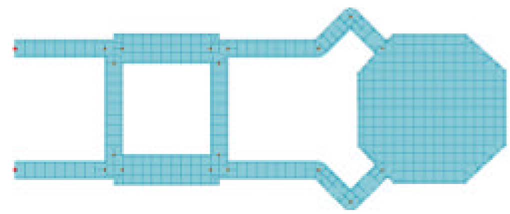

Fig. 2: 3D view of hybrid coupled octagonal microstrip patch antenna

**Antenna design:** The proposed antenna geometry is shown in Fig. 2. Hybrid coupler with 50 Ω impedance is fed into two sides of orthogonal radiating element. Antenna is simulated using advanced design system software.

Flame Retardant (FR4) material is having 4.4 relative permittivity, 0.02 loss tangent and the thickness of 1.6 mm. The first step in designing the rectangular patch antenna is to employ the following formula as an outline for the design procedures. By inserting triangular patches on all sides of the rectangular radiating element octagon shape is obtained. Each side of octagonal radiating element have length is 1.5 mm. Width of the patch (w):

$$w = \frac{1}{2f\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{r+1}} \quad (1)$$

To find effective dielectric ($\varepsilon_r$):

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\sqrt{\left[1+\frac{12h}{w}\right]} \quad (2)$$

Effective length (ΔL):

$$\Delta L = \frac{0.142h(\varepsilon_{eff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{eff\ -0.258})\left(\frac{w}{h}+0.8\right)} \quad (3)$$

The length of patch (L):

$$L = \frac{c}{2f\sqrt{\varepsilon_{eff}}}-2\Delta L \quad (4)$$

## RESULTS AND DISCUSSION

The measure of amount of power lost to the load is called return loss parameter and is shown in Fig. 3 . It is

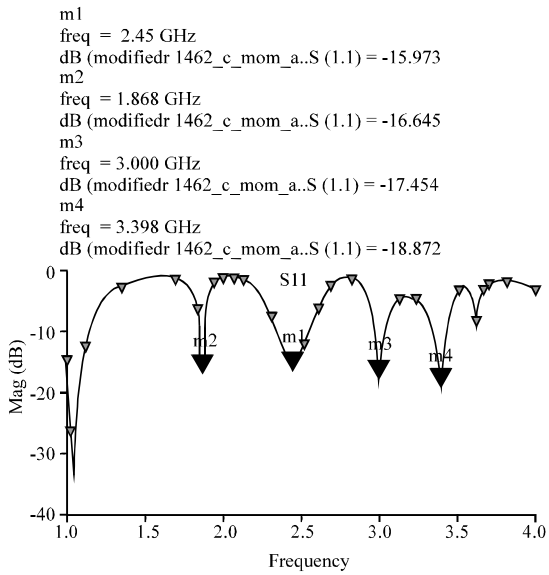


Fig. 3: Return loss vs. frequency graph

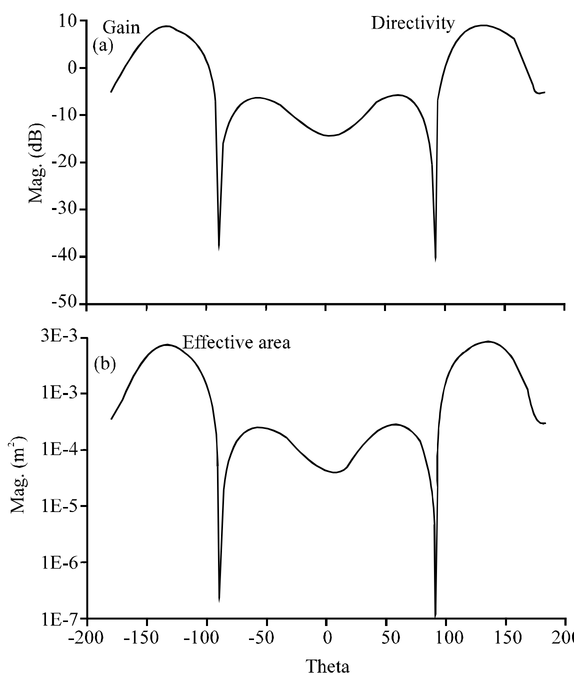


Fig. 4: a) Gain directivity vs. theta; b) effective area vs. theta

shown that antenna is having return loss values >-10 dB at all resonant frequencies which means proposed antenna is having good impedance matching. Ability of antenna to direct the power in a particular direction is defined by gain and directivity and is shown in Fig. 4a. This antenna is having high gain and directivity of 9.11 and 8.98 dB. Physical area of antenna capturing power from travelling electromagnetic wave is called as effective

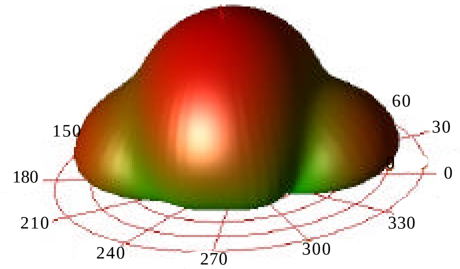


Fig. 5: Radiation pattern of hybrid coupled octagonal patch antenna

area and is shown in Fig. 4b. A far field radiation property of antenna with respect to power is shown in Fig. 5.

## CONCLUSION

An octagonal shaped antenna for multiband operation is presented here. Hybrid coupling is used to provide a high isolation level. The proposed antenna achieved the return loss of <-10 dB in all resonant frequencies which shows antenna is suitable for wireless communication.

Investigating this structure also shows it is having high gain and directivity hence proposed antenna can be useful in wireless applications in the frequency range of 2-6 GHz.

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