

## Design and Simulation of E-Slot Patch Antenna with Coaxial Feed for Multi Band Applications

Durga Prasad Reddy T\* and Ravindra Babu BVV

Department of ECE, ACEM, Madanapalle, Andhra Pradesh, India

### Abstract

The main object of this paper is to design and to simulate micro strip slot patch antenna for multiband applications. It is omnidirectional and stable radiation pattern. Hence rectangular shape antenna can be simulated using ANSOFT HFSS software. Parameters such as return loss, VSWR and radiation pattern are taken. Micro strip slot patch antenna becomes very popular day to day because of easy analysis and fabrication, low cost, light weight, easy fabrication. This paper proposed some shapes using feeding techniques are which has effective transmission based on frequencies. Micro strip patch antennas offer an attractive solution compact, conformal and low cost design of many wireless application systems. By increasing the substrate thickness and decreasing the permittivity of substrate the percentage of band width is increased. HFSS software is used for simulation and design of micro strip patch antenna where its version is 11.0. HFSS means High Frequency Structure simulator this was launched by the ANSOFT, designs are four slot patch antennas and the antennas work in the frequency ranges as follows 4.15-4.39 GHz, 10-11.6 GHz, 13.2-14.3 GHz, 16-17.1 GHz, 19.1-20 GHz, 4.4-4.5 GHz, 8.7-9.1 GHz, 11.54-12.85 GHz, 1.65 GHz, 2.24 GHz, 4.4-4.6 GHz, 5.6-5.8 GHz, 7.45-8.15 GHz It's main objective is used for MIMO applications, WLAN, Wi-MAX and RADAR, UWB, mobile communications, satellite space communications and microwave frequencies.

**Keywords:** Antenna; Radiation; Micro strip

### Introduction

MIMO technology gained popularity in wireless communications as they offers significant data throughput and link range without additional bandwidth or increased transmit power. Also they achieved array gain that improves the spectral efficiency and diversity gain that improves part of modern wireless communication standards such as IEEE 803.11 in (Wi-Fi), Wi-MAX [1].

The main parameter regarding MIMO systems is mutual coupling, which depends upon the distance between the elements in a MIMO system. If the distance is more, the mutual coupling between antennas becomes less and vice versa. Hence, by increasing the distance between the elements we can reduce the mutual coupling between the antennas. However, the distance between the antennas cannot be maintained too large, since MIMO systems have their major applications in Mobile terminals, laptops, WLAN Access Points and Wireless communications [2], where the size of the device can't be maintained too large. The main source of mutual coupling is flowing of surface current through ground in order to reduce these, there are several techniques like Electromagnetic band gap structure, detected ground structure [3,4], decoupling techniques, etc.

### HFSS

- It understands the antenna concept and analysing the performance of micro strip patch antenna.
- HFSS is a high performance full wave electromagnetic field simulator for arbitrary 3D volumetric passive device that integrates simulation visualization, solid modelling and automation is an easy to learn environment where solutions to your 3D EM problems are quickly and accurate obtained.
- ANSOFT HFSS employs the Finite Element Method (FEM), adaptive meshing and brilliant graphics to give you unparalleled performance and insight to all of your 3D EM problems.
- ANSOFT HFSS can be used to calculate parameters such as S-parameters, resonant frequency and fields.

**Different materials we have in HFSS:** The substrate selected for the design of the proposed antenna is verified by using different materials such as Epoxy Kevlar, FR4 epoxy, Air and RT/duroid 5880 [5] and among all these parameters Air substrate produces high impedance bandwidth as shown in Table 1. The dielectric constant of the material decreases then the bandwidth will increase we can observe in Table 1 and also we can create our own material in HFSS by mentioning the relative permittivity, relative permeability, dielectric loss tangents values.

RT/Duroid 5880 and FR4 epoxy are the substrates used for the design of the patch antenna.

### Features of RT/Duroid 5880

- Low electrical loss
- Isotropic
- Low moisture absorption
- Excellent chemical resistance
- Uniform electrical properties over frequency
- RT DURIOD 5880 laminates are easily cut, sheared and machine to shape
- Because of its low dissipation factor its usefulness extends to KU band

**\*Corresponding author:** Durga Prasad Reddy T, Student, Department of ECE, ACEM, Madanapalle, Andhra Pradesh, India, Tel: 9885070539; E-mail: [durgaprasad2194@gmail.com](mailto:durgaprasad2194@gmail.com)

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S.No	Material	Dielectric Loss Tangent	Relative Permittivity	Impedance Band Width
1	Air	0	1.0006	42%
2	Rogers RT/Duroid 5880	0.0009	2.2	35%
3	Epoxy	0	3.6	24%
4	FR4 epoxy	0.02	4.4	10%

Table 1: Different bandwidths obtained for different materials.

## Feedings Techniques

Feeding techniques are applied to feed or excite an antenna. There are four fundamental techniques used to feed or excite a micro strip antenna, which are grouped as

- Direct contact
- ❖ Micro Strip Line Feed
- ❖ Coaxial Feed Probe Feed
- Non-contact
- ❖ Aperture Feed
- ❖ Proximity Coupled Feed

**Micro strip line feed:** In a micro strip slot patch antenna the feed line [6] is the capable or other transmission line that connects the antenna with the transmitter or receiver. In a transmitting antenna, it feeds the radio frequency current from the transmitter to the antenna, where it is radiated as radio waves. In a receiving antenna it transfers the tiny RF voltage is induced in the antenna by the radio wave to the receiver. The following Figure 1 shows the micro strip line feed.

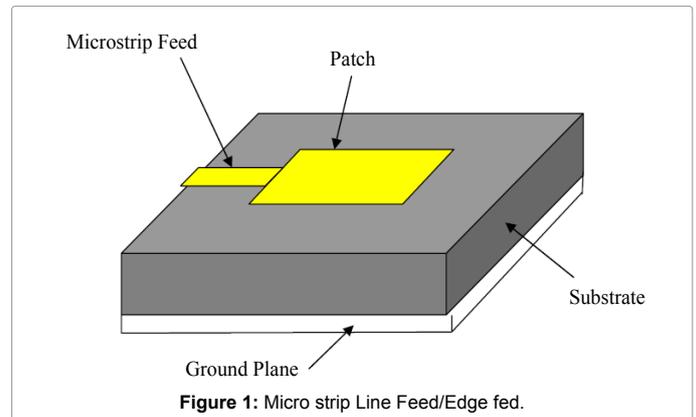


Figure 1: Micro strip Line Feed/Edge fed.

**Coaxial feed probe feed:** Coaxial cable is a rounded cable with a center conductor and a braided or solid metallic shield, usually copper or aluminum. The center conductor is separated from the outer shield by a dielectric, which is usually foam, air or a compressed gas such as nitrogen. The shield is covered with an outer cable sheath.

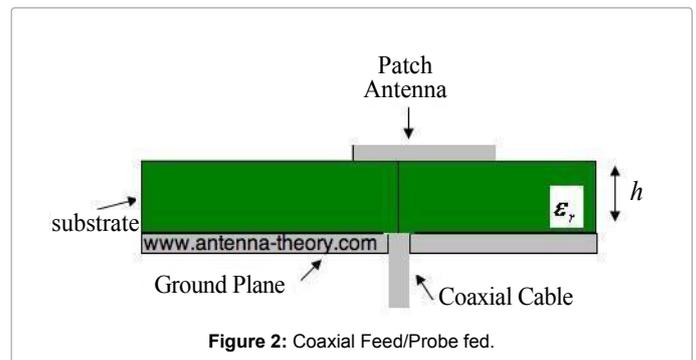


Figure 2: Coaxial Feed/Probe fed.

Micro strip antennas can also be fed from underneath via a probe as shown in Figure 2. The outer conductor is extended up to the patch antenna. The position of the feed can be altered as before to control the input impedance. If the height increases, the coaxial feed introduces an inductance into the feed that may need to be taken into consideration. In addition, the probe will also radiate, which can lead to radiation in undesirable directions.

## Antenna Designs

The main objective of the antennas used in MIMO systems is to improve the bandwidths of the patch antenna. The dielectric constant of the substrate decides the bandwidth of the micro strip antennas. Low dielectric constant of the substrate produces larger bandwidth, while high dielectric constant of the substrate results in similar size and low band width.

- E with co-axial feed antenna

**Reverse e with co-axial feed antenna:** The Reverse E slot patch antenna is shown in above Figure 3. In this structure, the Rogers RT/duroid 5880 (tm) material and it has the relative permittivity of 2.2, relative permeability of 1.0, dielectric loss tangent is 0.0009 in this the co-axial feeding.

The Reverse E slot patch antenna has the following results that the rectangular plot, radiation pattern and 3D rectangular plot is as follows from Figures 4-6 The frequency ranges in Reverse E slot patch antenna has the 4.2-4.6 GHz with -15.6 dB gain, 5.6-5.8 GHz with -18.4 dB gain,

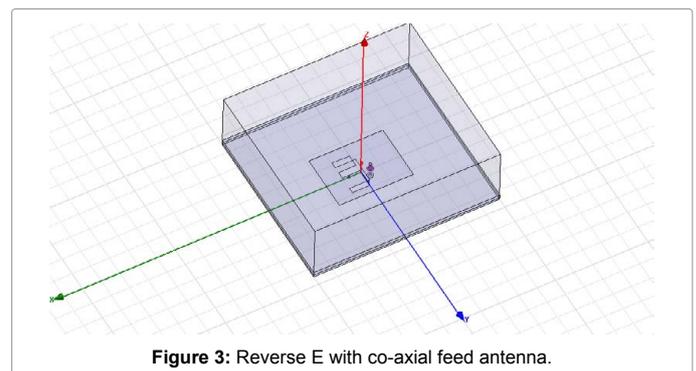


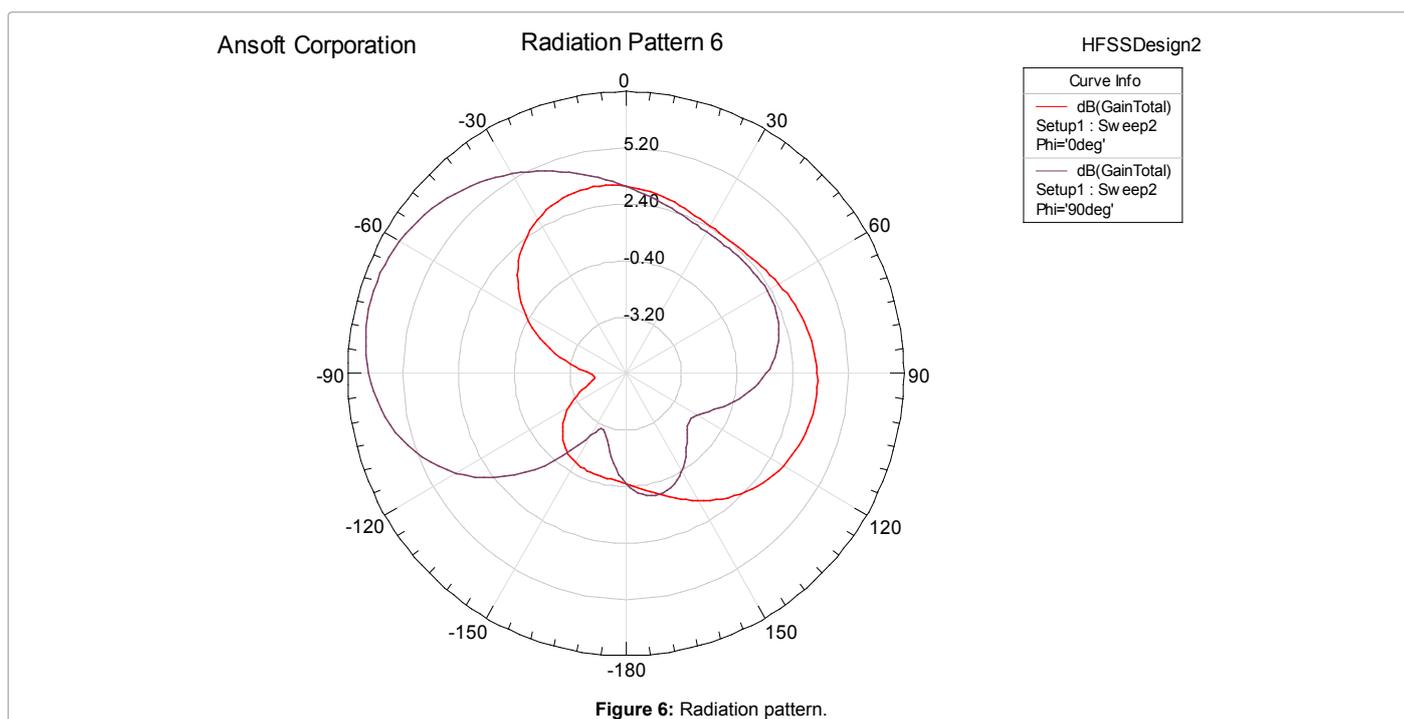
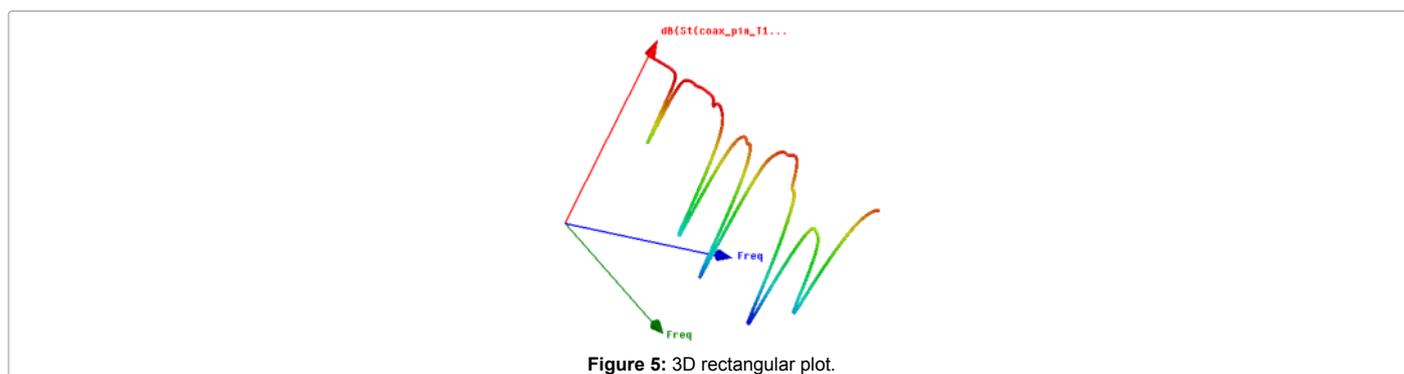
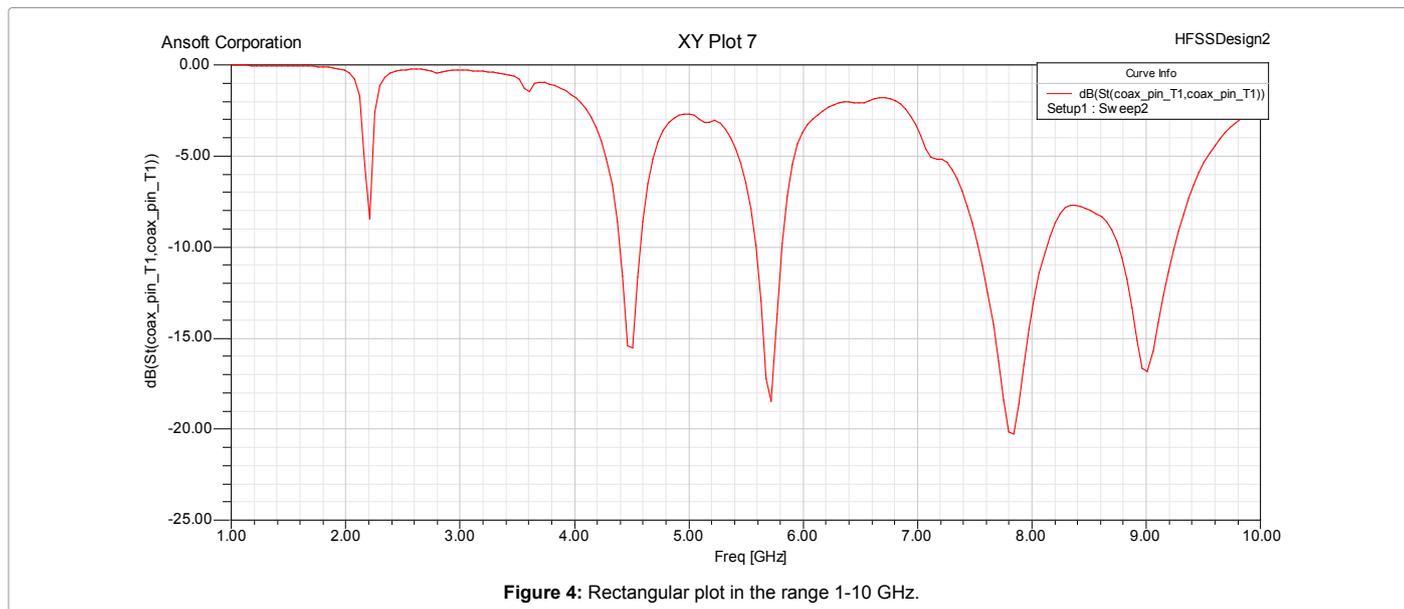
Figure 3: Reverse E with co-axial feed antenna.

7.45-8.15 GHz with -20 dB gain and 8.8-9.2 GHz with -17 dB gain and this frequencies has the following applications.

- WLAN, Wi-MAX and UWB
- MIMO, RADAR and satellite communication
- C, X bands in microwave.

## Conclusion

The design and simulation of micro strip slot patch antenna was successfully designed and analysed using ANSOFT HFSS. In this paper four types of micro strip slot patch antennas are designed and in this



three rectangular feed and one co-axial feed and the designed antennas will work in the area of MIMO applications, WLAN, Wi-MAX and RADAR, UWB, mobile communications, satellite communications and microwave frequencies.

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