Case Study

Microstrip Patch Antenna feeding 3D polar plot, Axial Ratio, Gain,VSWR

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ABSTRACT

This paper describes the effect of incorporation of Microstrip Patch Antenna feeding 3D polar plot, Axial Ratio, Gain,VSWR performance of the simple microstrip patch antenna (MPA). The various antenna parameters such as , 3D polar plot, Axial Ratio, Gain, and Voltage Standing Wave Ratio (VSWR) get much improved in proposed antenna with Defected Ground Structure. Comparison of the performance characteristics of the proposed antenna with simple MPA without defect has been presented by simulating the antennas with Finite Element Machine (FEM) based software High Frequency Structure Simulator (HFSS) software Version-13.0 package. Simulated results reveal that the Proposed antenna finds its application in C-band such as in satellite communications, Wi-Fi etc.

General Terms

3D polar plot, Axial Ratio, Gain, Voltage Standing Wave Ratio (VSWR), .

1. INTRODUCTION

Microstrip antenna is a topic of intensive research in recent years with the explosive growth of wireless system and booming demand for a variety of new wireless application. In recent years, as the demand of the small systems have increased, small size antennas have drawn much interest of researchers [1]. Microstrip antenna technology fulfill the requirements of modern communication system such as low profile, light weight, easy to fabrication, and conformability to mounting hosts in addition size reduction and bandwidth. Therefore, the selection of microstrip antenna is suitable to apply at various fields such as telecommunication, medical application, satellite and military system. But limited ground plane size is an essential requirement for its compactness as well as compatibility with the mobile wireless equipments. However, the bandwidth and the size of an antenna are generally conflicting properties i.e. improvement of one of the characteristics normally results in degradation of the other.

To overcome these drawbacks and to improve antenna characteristics, different techniques have been used by the researchers such as slotting, DGS, use of dielectric substrate of high permittivity etc. The other method to miniaturize the microstrip antenna is to modify its geometry using irises or folded structures based on the perturbation effect. Defected ground structure (DGS), where the ground plane metal of the microstrip antenna design is modified intentionally in order to enhance the performance. The name for this technique simply means that a "Defect" has been etched off in the ground plane, which disturbs the shield current distribution in the ground plane and influences the input impedance as well as current flow of the antenna. A defect in the ground plane causes to increase in effective capacitance and inductance.

DGS may have various shaped slot like U-shaped slot, Eshaped slot, L-shaped slot, I-shaped slot etc. which helps to improve resonant bandwidth. Different types of antennas works in different frequency bands such as L-band ranges between 1-2GHz, S-band ranges between 2-4GHz, C-band ranges between 4-8 GHz and X-band ranges between 8-12 GHz etc. Each of these frequency bands has different working applications. Similarly proposed antenna finds its application in C-band such as in satellite communications, Wi-Fi etc. In this paper work, the design incorporates G-Shaped Defected Ground Structure in ground plane, which disturbs shielded current distribution in ground plane.

2. ANTENNA DESIGN

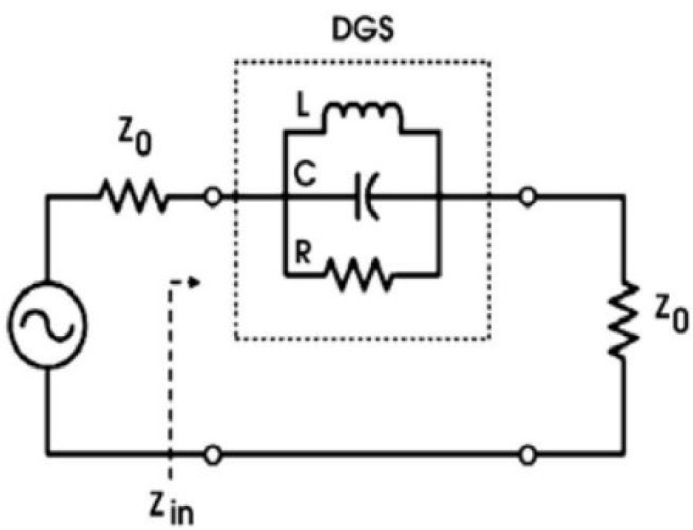
The equivalent circuit for a DGS is a parallel- tuned circuit in series with the transmission line to which it is coupled as shown in Fig. 1. The input and output impedances are that of transmission line section, while the equivalent values of L, C and R are determined by the dimensions of the DGS structure and its position relative to the transmission line. By specifying the following conditions, an antenna can be easily trimmed to the desired center frequency:

$f10 = c/(\varepsilon r)^{\wedge}1/2\ (1/2L)$

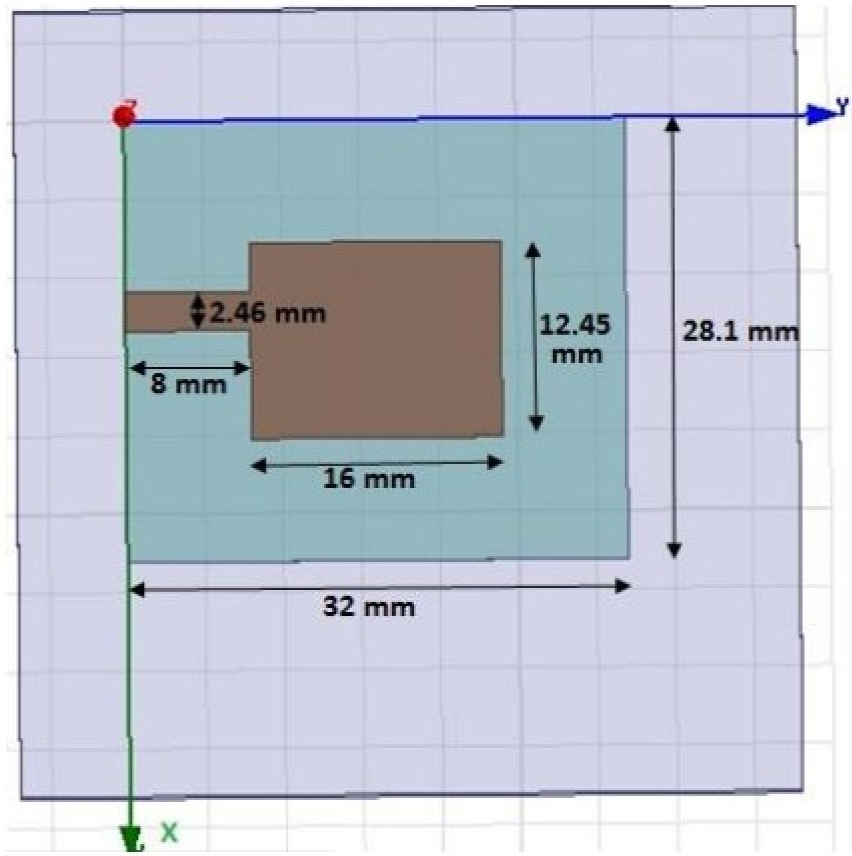
where, $f10$ is resonant frequency in case of rectangular patch, "L" is length of patch, εr is substrate's relative permittivity. This is equivalent to say that the length "L" is one-half of a wavelength in the dielectric:

$L = \lambda d/ 2 = \lambda 0/2/(\varepsilon r)^{\wedge}1/2$

where, λd is the wavelength in dielectric material.



Both MPA and proposed antennas are designed on Rogers RT/Duroid 5880 (tm) substrate with thickness (hs) of 0.794 mm having relative permittivity (Ɛr) of 2.2. The patch has the dimensions of 12.45mm × 16mm with height (hp) of 0.05 mm. The ground has the dimensions of 28.1 mm × 32 mm with height (hg) of 0.05 mm. Antenna is excited with microstrip feed having characteristics impedance of 50 Ω. The feed has dimension of 8 mm × 2.46 mm with height (hf) of 0.05 mm. The complete geometry of simple MPA is shown in Fig. 2. The proposed antenna design for C-band incorporates a GShaped slot in Ground. In G-shaped DGS antenna, the distance between inner turns is kept 9 mm and the width of turn is 2 mm.



G-shaped DGS antenna also gives a large bandwidth as compared to simple MPA. To acquire large bandwidth, an antenna must satisfy the following relation: $W < 2L$ (3) $W = 1.5\ L$ (Typical value) where, "L" represents the length of patch. The width "W" is usually chosen to be larger than L (to get higher bandwidth).

Bandwidth is related to substrate thickness (hs) and substrate permittivity(εr). If „hs " is greater than $0.05\lambda 0$, then probe inductance becomes too large to match the impedance. A higher substrate permittivity allows for a smaller antenna but lower bandwidth. Thus bandwidth and size of an antenna are generally conflicting properties i.e. improvement of one of the characteristics normally results in degradation of the other. In this paper, an appropriate dielectric material "Rogers RT/Duroid 5880 tm" is used for substrate with thickness (hs) of 0.794 mm having relative permittivity (εr) of 2.2 and also satisfies all the above mentioned conditions. In the design of patch, a few equations are used as reference before optimizing the dimension. With a specific resonant frequency fr , the width and the length of patch are expressed as follows.

$$W_P = \frac{1}{2\, f_r \sqrt{\mu_0 \varepsilon_0}} \sqrt{\frac{2}{\varepsilon_r + 1}} \tag{4}$$

$$L_P = L_e - \Delta L \tag{5}$$

$$L_e = \frac{c}{2\, f_0 \sqrt{\varepsilon_e}} \tag{6}$$

$$\Delta L = 0.412\, h\, \frac{(\varepsilon_e + 0.3)(\frac{W}{h} + 0.2664)}{(\varepsilon_e - 0.258)(\frac{W}{h} + 0.8)} \tag{7}$$

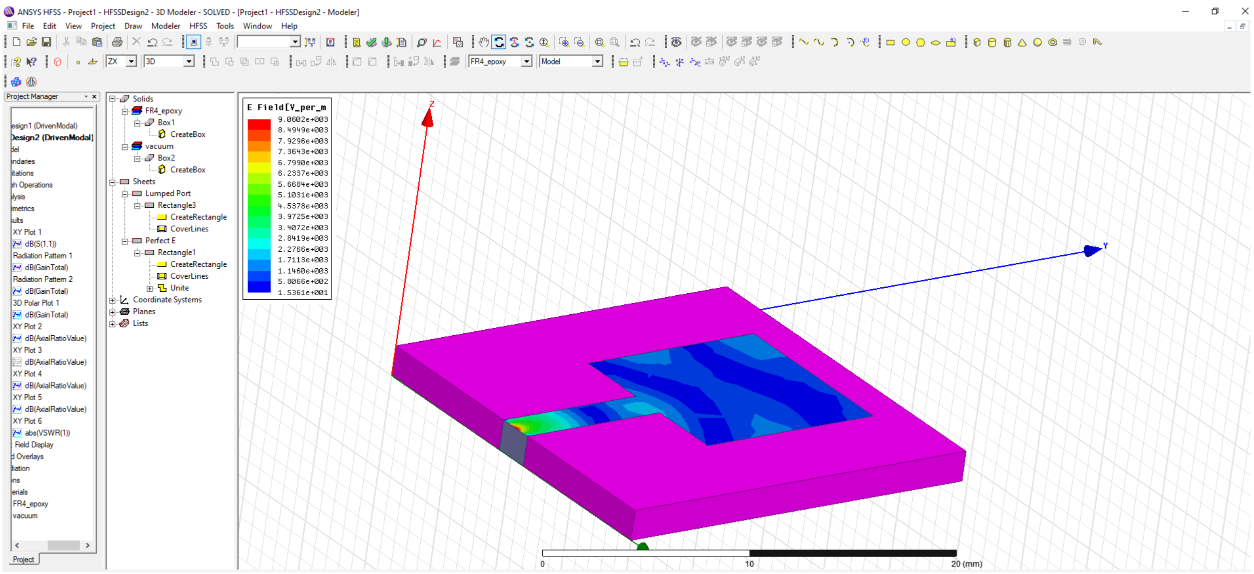
$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\,\frac{h}{W}\right]^{\frac{-1}{2}} \tag{8}$$

where , W_P = width of patch
L_P = length of patch
ΔL = extended length of patch
L_e = effective length of patch
ε_e = effective dielectric constant substrate
ε_r = relative dielectric constant of substrate

Table 1 shows some common design specifications for simple MPA.

3.DISCUSSIONS

The performance parameterrs of bothantennas,,simple microstrip antenna are simulated with high frequency structure simulator(HFSS) software version 13,0



----------->RETURN LOSS(S11)

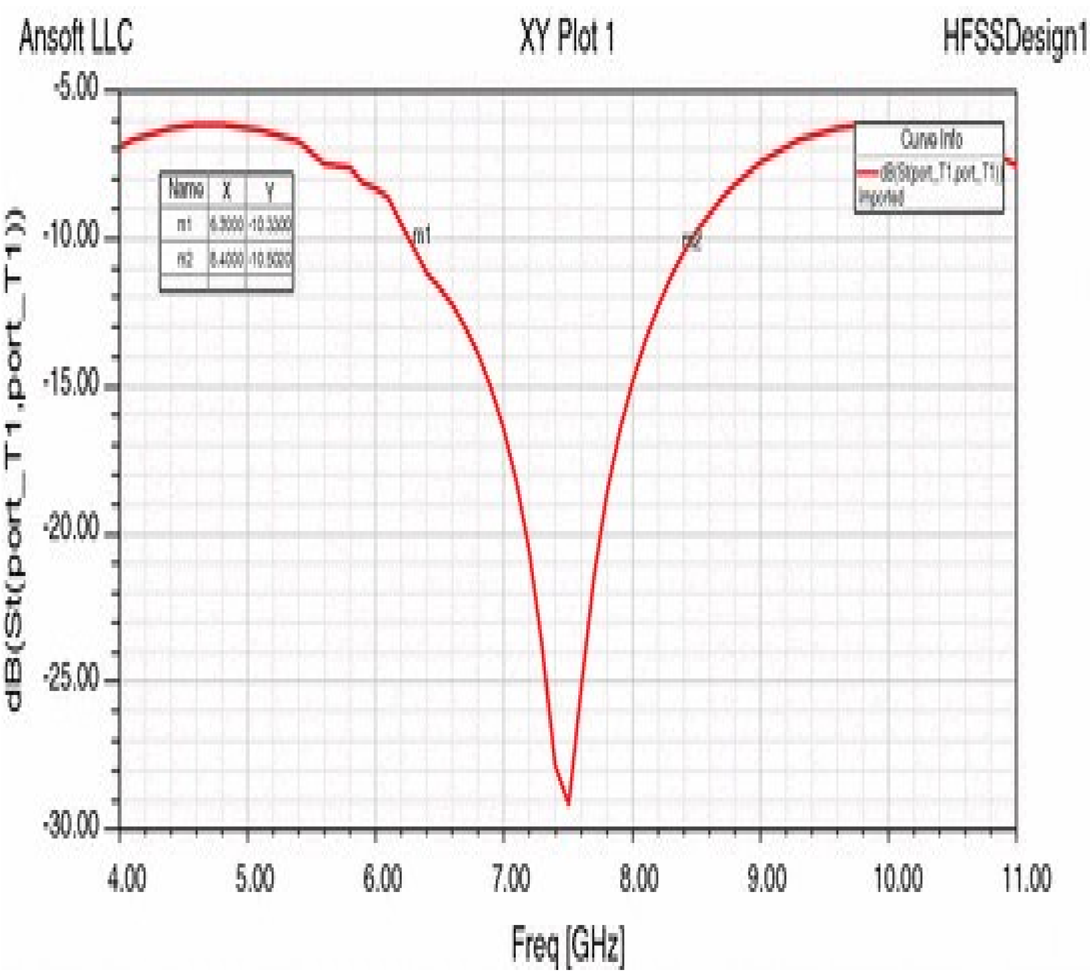
The return loss represents how **much power is reflected from the antenna and hence is known as the REFLECTION COEFFICIENT…**

Return loss gives the measure of how well a device is matched. A device is said to be well matched if the return loss is high. Learn more in: Soft-Computing-Based Optimization of Low Return Loss Multiband Microstrip Patch Antenna.

whereRL(dB) is the return loss in dB,$P_i$is the incident power and$P_r$is the reflected power.

Return loss is related to bothstanding wave ratio(SWR) andreflection coefficientΓ). Increasing return loss corresponds to lower SWR. Return loss is a measure of how well devices or lines are matched. A match is good if the return loss is high. A high return loss is desirable and results in a lower insertion loss.

From a certain perspective 'Return Loss' is a misnomer. The usual function of a transmission line is to convey power from a source to a load with minimal loss. If a transmission line is correctly matched to a load, the reflected power will be zero, no power will be lost due to reflection, and 'Return Loss' will be infinite. Conversely if the line is terminated in an open circuit, the reflected power will be equal to the incident power; all of the incident power will be lost in the sense that none of it will be transferred to a load, and RL will be unity. Thus the numerical values of RL tend in the opposite sense to that expected of a 'loss'.



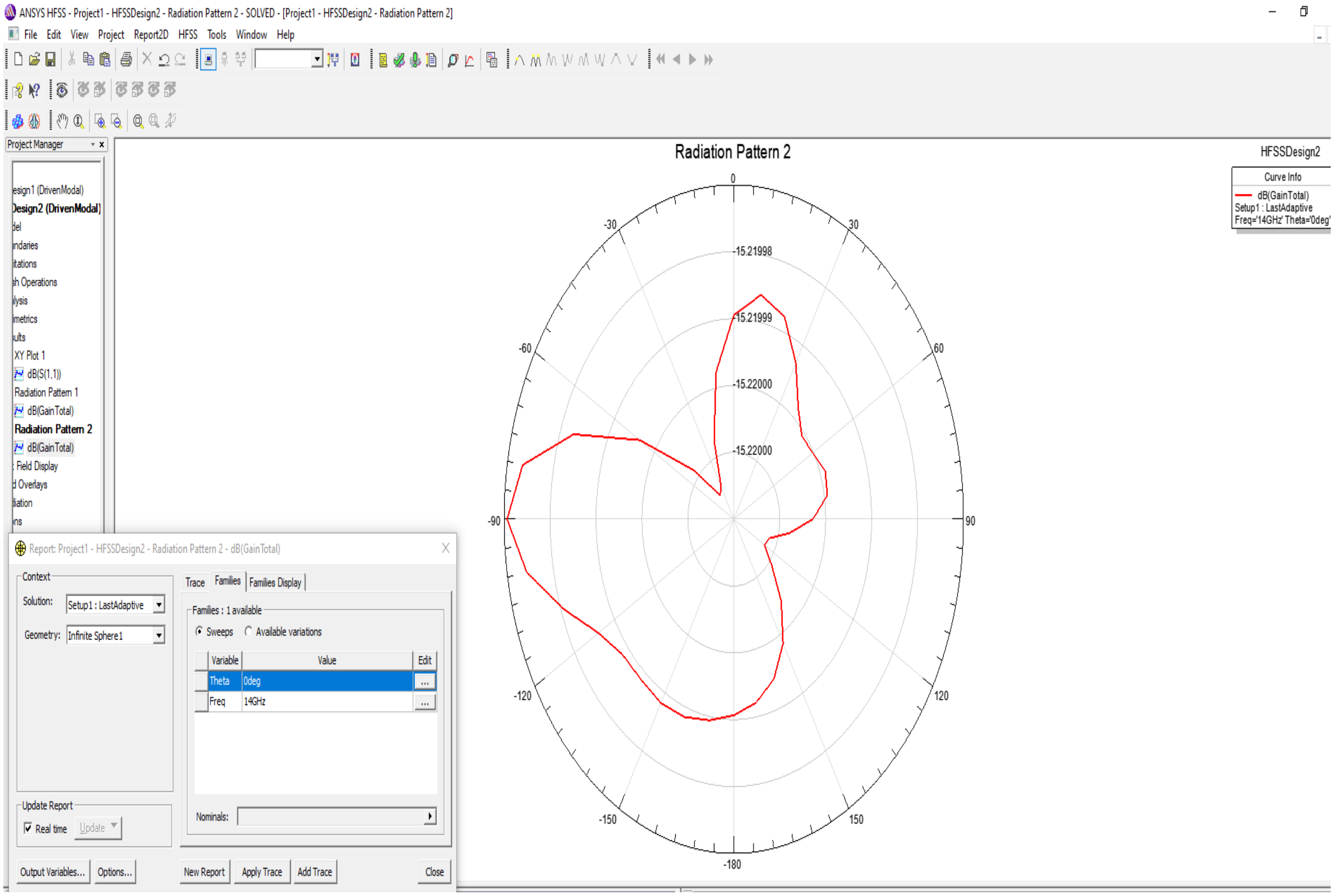
---------------→ FAR FIELD RADIATION….

In the field of antenna design the term radiation pattern (or antenna pattern or far-field pattern) refers to the directional (angular) dependence of the strength of the radio waves from the antenna or other source. ... Other software, like HFSS can also compute the near field.

The far field of an antenna is generally considered to be the region where the outgoing wavefront is planar and the antenna radiation pattern has a polar variation and is independent of the distance from the antenna.

The **near field** and **far field** are regions of the electromagnetic field (EM) around an object, such as a transmitting antenna, or the result of radiation scattering off an object. Non-radiative *near-field* behaviors dominate close to the antenna or scattering object, while electromagnetic radiation *far-field* behaviors dominate at greater distances.

Far-field E (electric) and B (magnetic) field strength decreases as the distance from the source increases, resulting in an inverse-square law for the radiated *power* intensity of electromagnetic radiation. By contrast, near-field E and B strength decrease more rapidly with distance: the radiative field decreases by the inverse-distance squared, the reactive field by an inverse cubed law, resulting in a diminished power in the parts of the electric field by an inverse fourth-power and sixth-power, respectively. The rapid drop in power contained in the near-field ensures that effects due to the near-field essentially vanish a few wavelengths away from the radiating part of the antenna.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Freq='14GHz' Theta='0deg'
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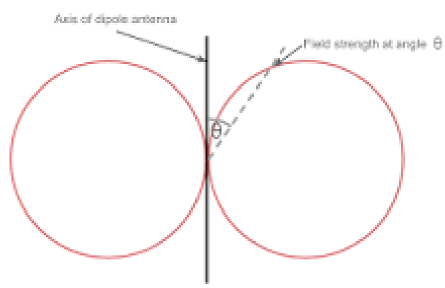
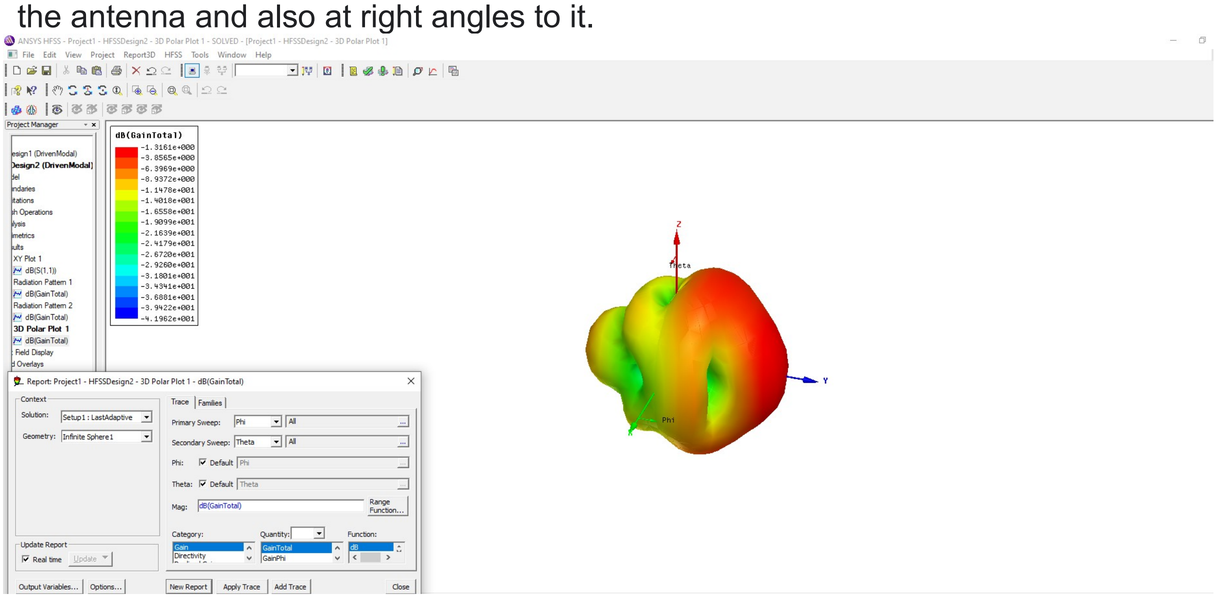
----------------→ 3D POLAR PLOT….

This paper presents the idea of recent developments and advancements in the field of wireless technology to realize high speed communications which is performed in wideband technology In this paper the wideband patch antenna is designed and fabricated.

What is polar plot in antenna?



A polar diagram is a plot **that indicates the magnitude of the response in any direction**. ... The radiation pattern shown on a polar diagram is taken to be that of the plane in which the diagram plot itself. For a dipole it is possible to look at both the along the axis of the antenna and also at right angles to it.

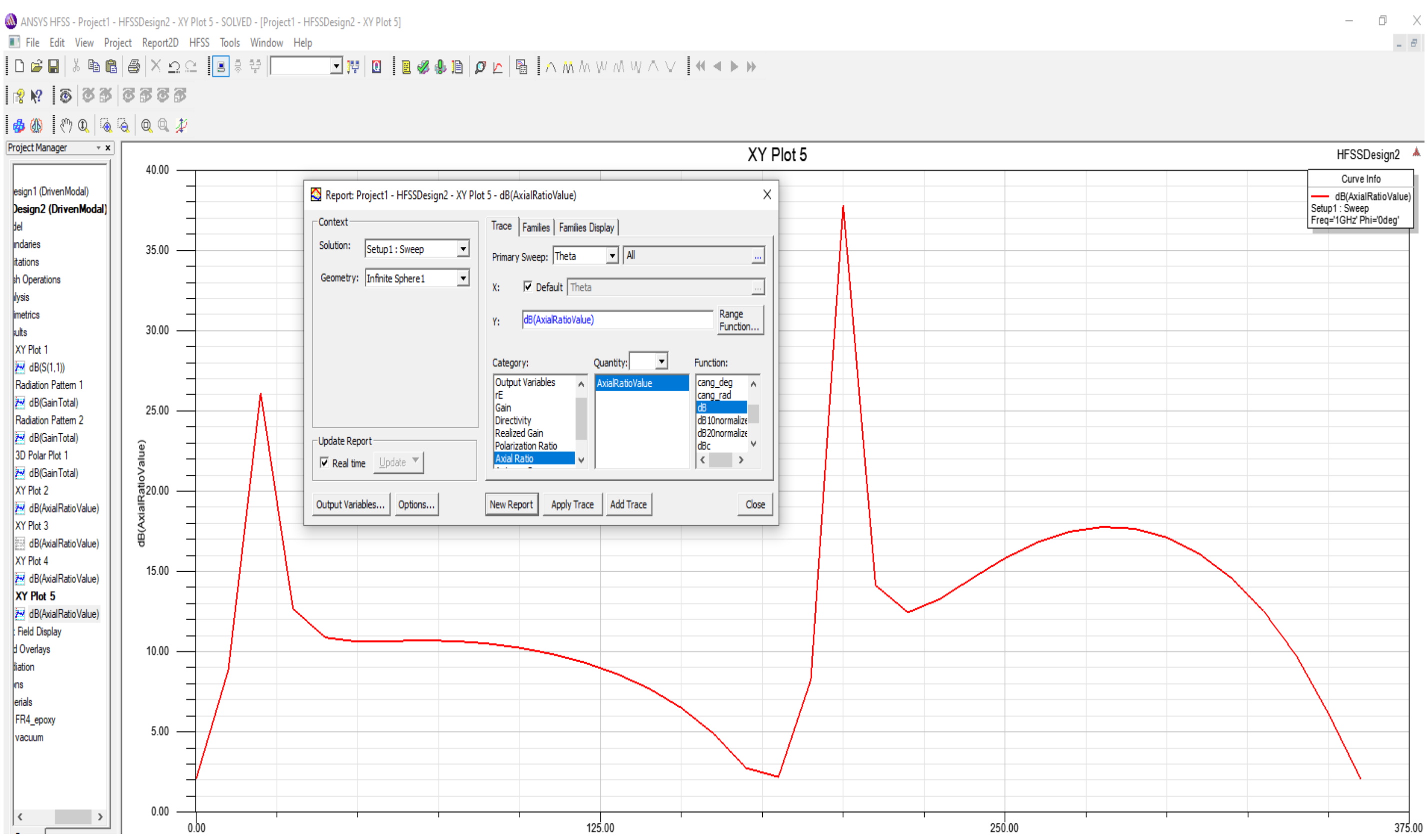


-------------→ AXIAL RATIO….

The Axial Ratio (AR) of an antenna is defined as the ratio between the major and minor axis of a circularly polarized antenna pattern. If an antenna has perfect circular polarization then this ratio would be 1 (0 dB).

he axial ratio is the ratio of orthogonal components of an E-field. A circularly polarized field is made up of two orthogonal E-field components of equal amplitude (and 90 degrees out of phase). ... This indicates that the deviation from circular polarization is less than 3 dB over the specified angular range.

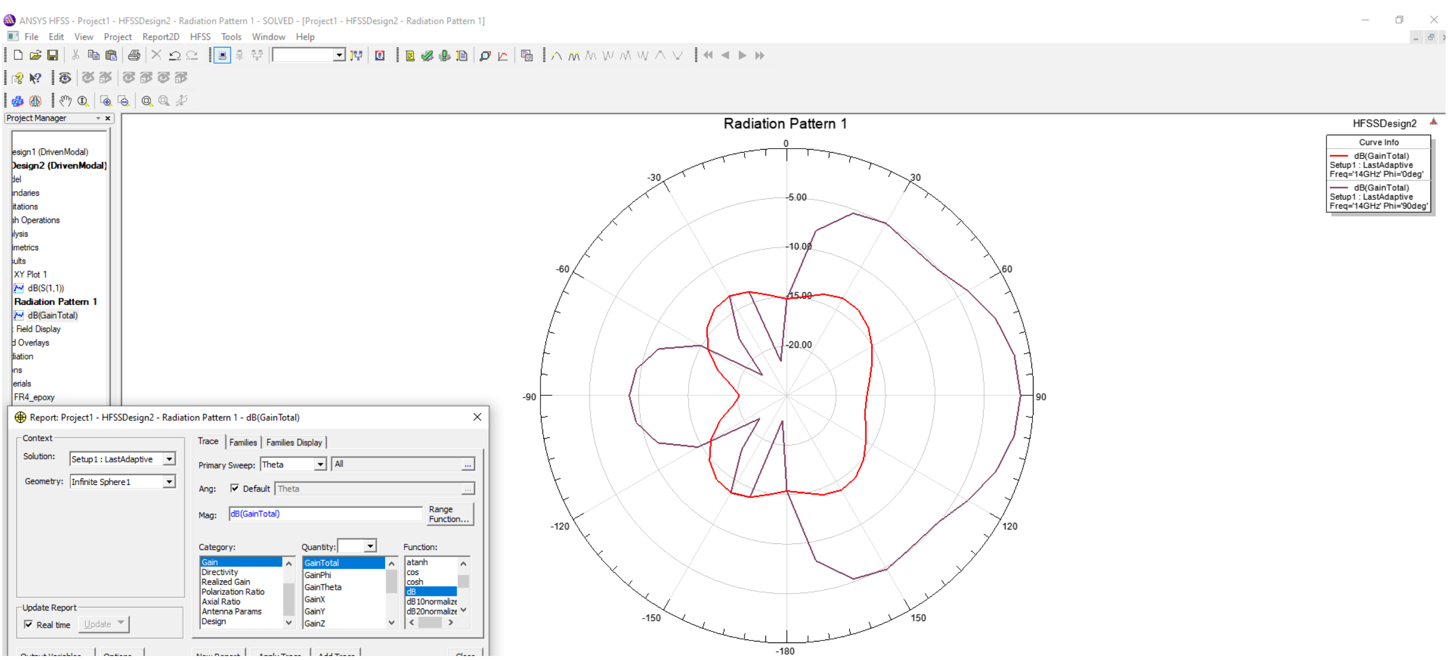
The axial ratio is the ratio of power received by linear dipole when kept in Horizontal direction to the power received by the dipole kept in vertical direction. In a simple word the amount of power of E component in Horizontal and vertical direction



-------------→ ANTENNA GAIN…

The term **Antenna Gain**describes how much power is transmitted in the direction of peak radiation to that of an isotropic source.Antenna gain is more commonly quoted than directivityin an antenna's specification sheet because it takes into account the actual losses that occur.

A transmitting antenna with a gain of 3 dB means that the power received far from the antenna will be 3 dB higher (twice as much) than what would be received from a lossless isotropic antenna with the same input power. Note that a lossless antenna would be an antenna with an antenna efficiency of 0 dB (or 100%). Similarly, a receive antenna with a gain of 3 dB in a particular direction would receive 3 dB more power than a lossless isotropic antenna.



---------------→ VSWR(VOLTAGE STANDING WAVE RATIO)….

VSWR (Voltage Standing Wave Ratio), is a measure of how efficiently radio-frequency power is transmitted from a power source, through a transmission line, into a load (for example, from a power amplifier through a transmission line, to an antenna).

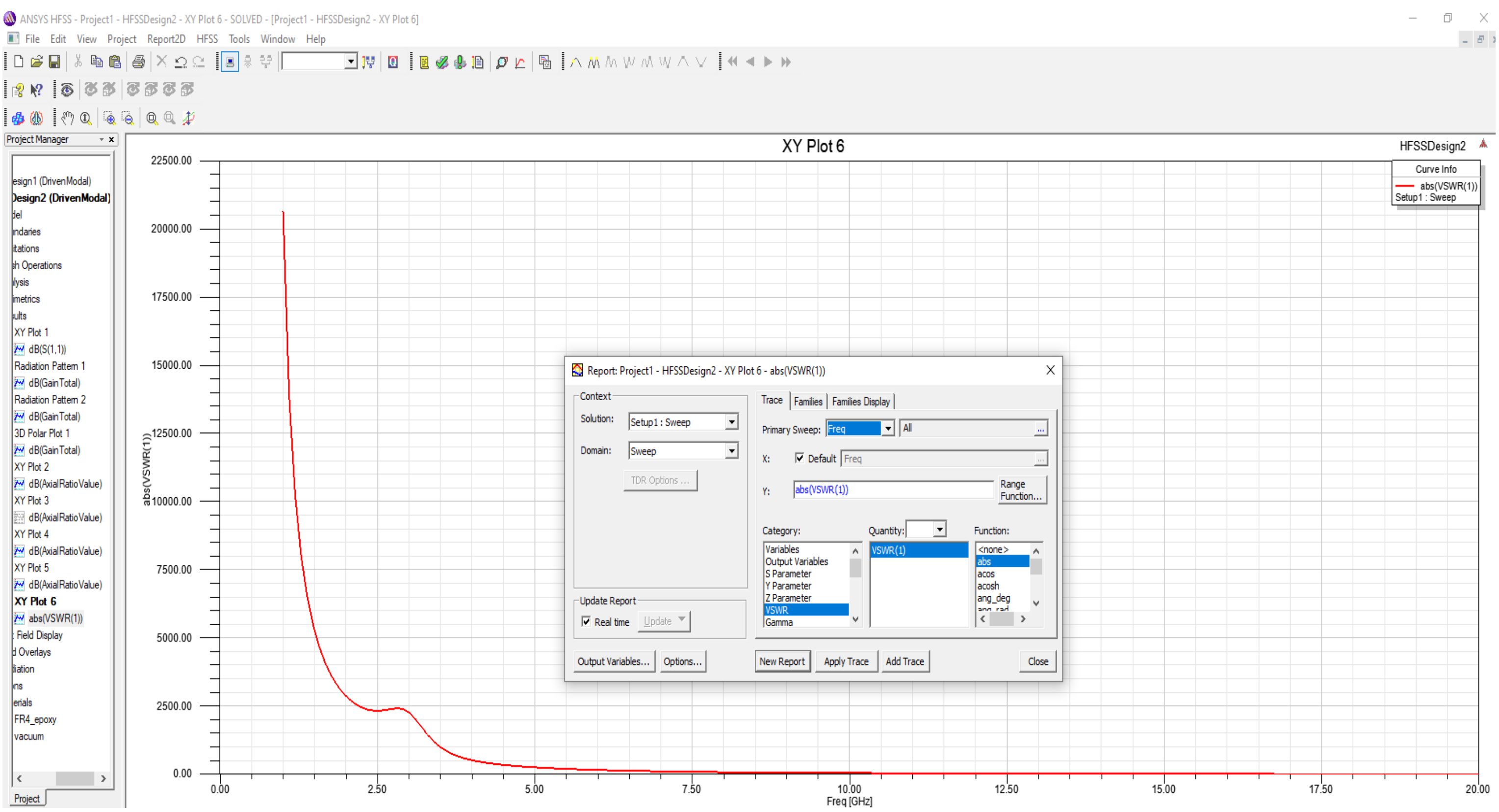
VSWR is defined as the ratio of the maximum voltage to the minimum voltage in standing wave pattern along the length of a transmission line structure. It varies from 1 to (plus) infinity and is always positive. Unless you have a piece of slotted line-test equipment this is a hard definition to use, especially since the concept of voltage in a microwave structure has many interpretations.

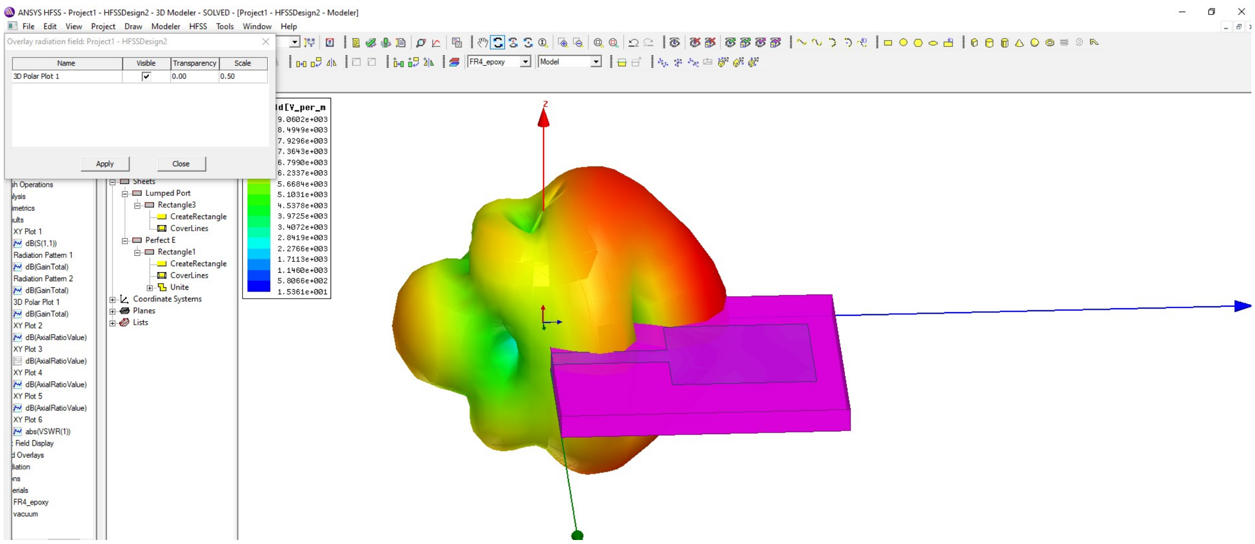
Sometimes VSWR is called SWR to avoid using the term voltage and to instead use the concept of power waves. This in turn leads to a mathematical definition of VSWR in terms of a reflection coefficient. A reflection coefficient is defined as the ratio of reflected wave to incident wave at a reference plane. This value varies from -1 (for a shorted load) to +1 (for an open load), and becomes 0 for matched impedance load. It is a complex number. This helps us because we can actually measure power.
The reflection coefficient, commonly denoted by the Greek letter gamma (Γ), can be calculated from the values of the complex load impedance and the transmission line characteristic impedance which in principle could also be a complex number.

$\Gamma = (Z_l - Z_0)/(Z_l + Z_0)$
The square of $|\Gamma|$ is then the power of the reflected wave, the square hinting at a historical reference to voltage waves.
Now we can define VSWR (SWR) as a scalar value:

$VSWR = (1 + |\Gamma|)/(1 - |\Gamma|)$ or in terms of s-parameters: $VSWR = (1 + |S_{11}|)/(1 - |S_{11}|)$

This is fine but what has it to do with common usage in ads and specifications. Generally, VSWR is sometimes used as a stand-in for a figure of merit for impedance matching. Sometimes this simplification of a scalar quantity and it's restricted definition can lead to confusion in the matter of a source to load match. Most of the time there is no problem but, technically, VSWR derives from the ratio using the load impedance and the characteristic impedance of the transmission line in which the standing waves reside and not specifically to a source to load match. I prefer to think of VSWR as a figure of merit and to use the reflection coefficient whenever I am trying to solve problLEM





---------→>> COCNLUSION…

The design of Simple Microstrip patch antenna(MPA) is shown and all the different parameters like

1.RETURN LOSS (S11)
2. FAR FIELD RADIATION
3.3D POLAR PLOT
4.AXIAL RATIO
5.GAIN
6. VSWR

are plotted and defined briefly in the above stages of explained by using on based software High Frequency Structure Simulator (HFSS) software Version-13.0 package. Simulated results reveal that the Proposed antenna finds its application in C-band such as in satellite communications, Wi-Fi ..

-------→> INFORMATION RESOURCES..

-WIKIPEDIA
-GOOGLE
-TK LO AND Y,Hwang “MICROSTRIP ANTENN of very high permitivity for personal communication” 1997 ASIA book,.