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Design of Wide Band Patch Antenna with DGS L Structure

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Abstract: ***In this paper we design and fabricate a compact probe-fed Rectangular Microstrip Patch Antenna working in the S-band (2-4 Ghz) part of the microwave band of the electromagnetic spectrum. The size of the antenna increases if the operating frequency is decreased. The aim is to reduce the operating frequency of the antenna keeping the size constant and being compact. The effect of antenna dimensions Length (L), and substrate parameters, relative Dielectric constant (ε_r), substrate thickness (t) on the Return Loss, Bandwidth, operating frequency are analysed. For designing and analysing purpose electromagnetic simulator IE3D software is used. The S band is used by weather radar, surface ship radar, and some communications satellites, especially those used by NASA to communicate with the Space Shuttle and the International Space Station.***

Keywords: Microstrip Patch Antenna, DGS, VSWR, Return loss etc

1. Introduction

Communication between humans was first by sound through voice. With the desire for slightly more distance communication came, devices such as drums, then, visual methods such as signal flags and smoke signals were used. These optical communication devices, of course, utilized the light portion of the electromagnetic spectrum. It has been only very recent in human history that the electromagnetic spectrum, outside the visible region, has been employed for communication, through the use of radio. One of humankind's greatest natural resources is the electromagnetic spectrum and the antenna has been instrumental in harnessing this resource. In high-performance aircraft, spacecraft, satellite and missile applications, where size, weight, cost, performance, ease of installation and aerodynamic profile are constraints, low profile antennas may be required. Presently there are many other government and commercial applications, such as radio and wireless communications that have similar specifications. To meet these requirements, microstrip antennas can be used. These antennas are low-profile, conformable to planar and nonplanar surfaces, simple and inexpensive to manufacture using printed-circuit technology, mechanically robust when mounted on rigid surfaces, compatible with MMIC designs, and when the particular patch shape and mode are selected they are very versatile in terms of resonant frequency, polarization, pattern and impedance [1].

Due to the improvement of one of the characteristic, this normally results in degradation of the other. 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 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.

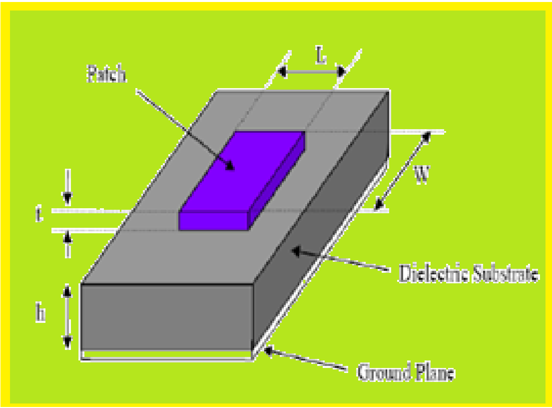


Figure 1: Microstrip Patch antenna

Compact microstrip antennas have recently received much attention due to the increasing demand of small antennas for personal communications equipment. For achieving microstrip antennas with a reduced size at a fixed operating frequency, the use of a high-permittivity substrate is an effective method. Compact operation of microstrip antennas can be obtained by meandering the radiating Patch [2].

2. Design Specification

Design parameters are calculated using the equations given by C. A. Balanis, *Antenna Theory* [1]. The essential parameters for the design of a rectangular Microstrip Patch Antenna are:

(i) Frequency of operation (f_o): The resonant frequency of the antenna must be selected appropriately. The Mobile Communication Systems uses the frequency range from 1800-5600 MHz. Hence the antenna designed must be able to operate in this frequency range.
(ii) Dielectric constant of the substrate (ε_r): The dielectric material selected for my design is silicon which has a dielectric constant of 2.55. A substrate with a high dielectric constant must be selected since it reduces dimensions of the antenna.

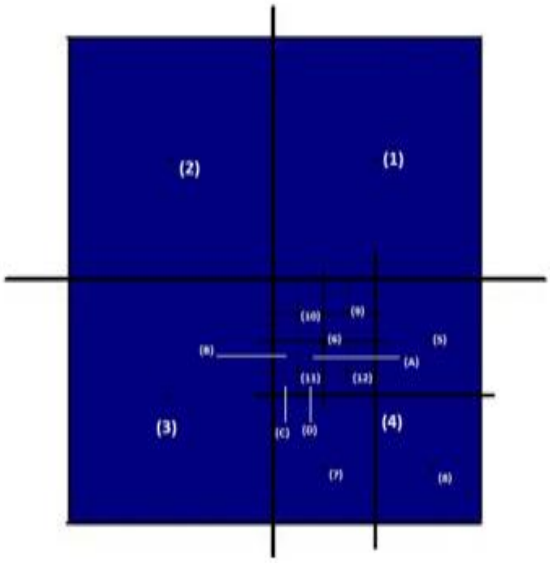
(iii) Height of dielectric substrate (h): For the microstrip patch antenna to be used in cellular phones, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is selected as 1.59 mm.

Parameters are selected and calculated as [3-4]

1. Dielectric constant (ε_r) = 2.55
2. Frequency (f_r) = 2.58 GHz.
3. Velocity of light (c) = 3×10^8 ms^{-1}
4. Practical width W = 30 mm.
5. Loss Tangent (tan δ) = 0.009.
6. Practical Length L = 34 mm.

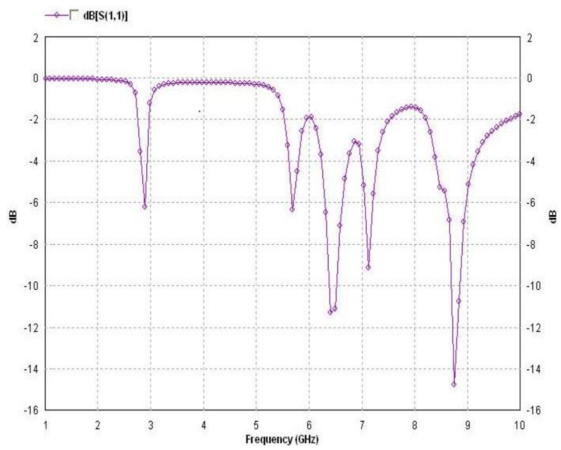
Design Step 1: Probe Feed: The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane.

Probe feed at point (0,-5):



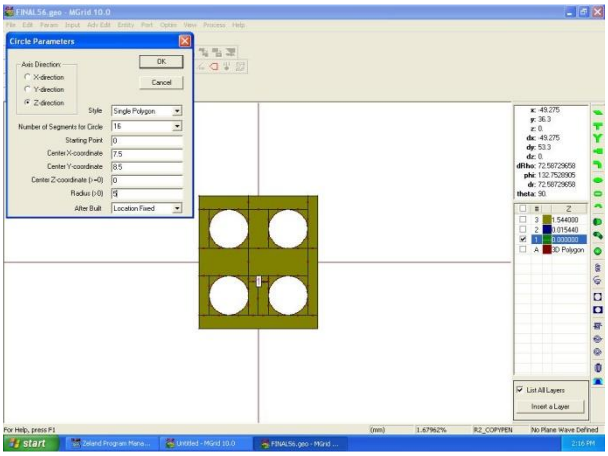
Obtaining feed point by dividing the microstrip patch according to the obtained return loss and operating frequency.

Patch Output with Probe Feed

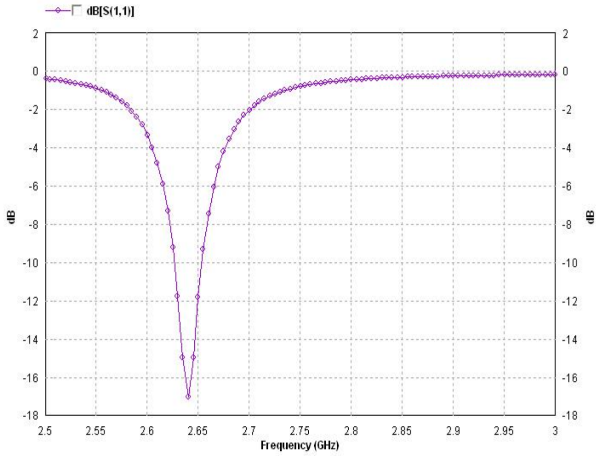


Design Step 2: Cut Holes

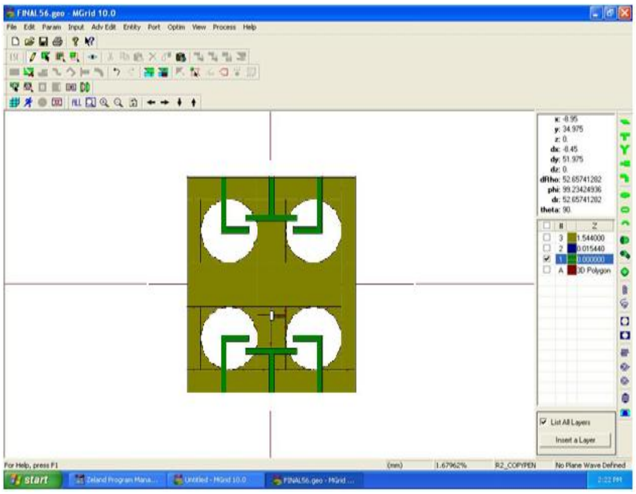
Cut the holes in patch with radius (7.5,8.5) (7.5,-8.5) (-7.5,8.5) (-7.5,-8.5):



Output with holes cut in the patch:



Design Step 3: Design the Defected ground Structure (DGS): DGS stands for Defected Ground Slot which is a high performance, compact size and low cost slot cut into the ground plate to meet the stringent requirements of modern microwave communication systems. DGS is an etched periodic or non-periodic cascaded configuration defect in ground of a planar transmission line (e.g., microstrip, coplanar and conductor backed coplanar wave guide) which disturbs the shield current distribution in the ground plane cause of the defect in the ground. This disturbance will change characteristics of a transmission line such as line capacitance and inductance. In a word, any defect etched in the ground plane of the microstrip can give rise to increasing effective capacitance and inductance. There are DGSs designs so as to improve the circuit performance.

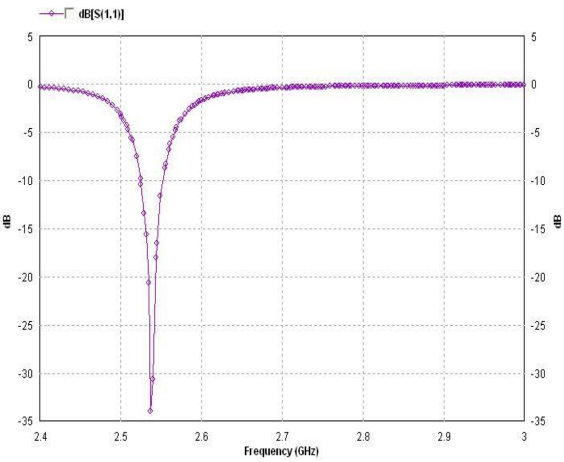


3. Result

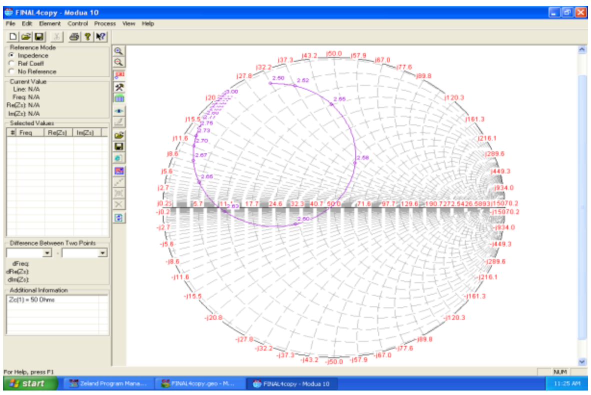
On designing of rectangular patch antenna on electromagnetic simulator IE3D using above parameters antenna parameters like return loss, VSWR and smith chart can be obtained.

Final Output with DGS and holes cut:

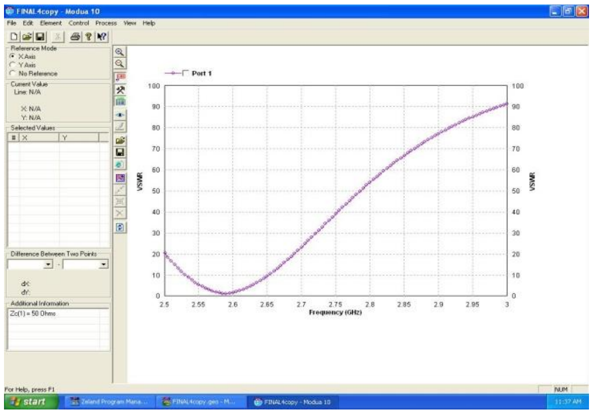
(i) Return Loss



(ii) Smith Chart



(iii) Voltage Standing Wave Ratio:



4. Conclusion

Design of Compact Rectangular Micro strip Patch Antenna with DGS L structure effect at 2.5 GHz (Probe Feed) has been completed using Zealand IE3D software and after simulation we get a return loss of -34 db at operating frequency 2.5 GHz. The simulation gave results good enough to satisfy our requirements to fabricate it on hardware which can be used wherever needed. The investigated results can be used to design the microstrip patch antenna to be used in the applications such as Wi-Fi and Bluetooth. For future work this design can further optimize by the help of Artificial Neural Network. ANN provides various algorithm to improve design and its working.

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