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FR-4 Substrate Based Microstrip Patch Antenna for Archaeology Application

R.Ashra
Electronics and Communication Engineering
Bannari Amman Institute of Technology,
Sathyamangalam.
ashra.ec14@bitsathy.ac.in

R.Devika
Electronics and Communication Engineering
Bannari Amman Institute of Technology,
Sathyamangalam.
devika.ec14@bitsathy.ac.in

Abstract

A Microstrip patch antenna has narrow bandwidth and can withstand mechanical stress. Due to their compact size they can be easily placed without protruding out. Archaeology is to learn more about past societies and the development of the human race. The ground penetrating radar (GPR) consist of transmitting and receiving antennas. When an artifact is buried under the ground and this sensor is moved over the empty soil to a position over a target (artifact), the reflection from the target causes an increase in coupling between the antennas resulting in the increase in the coupling and can be used to detect the buried objects using ADS software. The FR-4 material having dielectric constant of 4.4 and thickness of 1.5 mm has been employed as substrate. It has been observed that the proposed antenna is resonant at 552 MHz with corresponding return loss of -19.22 dB. The antenna has been designed and simulated using ADS 2013. The antenna has been fabricated and tested for experimental validation using Network Analyzer. It has been observed that the practical results closely match with the simulated results of the antenna.

Keywords— ADS, dB, FR-4, gain, GHz, Archaeology, MHz, Network Analyzer, return loss

I. INTRODUCTION

Antenna converts the electrical energy into RF signal at the transmitter and RF signal into electrical energy at the receiver side. An antenna is a very important device in wireless applications. The construction of rectangular patch in the antenna is made up of a conducting material Cu (Copper) or Au (Gold) and this can be in any shape of rectangular, circular, triangular, elliptical. A micro strip antenna consists of a rectangular patch on a ground plane separated by dielectric substrate. Antenna consists of radiating patch on one side of a dielectric substrate which has a ground plane on the other side

Micro strip antenna have a number of advantages which are small size, low profile, low weight but have a number of disadvantages like low bandwidth, low gain. Fractal geometry has been applied on patch of antenna instead of removing. Fractal geometry composed self-similar structure. When fractal geometry is applied on the cuts which are made up on rectangular patch which changes the current flow direction. Antenna is resonating at different bands of frequency. The operating bands are L, S, and C and X band. When fractal geometry is applied, it can be useful of applications like GPS, GSM, satellite, communication and the number of iterations increases, size of antenna decreases.

II. LITERATURE REVIEW

Research Paper on: “Design of rectangular stacked microstrip antenna for Dual band”. A dual-band characteristic of single layer stacked rectangular microstrip antenna is experimentally studied. The variations of the length and width of the stacked rectangular patch antenna has been done and found dual resonance with increasing lower resonance frequency and almost constant upper resonance frequency with increases of the length & width of rectangular microstrip antenna. The VSWR has been measured with the help of Network analyzer. In this paper, rectangular patch antenna is designed by using parasitic stubs and slot. To eliminate stray electric field, remove the upper two corners of patch by using edge tapering. It has higher bandwidth than conventional antenna. The proposed antenna is implemented and fabricated on FR4 Epoxy Glass substrate (er = 4.4) with thickness of 1.6 mm. Rowe et al presents the microstrip patch antennas for MMICs.50Ω microstrip feed line in stacked antenna, emulates The high dielectric constant is emulated on alumina substrate materials used in MMICs. The etched parasitic patch elements in Literature Review 35 Rogers RT/duroid 58880 laminates and are separated by form dielectrics. The broad impedance bandwidth, large front to back ratio neglects the need for the cavities to reduce back radiation. In proposed antenna structure exhibits an upgrade in the stacked patch antenna.High directivity fractal boundary microstrip fractal boundary Microstrip patch antenna presented by Borja et al. patch antenna with a fractal boundary exhibits localized modes. Array of antennas behaves as the fractal boundary antennas During in phase the modes are localized properly, a broadside pattern is generated, the increase in directivity in comparison to the antenna directivity in fundamental mode frequency.

DESIGN SPECIFICATION

The resonant cavity is created by metallic patch , where the top of the cavity is patch, the bottom of the cavity is the ground plane, the sides of the cavity are formed by the edges of the patch. The edges of the patch act approximately as an open-circuit boundary condition.

On analyzing the patch antennas it seem that the behaviour and point of view is very clear. The electric field is essentially inside the patch cavity of z directed and independent of the z coordinate. so, the described patch cavity modes have double index (m, n). The electric field of rectangular patch has the form

$$E_z(x,y) = A_{mn}\cos\left(\frac{m\pi x}{L}\right)\cos\left(\frac{n\pi y}{W}\right)$$

Where L is the patch length and W is the patch width. Usually operating the patch is in (1, 0) mode, so that L is the resonant dimension, and essentially the field constant is in the y direction.The metal patch has bottom surface current with x directed and is given by, and is given

$$J_{sx}(x) = A_{10}\left(\frac{\pi / L}{j\omega\mu_0\mu_r}\right)$$

The current is maximum at the centre of the patch, x = L/2, while the electric field is maximum at the two "radiating" edges, x = 0 and x = L.

The width W is usually chosen to be larger than the length (W = 1.5 L is typical) to maximize the bandwidth, since the bandwidth is proportional to the width. (To avoid excitation of the (0,2) mode the width should be kept less than twice the length.) At first review, that may appear the microstrip antenna is an powerful radiator then electrically thin, till will be effectively shorted from the close proximity to the ground plane. However, the Q of the cavity increases as h decreases (the radiation Q is inversely proportional to h). so,modal field at resonance is inversely proportional to h because of amplitude A10. Hence, radiated field is strength from a resonant patch is independent of h, if losses are ignored. The resonant input resistance will likewise be nearly independent of h. This tells patch antenna is effective radiator for thin substrates, even the bandwidth is very small.

ANTENNA GEOMETRY

FR-4 (Flame Retardant 4) used as substrate to design the proposed antenna having dielectric constant of 4.4 and thickness of 1.5 mm. The geometry of proposed antenna has been shown in Fig. 1. The antenna has a slotted radiating patch with dimensions as shown in Fig. 1, Fig. 2 and fig. 3 respectively.

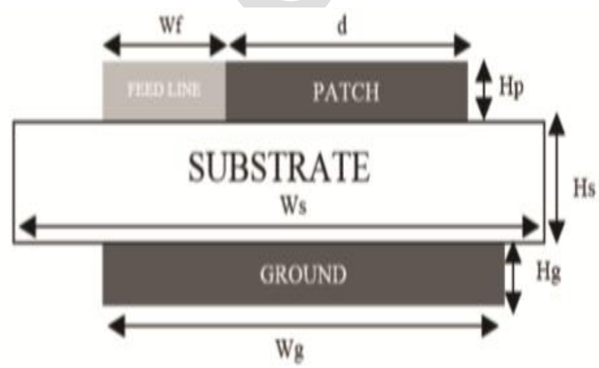

Fig.1. Side view of the proposed antenna

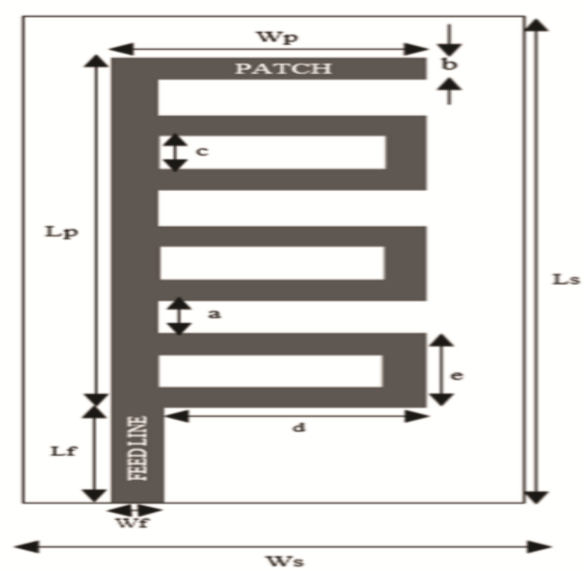

Fig.2 Top view of the proposed antenna

The antenna has reduced and defected ground plane of dimensions 25mm x 25mm as shown by bottom view of antenna in fig. 3. The substrate of thickness 1.5 mm and copper of thickness 17 microns has been employed in the microstrip patch antenna design as shown in fig. 1

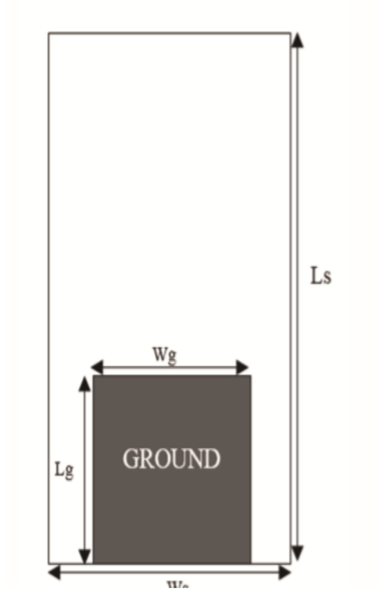

Fig. 3. Bottom view of the proposed antenna

A. *Antenna dimension*

The Advanced Designed System has been used to design proposed microstrip patch antenna.The performance of proposed antenna has been analyzed in terms of return loss (dB), directivity (dBi), gain (dB), impedance bandwidth (GHz), VSWR and antenna impedance (ohms).Selection of substrate and thickness of the microstrip patch antenna The length of the substrate (Ls) is 108mm.

The antenna parameter can be measured by changing the substrate thickness from 0.5 mm to 4.5 mm for the inset feed rectangular microstrip patch antenna. The degradation of Antenna performance occurs when substrate material with higher dielectric constant in microstrip patch antenna design.

Fig.4 which indicates that the antenna has resonant frequency of 552 MHz with corresponding bandwidth of 205 MHz (761MHz to 966MHz)

B. *Software results*

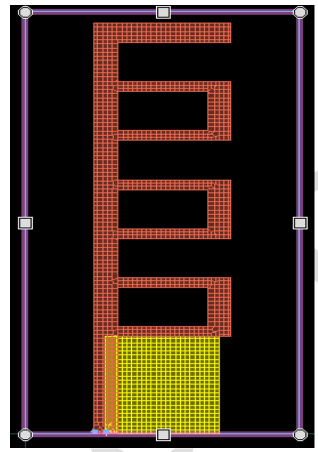

Fig. 4. Software model of the proposed antenna

Antenna Dimensions	**Value (IN MM)**
Length of the substrate Ls	108
Width of the substrate Ws	80
Thickness of the substrate Hs	2.4
Length of the ground surface Lg	25
Width of the ground surface Wg	25
Thickness of the ground surface Hg	0.019
Length of the patch Lp	30
Width of the patch Wp	30
Thickness of the patch Hp	0.019
Length of feedline Lf	25
Width of feedline Lf	5.4
A	10
B	5
C	10
D	24.6
E	15

Fig. 5. Antenna Dimension

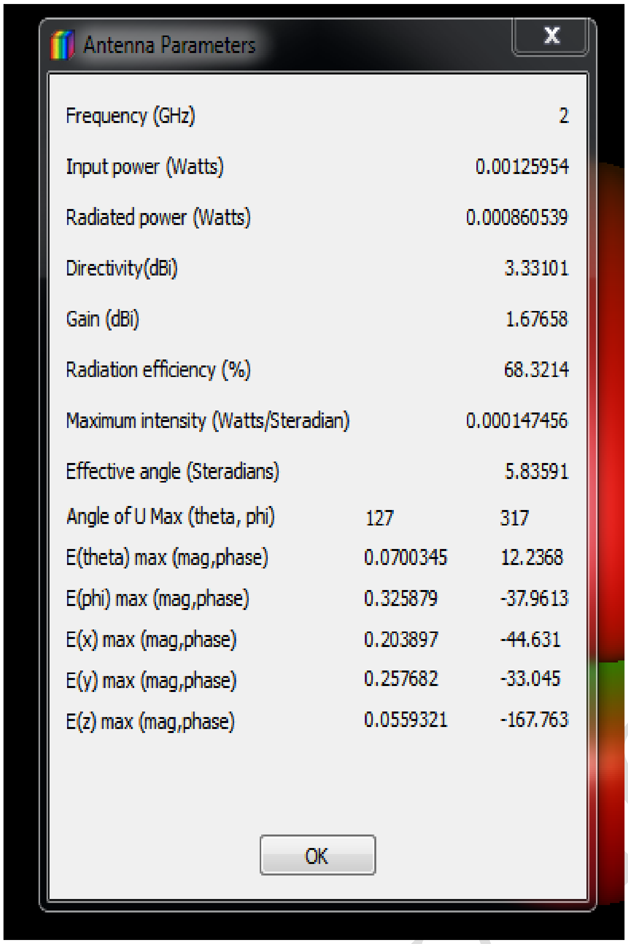

Fig. 6. Antenna parameter of the proposed antenna

III. CONCLUSION

ADS Software has been used for the design of FR-4 based microstrip patch antenna. The FR-4 material having dielectric constant of 4.4 and thickness of 1.5 mm has been employed as substrate. The slotted radiating copper patch has been placed on the top of the substrate and the copper ground has been placed on the bottom side of substrate. The ground plane has been reduced as well as defected in order to enhance the antenna performance parameters in terms of impedance bandwidth and return loss (S11). It has been observed that the proposed antenna is resonant at 552 MHz with corresponding return loss of -19.22dB. The proposed antenna has been practically fabricated and tested for practical results using network analyzer E5071C and anechoic chamber. The practically tested antenna is resonant at 815 MHz with corresponding return loss of -28.487 dB and impedance bandwidth of 165MHz. The proposed flexible microstrip patch antenna can be suitably employed for buried archaeology.

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