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Defected Ground Substrate Slotted Microstrip Patch Antenna design for Fixed Satellite, Mobile Satellite and Space Research Applications

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***Abstract*—In this paper, the substrate slotted microstrip patch antenna for X-band fixed satellite, mobile satellite and space research applications has been proposed. This proposed design has been fabricated over FR4 substrate having dielectric constant ε_r = 4.4 and thickness of 1.57 mm. The designed antenna is a wideband antenna with percentage bandwidth of 17.11% (7.18GHZ-8.51GHz) and with resonating frequency of 7.77GHz. The antenna has been fed by microstrip feedline via impedance transformer to match the input impedance of the antenna with the 50Ω impedance of SMA connector. The proposed antenna has been analyzed in terms of return loss(S_{11}), Voltage Standing Wave Ratio (VSWR), gain, directivity, smith chart and Half Power Beam Width(HPBW)The designed antenna has return loss (S_{11}) of -68.05dB, gain of 4.904dB and directivity of 4.6 dBi. The proposed antenna can be suitably employed for X-band applications − fixed earth exploration satellite, space research, defense systems, radio determination and UWB(Ultra-Wide Band), weather satellites and satellite payload telemetry applications. The proposed antenna has been designed and simulated in CST Microwave Studio 2014.**

***Index Terms*—CST Microwave Studio 2016, return loss (S_{11}) space research, wideband antenna.**

I. Introduction

Rectangular microstrip patch antennas have receivedmuch attention because of their low cost, low profile, andlightweight properties[1].The microstrip patch antenna also termed as patch antenna, is usually fabricated on a dielectric substrate which acts as an intermediate between a ground plane at the bottom side of substrate and a radiating patch on the top of substrate[2][3]. The selection of substrate is the most important parameter while designing an antenna. The most commonly used dielectric substrate in antenna designing is Flame Retardant 4 (FR4). The feeding can be defined as a means to transfer the power from the feed line to the patch, which itself acts as a radiator. The antenna can be fed by various feeding methods like coaxial feed,proximity coupled microstrip feed and aperture coupled microstrip feed[4][5][6].One of the limitations of the microstrip patch antennas is the narrow impedance bandwidth. Several techniques have been investigated to improve the impedance bandwidth of microstrip patch antenna[7]. This includes meandering slots in the ground plane[8]and optimally designed impedance matching network [9].

X band technology has been broadly used in various applications because of its high data transmission rate, large bandwidth and short-range features. Designing X band antennas has tempted the interest of many researchers and is still a major challenge to equalize these applications[10][11][12].

Section II deals with the antenna design specifications which describes the dimensions of the designed antenna. Section III illustrates the performance of proposed antenna in terms of bandwidth, return loss (S_{11}), gain, directivity and VSWR plot. Section IV describes the nutshell of the research along with its application areas.

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II. Design Specifications

The antenna has been designed and simulated in CST Microwave Studio 2014. It has been fabricated using FR4 substrate of thickness T_s=1.57mm and dielectric constant of ε_r=4.4 with tangent loss of δ= 0.025. The patch and ground

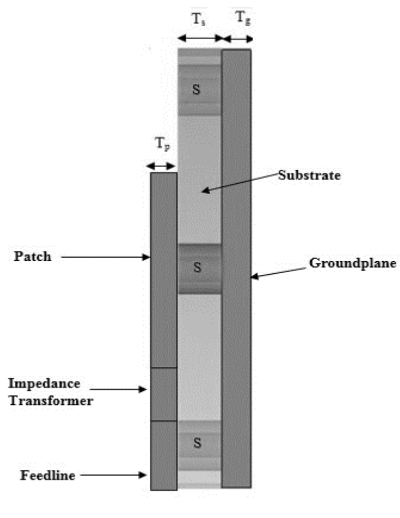

Fig.1 Top view of proposed antenna in CST Microwave Studio 2014

are made of copper having thickness T_p=T_g=0.02 mm as shown in side view of antenna in fig. 1. The antenna has compact area of 17.16×33.98mm^2. Three slots haven cut in substrate, each of inner diameter of D_{is}=0.5mm and outer diameter of D_{os}=1mm, in order to improve the bandwidth and return loss of as shown in fig. 2 and 3 respectively. To further enhance the bandwidth, ground has been defected to dimensions 17.16×21.98mm^2. The feedline of specific width has been chosen so as to match its impedance with the 50Ω impedance of SMA co-axial connector All other design

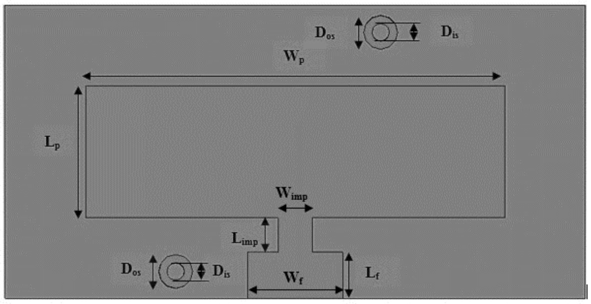

Fig. 2 Top view of proposed antenna in CST Microwave Studio 2014

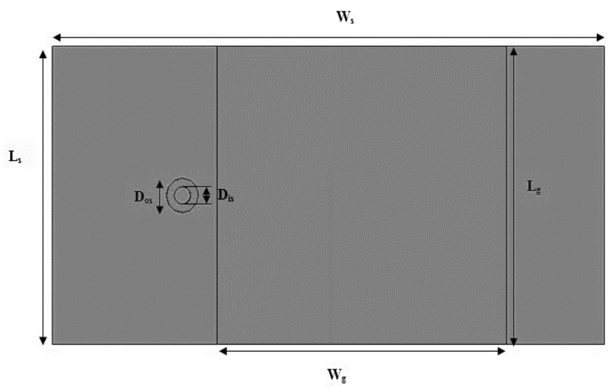

Fig. 3 Back view of the proposed antenna in CST Microwave Studio 2014

TABLE I. ANTENNA DIMENSIONS

Antenna Dimensions	**Value (mm)**
Length of substrate, L_s	17.16
Width of substrate, W_s	33.98
Thickness of substrate, T_s	1.57
Length of ground plane, L_g	17.16
Width of ground plane, W_g	21.98
Thickness of ground plane, T_s	0.02
Length of patch, L_p	7.74
Width of patch, W_p	24.56
Thickness of patch, T_p	0.02
Inner diameter of slot, D_{is}	0.50
Outer diameter of slot, D_{os}	1.00
Distance of slot from extreme left of the substrate	7.00
Distance of slot from extreme top of substrate	2.00
Width of impedance transformer, W_{imp}	2.00
Length of feedline, L_f	3.00
Width of impedance transformer, L_{imp}	2.00
Width of feedline, W_f	5.58

parameters have been discussed in Table I.

III. Simulated Results

The simulated antenna has been scrutinized in terms of return loss plot (S_{11}) (dB), bandwidth (GHz), resonating frequency (GHz), gain (dB), directivity (dBi), VSWR plot and smith chart.

As shown in fig. 4 the designed antenna resonates at 7.77GHz with minimal return loss (S_{11}) of -68dB. Fig. 5 illustrates that the proposed antenna has operating bandwidth of 1.325GHz thus making it a wide band antenna. The simulated antenna has gain of 4.904dB and directivity of 4.644dBi as shown in fig. 6 and fig. 7 respectively. The fig. 8 depicts the VSWR plot of the proposed antenna. The value of VSWR for operating range of frequencies (7.18GHz-8.5GHz) is 1, which is less than the maximum acceptable value of 2. Fig. 9 represents the Half Power Beam width (HPBW) of the simulated antenna. It has been observed that for the simulated antenna design the beamwidth is 96.5 degrees. The impedance of the simulated antenna is matched with the SMA connector to ensure the maximum power transfer through the connector to feedline ass shown in fig.10.

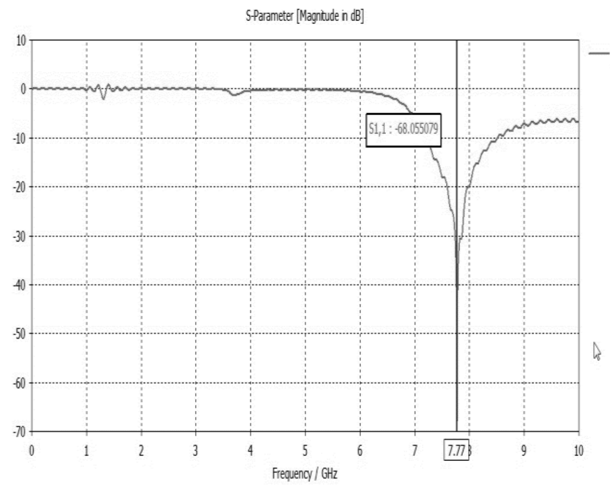

Fig. 4 Return loss (S_{11}) plot of simulated antenna showing its resonant frequency in CST Microwave Studio 2014

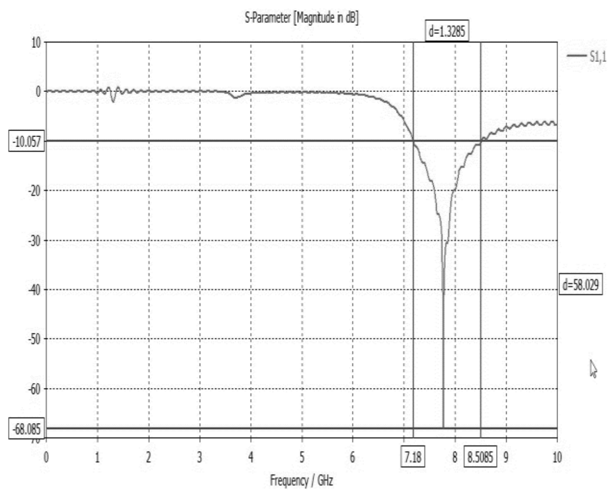

Fig. 5 Return loss (S_{11}) plot of simulated antenna showing its operating bandwidth in CST Microwave Studio 2014

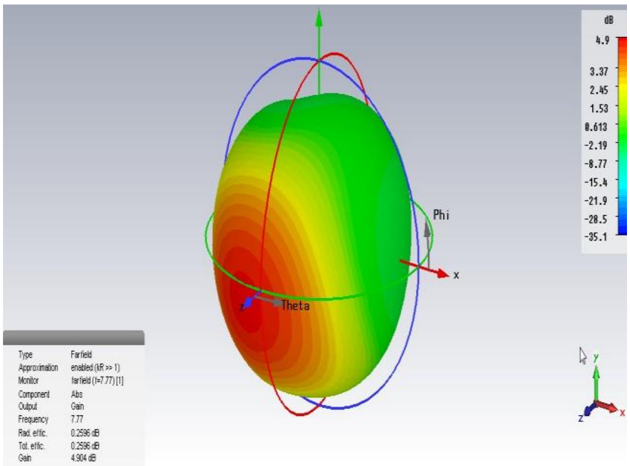

Fig. 6 Gain of proposed antenna in CST Microwave Studio 2014

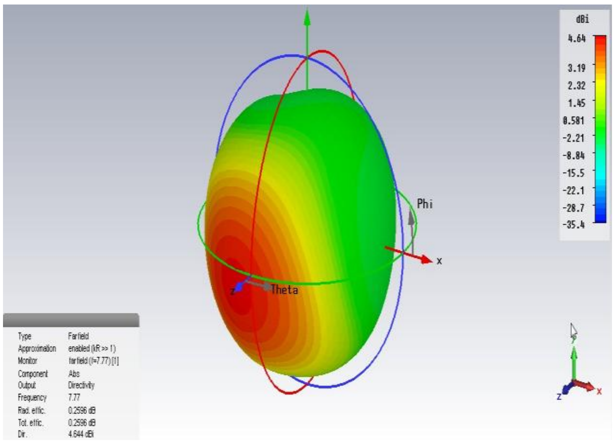

Fig. 7 Directivity of proposed antenna in CST Microwave Studio 2014

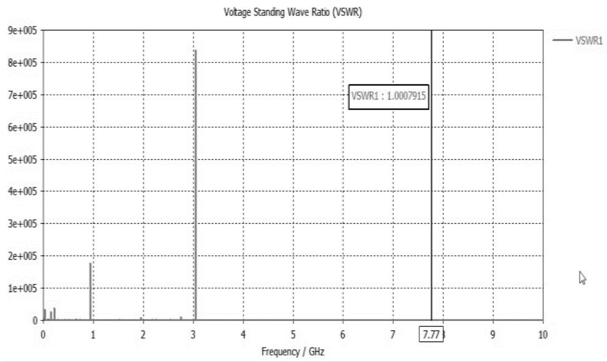

Fig. 8 VSWR plot of proposed antenna in CST Microwave Studio 2014

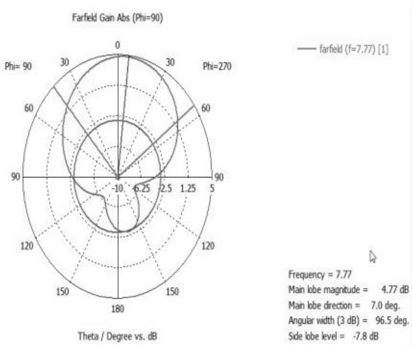

Fig. 9 Half Power Beamwidth (HPBW) of proposed antenna in CST Microwave studio 2014

IV. Conclusion

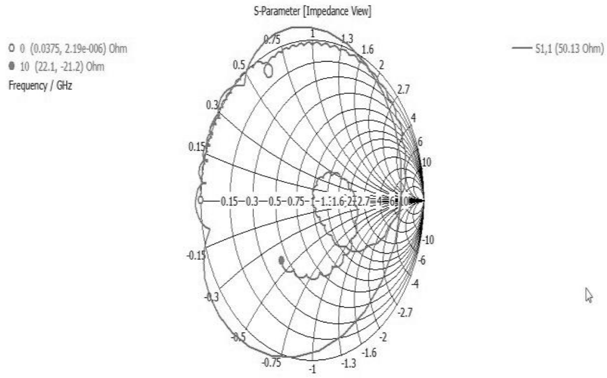

Fig. 10 Smith chart plot of proposed antenna in CST Microwave Studio 2014

The proposed antenna has been simulated and designed in CST Microwave Studio 2014. The proposed antenna resonates at 7.77GHz with operating bandwidth of 1.325GHz and minimal return loss(S_{11}) of -68dB. The proposed antenna has gain of 4.904dB and directivity of 4.644dBi. The proposed antenna can be suitably employed for passive sensors (7.235GHz-7.250GHz), fixed earth exploration satellite for radio determination and UWB applications, space research, defense systems(7.250GHz-73.3GHz), weather satellites (7.45GHz-7.55GHz), radio determination and UWB (Ultra-Wide Band), radio astronomy(8.215GHz-8.4GHz) and space research (8.4GHz-8.5GHz) and satellite payload telemetry applications.

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