Multiple Rectangular Slotted Patch Antenna with Roof-top Shaped at 15.3 GHz

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***Abstract*—In this paper, a compact sized, high frequency microstrip patch antenna with probe feeding is designed, simulated, built and tested. The patch of the antenna is diamond shaped which has a rectangular slot in the upper-center. Main contribution of the paper is to perturb the side edges of the patch and to add a rectangular slot. Parametric study of that two-substrate change was investigated. The proposed structures were simulated by using the Sonnet Suites, a planar 3-D electromagnetic simulation software which gave S11 value of -13.82 dB and gain value of 6.33 dB at 15.3 GHz.**

***Keywords*—Mobile equipment, rectangular slot, roof shaped, single band, wireless communication.**

I. INTRODUCTION

With the advancements of mobile and wireless technologies, the consumer market is demanding compact size handsets with multiple functions. Microstrip antennas are a suitable candidate for these applications due to their inherent properties including low weight, low manufacturing cost, conformability and low profile in comparison to conventional antennas [1].

Pentagonal geometry is one of the various shapes for microstrip antennas capable of circular polarization operation that has been reported in literature, but it can be also used for linear polarization [2]. Electrically thick dielectrics increase bandwidth, but also introduce impedance matching challenges [3].

Slotted microstrip antenna possesses better bandwidth, return loss, gain and directivity when compared with non-slotted microstrip patch antenna [4]. The limitations of MSA such as narrow bandwidth, low gain and low efficiency can be minimized by selecting a proper substrate material, as permittivity of substrate is the critical parameter to control bandwidth, radiation pattern, and efficiency of patch antenna [5].

Furthermore, Multiband microstrip antennas are in demand, because they can reduce the cost and size of the communication systems. They are used in lots of applications such as wireless local area network (WLAN), satellite communications and global system for mobile (GSM) [6]. In addition, different types of dual band microstrip patch antennas are presented in literatures such as dual band microstrip antenna with single patch [7] and stacked patches [8] and using two separate antennas which are connected to by a shorting pin [9] and using metamaterial branch-line coupler [10].

The Wireless communication is mainly concentrated on the antenna size. The reduced antenna size results in small sensor node and low power consumption [11]. So the antenna can be a low profile, low powered and high frequency micro strip antenna. The antenna size is proportional to 1/√ξr [12]. Small antenna concept is the one which uses planar antenna and by adjusting the electrical size the desired center frequency can be obtained [13].

Microstrip patch antennas are usually designed to eliminate the imaginary part of the input impedance. Edge fields are also important and they bring an additional length to the antenna. This length depends on the relative permittivity of the dielectric, dielectric height and patch width [14].

Embedded microstrip antennas have been used therapeutically for a number of applications including cardiac ablation, balloon angioplasty and cancer treatment using hyperthermia. Designers of antennas for sensing or therapy capitalize on some of the problems that plague embedded antennas for communication antennas are inherently sensitive to their environment and inherently deposit large amounts of power in the near field of the antenna, particularly when it is embedded in a lossy material, thus becoming good therapeutic tools [15].

The rest of this paper is organized as follow: the design steps are described in Section II, simulation and parametric study in Section III, and results and conclusion are presented in Section IV of the paper.

II. DESIGN STEPS

The size of the antenna is 6.4 × 6.4mm. Substrate material is Rogers RT6002 and the thickness of it is 0.762 mm (ε_r= 2.94, dielectric loss tangent = 0.0012). The thickness of air is taken

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as 3 times of the thickness of the Rogers RT6002, (3 mm). Probe feeding technique is adopted in this antenna design. Feed point can be moved to any desired location on patch to achieve input impedance. Fig. 1 shows the picture of the fabricated antenna.

III. SIMULATION AND PARAMETRIC STUDY

A comprehensive parametric study of a triangular shaped double-slit microstrip patch antenna has been carried out to understand the effects of various triangular slits. Analyses were performed using a commercial software. The frequency range is between 10 - 20 GHz. In two different frequency values, obtained magnitude values were -10dB below. When the magnitude of S11 is -14.12 dB, gain is 6.33 dB at 15.3 GHz. In second analysis, frequency was 14.7 GHz and S11 was -24.5 dB and the antenna's gain is 4.18 dB. A prototype of this antenna is tested by using an HP8720D network analyzer. Fig. 2 shows the comparison between simulated and measured S-parameters' results of the proposed antenna. It is noticed that there are some difference between the simulation and measurement results. These differences can be considered acceptable as long as its effect on the resonant frequency is not high and the frequency band does not shift much. The discrepancies are mostly due to the insertion loss of SMA connectors, surrounding environment that influences on wave reflection, or the fabrication tolerances. S11-frequency graph is shown and -13.82 dB magnitude is found at 15.3 GHz. In Fig. 3, gain-frequency Graph is shown and +6.33 gain is found at 15.3 GHz. Note that cross-polarization level is less than -17 dB. Fig. 4 has the simulated antenna with changed parameters. Table I provides the list of variables changed and their values and Table II provides frequency gain input match verses modified gap. Variables B, C and E has great effect on antenna gain. Highest gain is achieved when B is 0.1mm.

Fig. 1. Picture of the fabricated antenna.

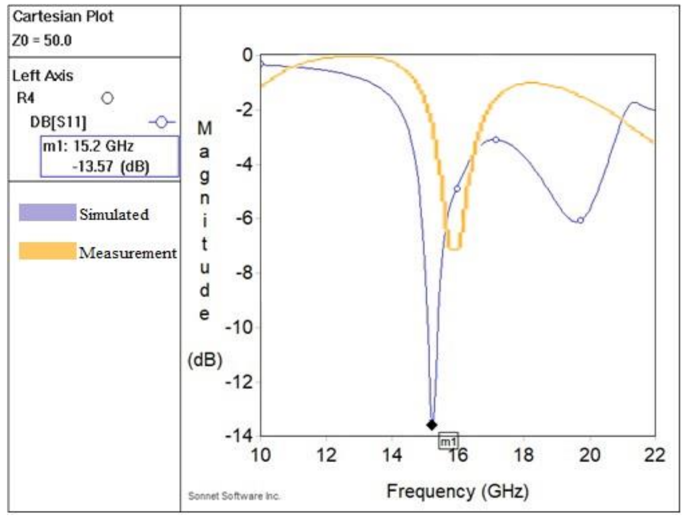

Fig. 2. S11 graph.

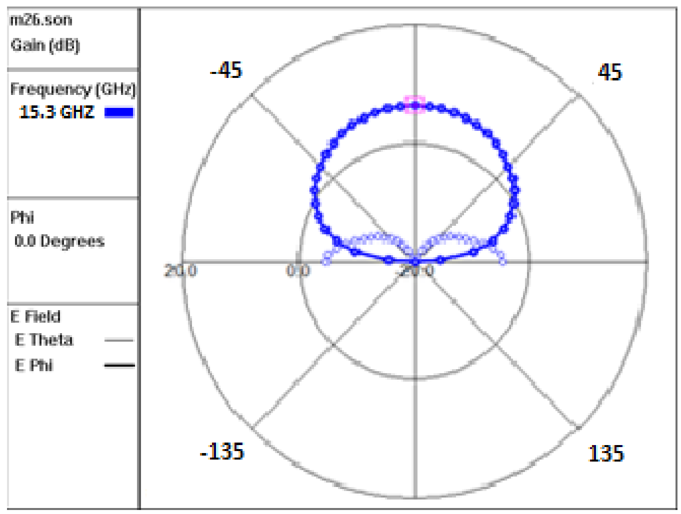

Fig. 3. Radiation pattern (gain) graph.

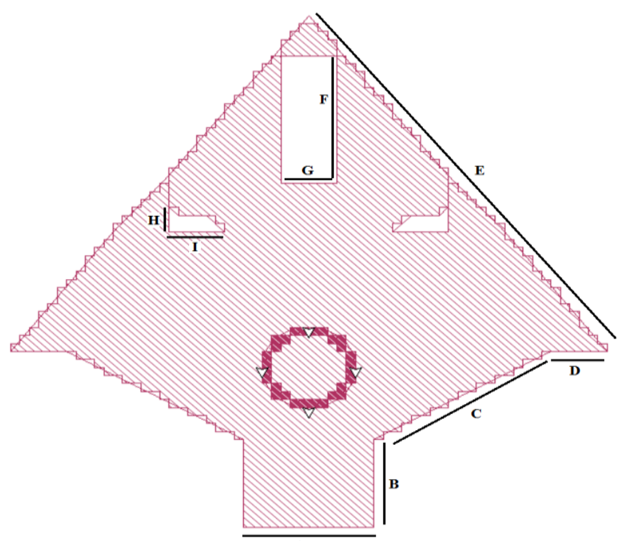

Fig. 4. Top view of the simulated antenna and its parameters.

TABLE I. CHANGING PARAMETERS

Variable	Value
A	1.4 mm
B	1.1 mm
C	2.2 mm
D	0.6 mm
E	5.3 mm
F	1.6 mm
G	0.6 mm
H	0.3 mm
I	0.6 mm

TABLE II. FREQUENCY-GAIN-INPUT MATCH WITH MODIFIED GAP

Variable	Freq. (GHz)	S11 (dB)	Gain (dB)
B = 2.1mm	22.7	-18.7	1.92
B = 0.1mm	20.2	-12.0	6.27
C = 2.7mm	16.6	-16.15	6.11
D = 1.6mm	23.4	-18.6	3.92
E = 5.8mm	25.2	-23.3	4.24

IV. CONCLUSION

A comprehensive parametric study has been carryout out on perturbed pentagonal cross-slotted patch antenna. Throughout our design steps in this conclusion part of this project we can say that designing roof shaped rectangular shaped antenna is not easy to optimize due to limitations, dielectric material type, gain - frequency relation, feeding type and technique. Compared to the first analysis, in the second analysis there was a decrease in the gain value. So, when the frequency is at 15.3 GHz, S11 is -13.82 dB and the gain value is found as + 6.33 dB. In the second analysis when the frequency is at 14.7 GHz, S11 value is -24.5 dB and the gain is found as +4.18 dB.

By varying the thickness, different parameters of the designed antenna can be optimized. Proposed antenna can be used in different applications such as in wireless communication and S band applications.

Two different analyses were compared in this article. We are also in the process of measuring the fabricated antenna for further studies on single band operations.

The simulations results are performed using Sonnet software [16].

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