Perturbed Hexagonal Antenna at 14.7 GHz

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Abstract—This paper represents a high-gain, single resonance microstrip patch antenna which operates at 14.70 GHz. Measurement result of electric field phi-polarized gain is 10.72 dB. There is an alternative design with four rectangular slots at 19.60 GHz. This antenna has compact structure thereby achieving size benefits over previously published works in literature. As a reason of large slitted structure the antenna manufactured easily and works well at high frequencies with more than 10 dB gain.

Keywords—Hexagonal; high frequency; microstrip patch antenna; slit; slot.

I. Introduction

Microstrip patch antennas (MPA) are a class of planar antennas which have been researched and developed extensively in the last three decades [1]. Simply a microstrip antenna is a rectangular or other shape, patch of metal on top of a grounded dielectric substrate. Microstrip patch antennas are attractive in antenna applications for many reasons [2]. Hexa shape microstrip antenna has smaller size compared to the square and circular microstrip antennas for a given frequency [3-6]. Some of the principal advantages of microstrip antennas compared to conventional microwave antennas are; light weight, low volume, thin profile configurations, low fabrication costs, linear, and circular polarizations are possible with simple feed, dual-frequency, and dual-polarization antennas can be easily made, no cavity backing is required, can be easily integrated with microwave integrated circuits [7]. However, with such great advantages come drawbacks. Microstrip patch antennas are known for having narrow bandwidths and narrow design tolerances [8]. The single-feed technique has the advantage of not requiring an external polarizer such as a 90 degree hybrid coupler. This technique can be found in literature such as [9] and [10]-[12].

II. Design and Simulation Results

Marjan Mokhtaari and Jens Bornemann introduced Printed-Circuit Antennas for Ultra-Wideband Monitoring Applications which operates between 3 GHz and 30 GHz [12]. In this work, a similar antenna is designed with two slits but as a result, single-polarization is achieved with high-gain. Dimensions of the antenna is 28×18.54 mm. Top view of the antenna is in Figure 1. Design 1 had −26.0413 dB input match with gain of 10.17 dB's at 14.70 GHz. Second design step was adding some slits right side and left side of the antenna. As a result, 0.01 dB less gain was obtained as compared to Design 1. Third design step was changing the location of the slits. When the slits were shrinked by 0.1 mm in the x-axis, design improved as seen in Table 1's left column. When the slits were expanded by 0.1mm in the x-axis, design parameters degraded as seen in Table 2's left column.

TABLE I. Frequency-Gain-Input Match When Slit Decrease

Design Steps	Frequencies	Gain (dB)	Input Match (dB)
1- a(2.1)b(2.4)	*14.70 GHz*	*10,17*	*−26,04*
2- a(2.0)b(2.3)	*14.70 GHz*	*10,16*	*−27,36*
3- a(1.9)b(2.2)	*14.70 GHz*	*10,19*	*−27,27*

TABLE II. Frequency-Gain-Input Match When Slit Increase

Design Steps	Frequencies	Gain (dB)	Input Match (dB)
4- a(2.2)b(2.5)	*14.70 GHz*	*10,19*	*−23,27*
5- a(2.3)b(2.6)	*14.70 GHz*	*10,20*	*−22,09*
6- a(2.4)b(2.7)	*14.70 GHz*	*10,21*	*−20,90*

We change dielectric constant to see the effect on S11 and gain. The results are shown in Table 3.

TABLE III. S11 and Gain Results With Different Dielectrics

Dielectric Constant	S11 (dB)	Gain (dB)
2,80 (εr)	*−20,42*	*10,24*
2,85 (εr)	*−20,75*	*10,26*
2,90 (εr)	*−20,45*	*10,30*
3,00 (εr)	*−21,45*	*10,32*
5,00 (εr)	*−37,78*	*10,72*

In order to see the fabrication tolerances the dielectric thickness was changed. The results are shown in Table 4.

TABLE IV. S11 and Gain Results with Different Thickness

Thickness	S11 (dB)	Gain (dB)
0,700 (mm)	*−27,50*	*10,83*
0,762 (mm)	*−37,78*	*10,72*
0,730 (mm)	*−29,43*	*10,84*
0,800 (mm)	*−31,32*	*10,69*
0,830 (mm)	*−22,96*	*10,70*

First slit's dimension is 3.6×1.8 mm which is at left side of the antenna (a), second slit's dimension 3.7×1.8 mm slit which is at right side of the antenna (b). Note that, slit dimensions are slightly different.

III. Fabrication Results

Before the antenna was fabricated on Rogers RT/Duroid 6002 substrate with εr=2.94 and 0.762 mm (30 mil) thickness. Figure 1 has top view of the fabricated main design.

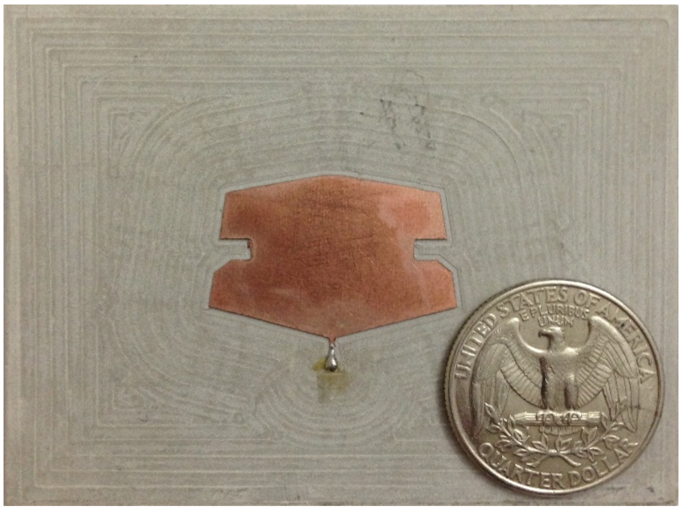

Fig. 1. Top View of the Fabricated Main Design

After we fabricated the antennas, we measured them at Tübitak. The comparison of simulation and measurement input match results graphic is in figure 2. Also comparison of simulation and measurement gain graphic of main design is shown in figure 3. We can see the simulation results of E Theta (blue) and E Phi (red) on the graph in figure 3.

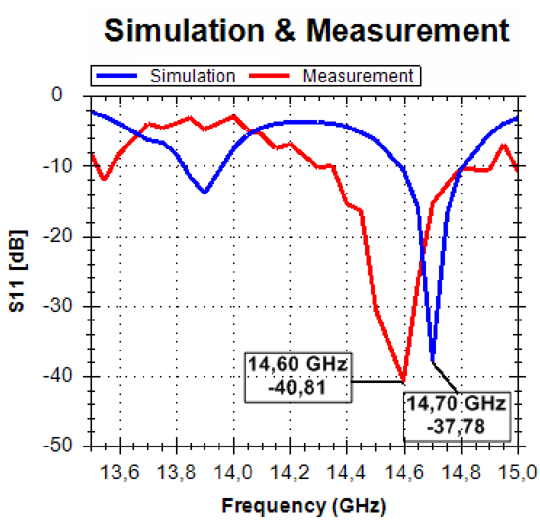

Fig. 2. Input Match Comparison of the Main Design.

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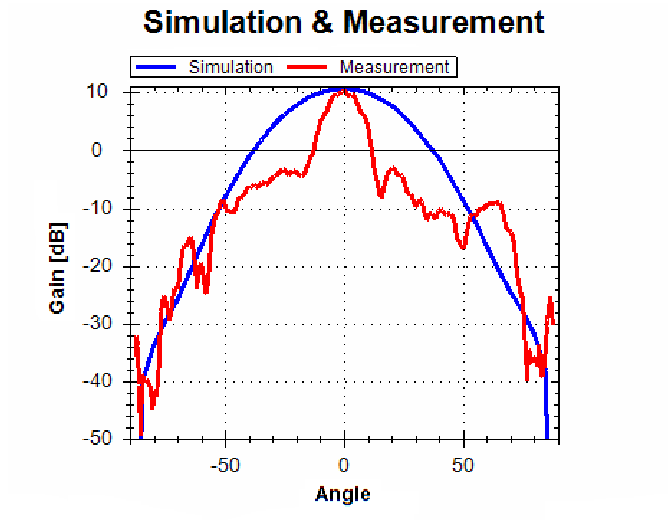

Fig. 3. Gain Comparison of the Main Design.

IV. Conclusion

In this work, a single-fed, single-resonance, high gain microstrip patch antenna is designed, simulated, fabricated, and tested. Design was modified by making an optimization on geometry, resulting slits, and slots on the body of the antenna. The measured S11 and radiation patterns of antennas are found to be in good agreement with the simulated results and the performance of the proposed antenna is better comparing the conventional existing microstrip patch antennas found in the literature in terms of size and gain.

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