E-Shaped High Gain Microstrip Patch Antenna

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Abstract: : In this work, an E shape microstrip patch antenna which operates at two center frequencies of 1.84 GHz and 2.91 GHz, is designed and simulated. As a commercial simulation tool, Sonnet Suites [1], a planar 3D electromagnetic simulator was used. Details of the simulation results are presented and discussed. Main application of the work would be the airway radar systems in UHF band (IEEE 802.11) and also worldwide interoperability for microwave access (WiMAX) systems in IEEE 802.16 band.

Keywords: Microstrip, Patch, Antenna, E shape

1. Introduction

In this design study, the main purpose was to design an E shape microstrip patch antenna for the airway radar systems used in the frequency range of 1 to 4 GHz. Some articles and applications are examined about microstrip antennas [2-8]. There are a few E shape antennas compared to this work. The side surfaces that used in one antenna are 65 mm. In the center of the shape, the antenna is contributed from a point that is 1/3 far from the surface [2]. There are designs of probe-fed rectangular patch antennas as compared to this study [3-4]. In another work, the shape is designed by forming cutting lines on the sides and obtained more productive results [5]. That design is used GSM-1800 protocol and microwave frequency band is L. The changes of the gap and the height of the antenna can affect the resonant frequency [6]. The frequency range is 1GHz – 4 GHz. There is a UHF band antenna which operates between 800 MHz - 3 GHz as compared to this work, but they have a wider bandwidth [7]. On the other hand, another dual-frequency antenna which operates in different bands, but we obtained more gain compared to that study [8]. An optimizations is performed on the geometry and substrate by changing several parameters. Details of this is in the following section.

2. Design Procedure

Top view of the antenna can be seen on Figure 1. The antenna is in a 1000 x 1000 mm. box with 105 x 65 mm. patch dimensions. Dielectric thickness is 5.6 mm (ε_r =1), and air thickness above this dielectric is 300 mm. Design started with the main patch shown in Fig. 1. A size optimization is conducted. Those values are in Table 1. A 3-D view of the antenna is in Figure 2.

Table 1:Comparison of the size of the antenna

Antenna Size (mm)	Magnitude (S11:dB)	Resonance Freq.(GHz)	Z_{in} (real)	Z_{in} (imaginary)	Gain(dB)
103x65	-25,3649	1,84	23,27192	16,06241	10,33962
105x65	**-31,9617**	**1,84**	**53,24217**	**18,03211**	**10,36966**
107x65	-30,6986	1,84	59,68214	17,40676	10,41159

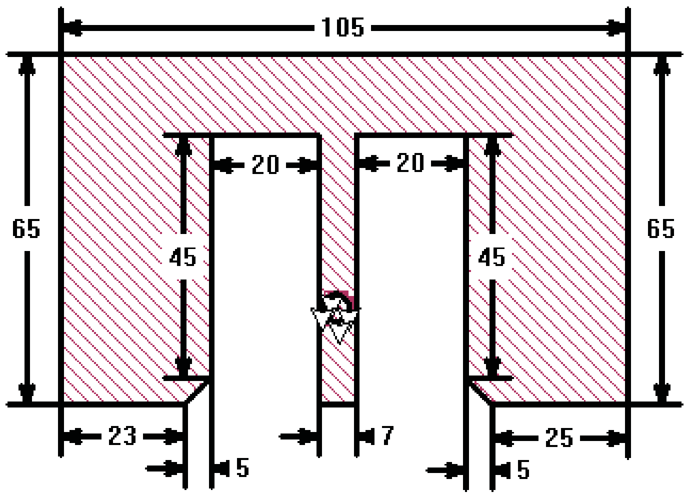

Fig. 1. Top view of the antenna.

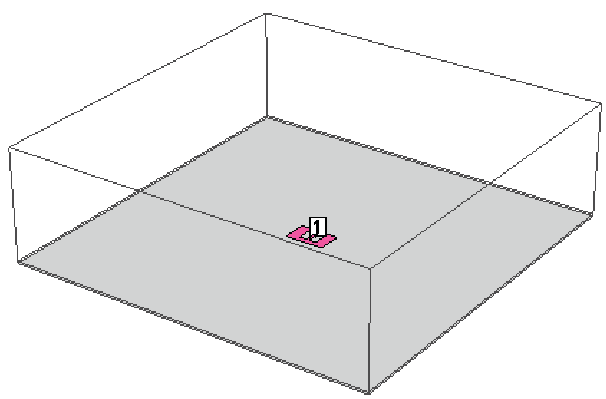

Fig. 2. 3D view of the antenna.

The next work was the optimization of the air layer thickness. The results are seen in Table 2.

Table 2:Optimization of the air layer thickness

Air thickness (mm)	Magnitude (S11:dB)	Resonance Freq.(GHz)	Z_{in} (real)	Z_{in} (imaginary)	Gain(dB)
270	-30,6007	1,84	27,28932	24,30392	10,28883
300	**-31,9617**	**1,84**	**53,24217**	**18,03211**	**10,36966**
330	-35,7560	1,84	36,45755	18,40471	10,24040

The optimization on the dielectric thicknesses is seen at Table 3.

Table 3 :Comparison of the dielectric thickness

Dielectric thickness (mm)	Magnitude (S11:dB)	Resonance Freq.(GHz)	Z_{in} (real)	Z_{in} (imaginary)	Gain(dB)
5,4	-24,7331	1,84	39,6674	15,57604	10,36387
5,6	**-31,9617**	**1,84**	**53,24217**	**18,03211**	**10,36966**
5,8	-31,2310	1,84	37,80494	19,33042	10,37492

The next step was the optimization of the patch. By doing that, the second resonance frequency value of 2.91 GHz is obtained with shortening the middle section of E shape by 4 mm.

3.Simulation Results

Simulation results of the input match (S11) is in Fig. 3. The real part of the input impedances are 53,24 Ω for 1.84 GHz and 50.12 Ω for 2.91GHz.

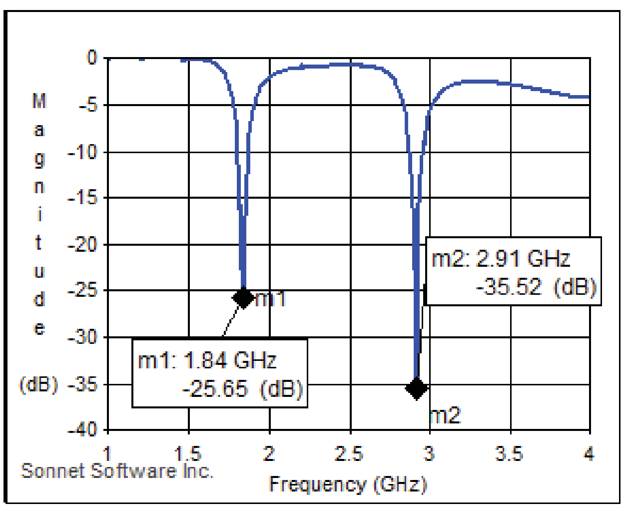

Fig. 3. Input ref. coefficents with dual resonance frequencies.

Theta polarized electric field radiation patterns are in Figures 4 and 5 respectively, for two resonance frequencies. The second resonance frequency of 2.91 GHz has an intermediate gain with maximum gain of 8.03 dB at $\theta = 30^0$.

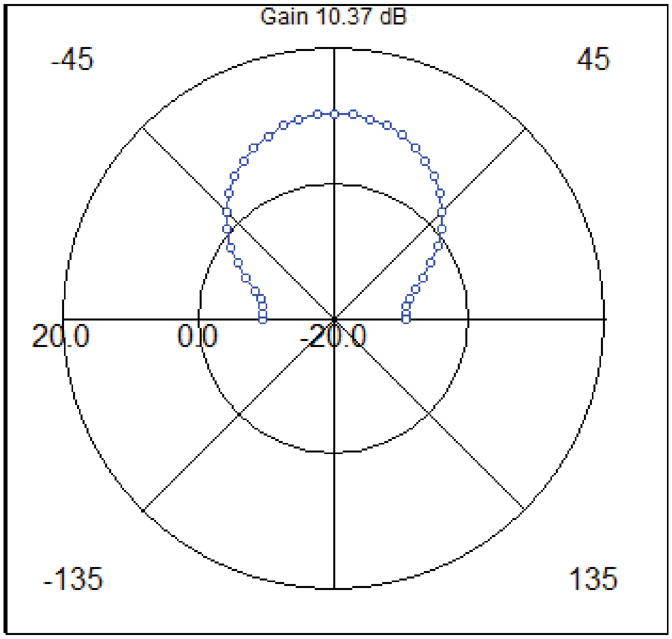

Fig. 4. Radiation pattern at 1.84 GHz.

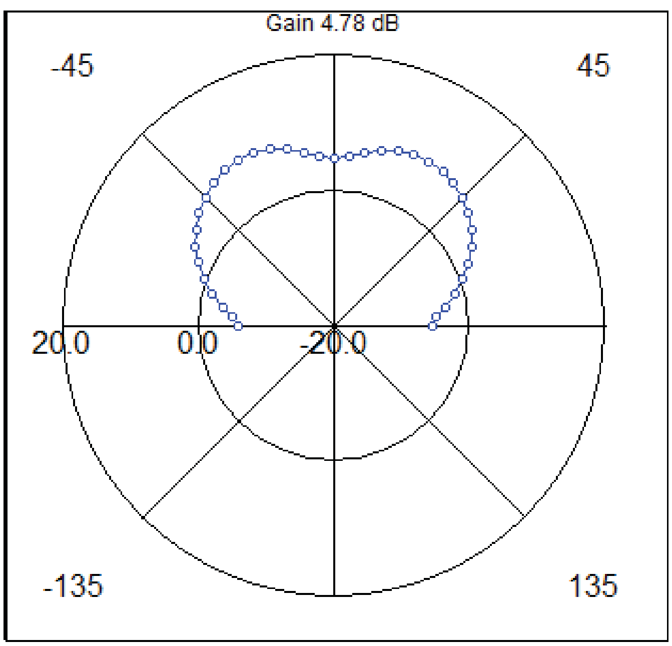

Fig. 5. Radiation pattern at 2.91 GHz.

Figure 6 and 7 have the current on the antenna which shows that main radiated elements are inside edges for the first resonance frequency and, near the probe feed (center leg of E) for the second resonance frequency.

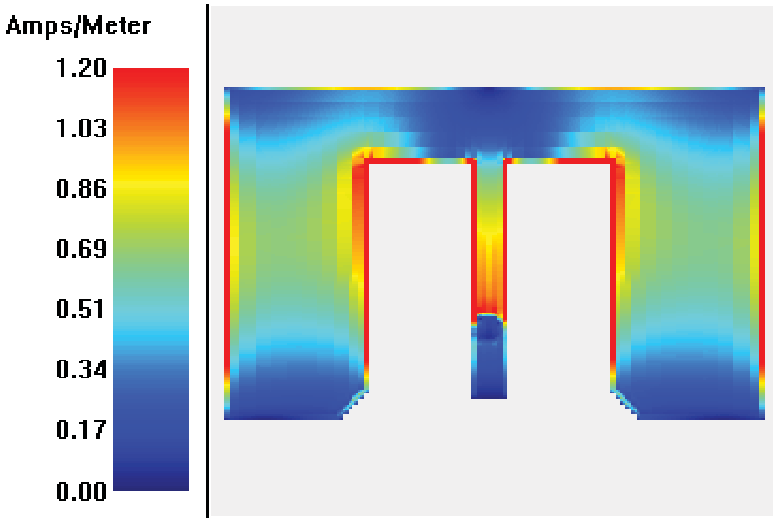

Fig. 6. Current distribution (1.84 GHz) on the antenna.

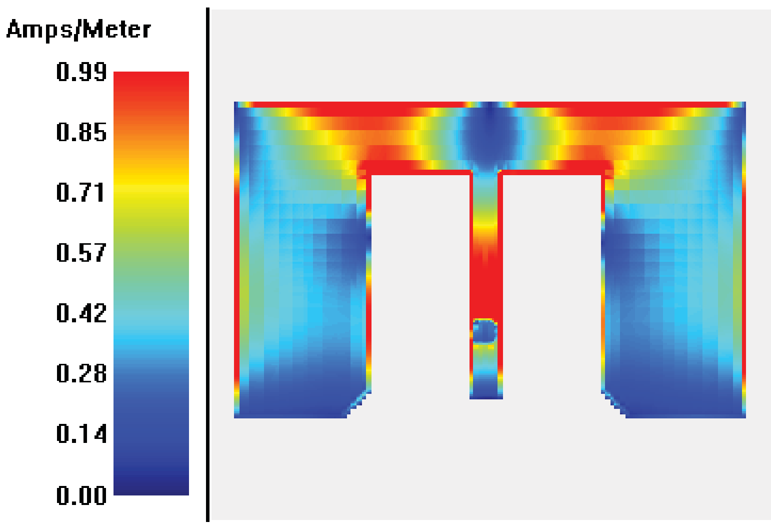

Fig. 7. Current distribution (2.91 GHz) on the antenna.

4.Conclusions

In this design study, the main goal was to design and simulate a dual-resonance patch antenna for 1.84 Ghz and 2.91 Ghz. The changes that are made in the patch geometry helped to improve design parameters such as return loss, gain and Z_{in} Obtained simulated results show the design specifications are achieved as seen on Table 4.

Table 4: Final Results of the design

Resonance Freq.(GHz)	Magnitude (S11dB)	Z_{in} (real)	Gain(dB)
1.84	-25.65	53.24	10.37
2.91	-35.52	50.12	8.03 θ= 30^0

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