Dual-Band Patch Antenna at 15 GHz

Taha İmeci [1], Hakan Hızarcıoğlu [2] and Derya Arıcan [2]

[1] Department of Electrical and Electronics Engineering
KTO Karatay University, Konya, TURKEY
taha.imeci@karatay.edu.tr

[2] Department of Electronics and Communication Engineering
Haliç University, İstanbul, TURKEY
hakanhizarcioglu@yahoo.com.tr, aricanderya@hotmail.com

Abstract: In this work, a dualple resonance microstrip patch antenna is designed and simulated in the 11 – 16 Ghz band. Simulated results show 3 resonance frequencies which have return losses under –20 dB level with the –10 dB return loss bandwidth of approximately 15% between 13 – 15 GHz. Simulations are performed with help of Sonnet Suites [1], a planar 3D electromagnetic simulator. Details of the simulation results are presented and discussed.

Keywords: Microstrip, Patch, Antenna, Dual-Band, Wideband

1. Introduction

This study aims a dual-band microstrip patch antenna design and simulation. Three resonances are maintained at 12.38 GHz, 13.88 GHz, and 15.12 GHz. The real and (imaginary) parts of the input impedances are 47.8 (5.4) Ω, 48.3(4.9) Ω, and 44.9 (9.3) Ω, respectively. Maximum theta polarized electric field gain is 5.32 dB. Gains have three spot beams and relatively narrow beamwidths. Design consists of step by step changes on the geometry which improves the values required in specifications. Those steps are explained in tables and simulated results are presented in figures. Previous works are also dealing with the bandwidth increasing techniques by changes on the geometry and by adding RF-MEMS switches [2]. There is a tri-band patch antenna at [3], with double notches and triangular tapered feeding line. It is observed that broadband matched double-notched patch antenna is suitable for tri-band operations from simulation and experimental results. In [4], a similar, triangular shape antenna as compared to this work is analyzed. In that work, the effects of position of shorting pin and feed-probe in an equilateral triangular microstrip patch antenna are theoretically taken into account using transmission line model.

2. Design Procedure

Figure 1 has the top view and Figure 2 has the 3D view of the antenna. The type of the chosen commercial substrate is FR-4 (ε_r = 4.9, h=1.9 mm). Dimensions of the box are as follows: the length of the X-axis = 304.80 mm, the length of the Y-axis = 250.40 mm. Dimensions of the microstrip patch antenna are: the length of the X-axis = 30.48 mm, the length of the Y-axis = 28.44 mm. Probe feed is applied as seen in Figures 1 and 2.

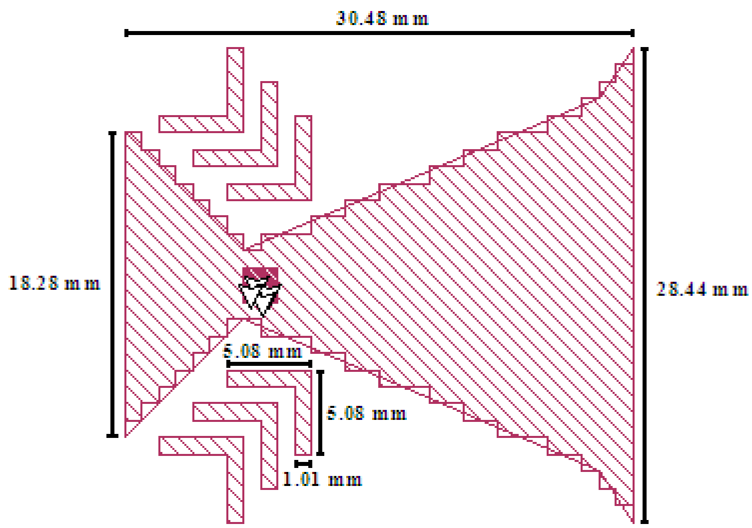

Fig. 1. Top view of the antenna.

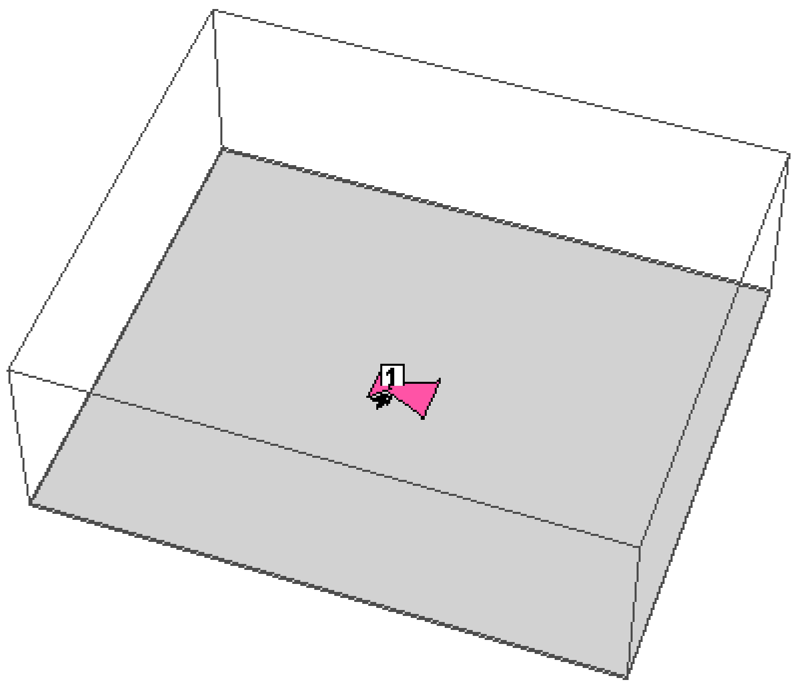

Fig. 2. 3D view of the antenna.

The design started with the triangular shape but there was only one resonance at 12.5 GHz.

Table 1:Values of the parameters with design step 1

PARAMETERS	f_c(GHz)	S_{11}(dB)	BW(MHz)	BW(%)	Gain_{max} (dB)	θ=40° Gain(dB)
Step 1	12.50	- 22.78	980	7.84	θ=25°⇒6.09	4.87

The next step was to add the same but smaller shape of the flipped patch on the left-hand side of the feed. This helped to reduce the S11 and increase the gain.

Table 2:Values of the parameters with design step 2

PARAMETERS	f_c(GHz)	S_{11}(dB)	BW(MHz)	BW(%)	Gain_{max} (dB)	θ=40° Gain(dB)
Step 2	13.38	- 26.68	760	5.68	θ=25°⇒6.23	3.37

After that, the right-hand side of the patch corners are bended a little bit and, this caused the other two resonances.

Table 3:Values of the parameters with design step 3

PARAMETERS	f_c(GHz)	S_{11}(dB)	BW(MHz)	BW(%)	Gain_{max} (dB)	θ=40° Gain(dB)
Step 3	12.52	- 14.49	370	2.95	θ=30°⇒6.57	5.00
	13.64	- 11.69	150	1.09	θ=-5°⇒5.22	3.95
	15.18	- 13.14	200	1.31	θ=40°⇒3.58	3.58

Finally, the L-shaped floating symmetric radiators were added near the feeding. The final results are achieved after this modification on the patch, i.e., the bandwidth and especially gain increased around θ = 40^0.

Table 4:Values of the parameters with design step 4

PARAMETERS	f_c(GHz)	S_{11}(dB)	BW(MHz)	BW(%)	Gain_{max} (dB)	θ=40° Gain(dB)
Step 4	12.38	- 24.52	830	6.70	θ=30°⇒6.94	5.32
	13.88	- 25.55	2040	14.69	θ=40°⇒4.83	4.83
	15.12	- 19.07	2040	13.49	θ=40°⇒3.40	3.40

3. Simulation Results

Figure 3 has the return loss with the bandwidths shown in captions. Figures 4, 5, and 6 have the theta-polarized electric field radiation patterns. Maximum gain levels are shown in captions. Figure 7 shows that, the current is intense near the feeding, and around the center of the antenna.

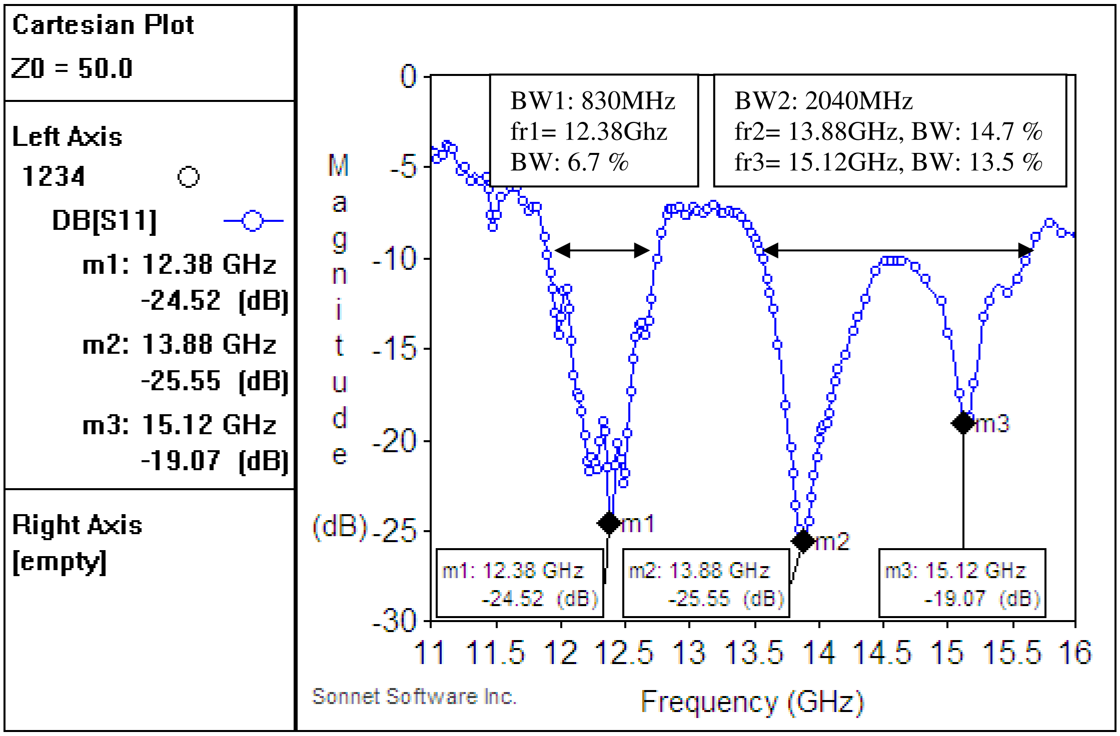

Fig. 3. Return loss of the dual-band microstrip patch antenna.

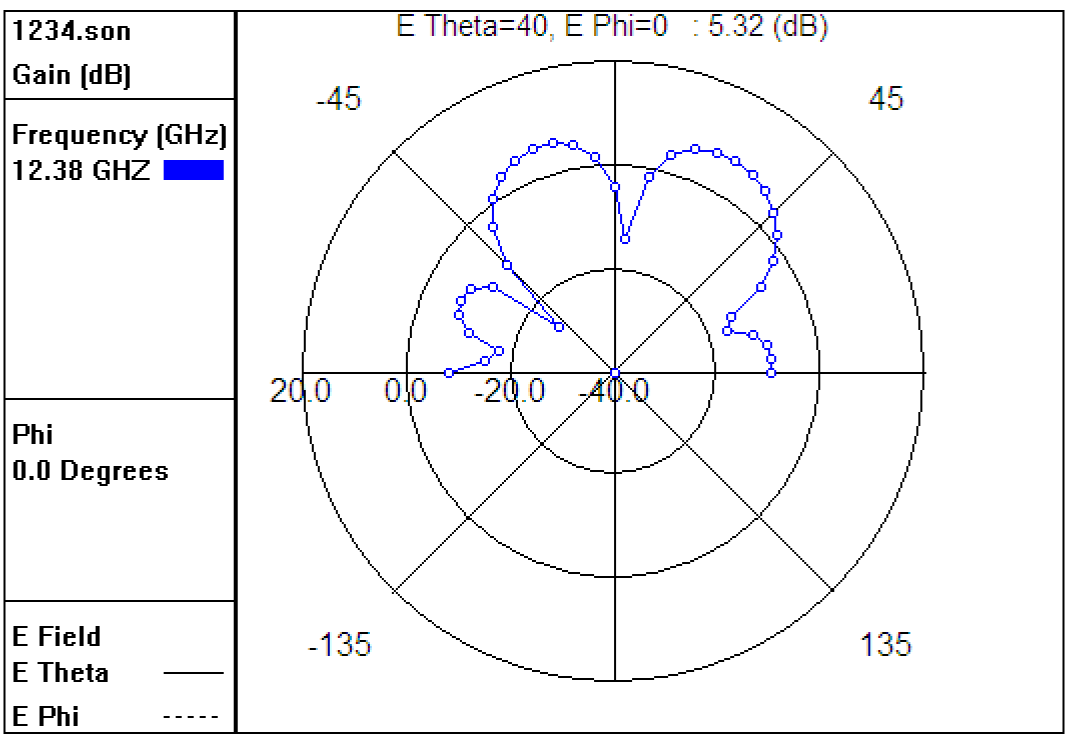

Fig. 4. Far field radiation pattern of the antenna at 12.38 GHz.

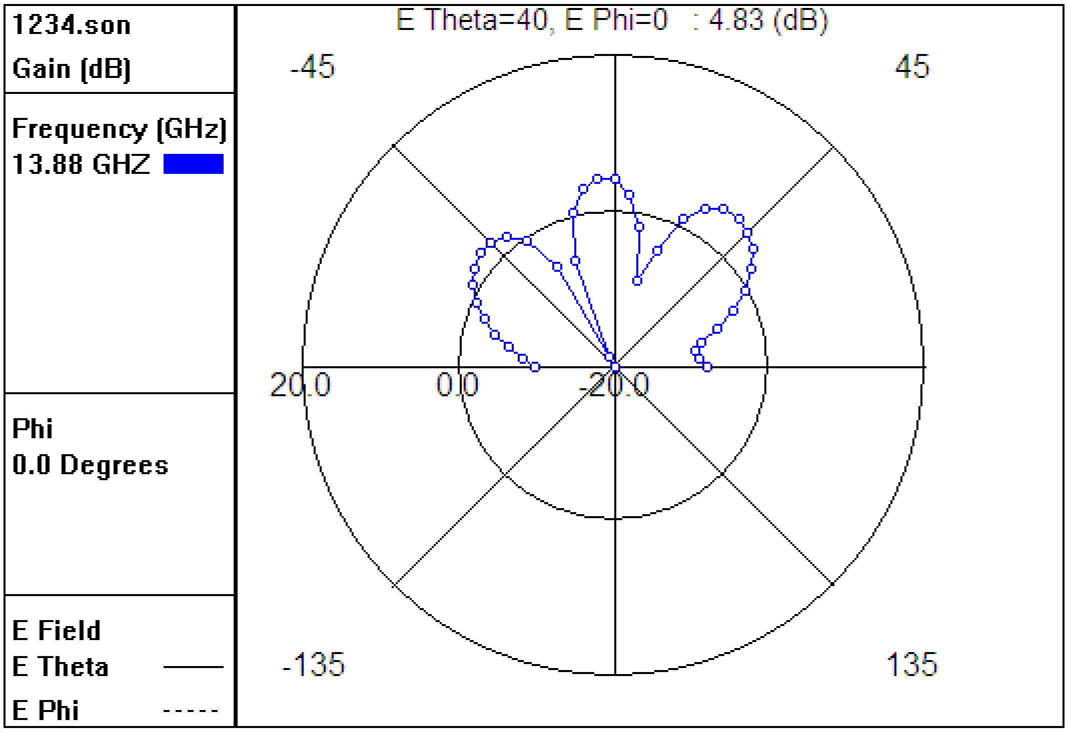

Fig. 5. Far field radiation pattern of the antenna at 13.88 GHz.

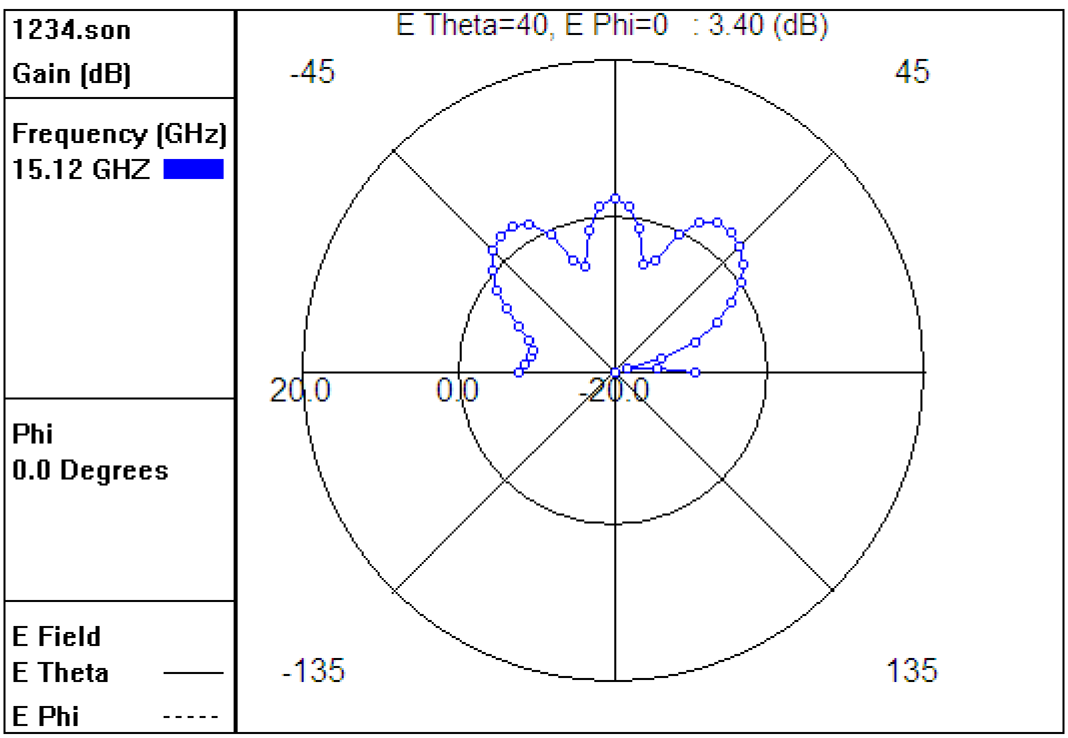

Fig. 6. Far field radiation pattern of the antenna at 15.12 GHz.

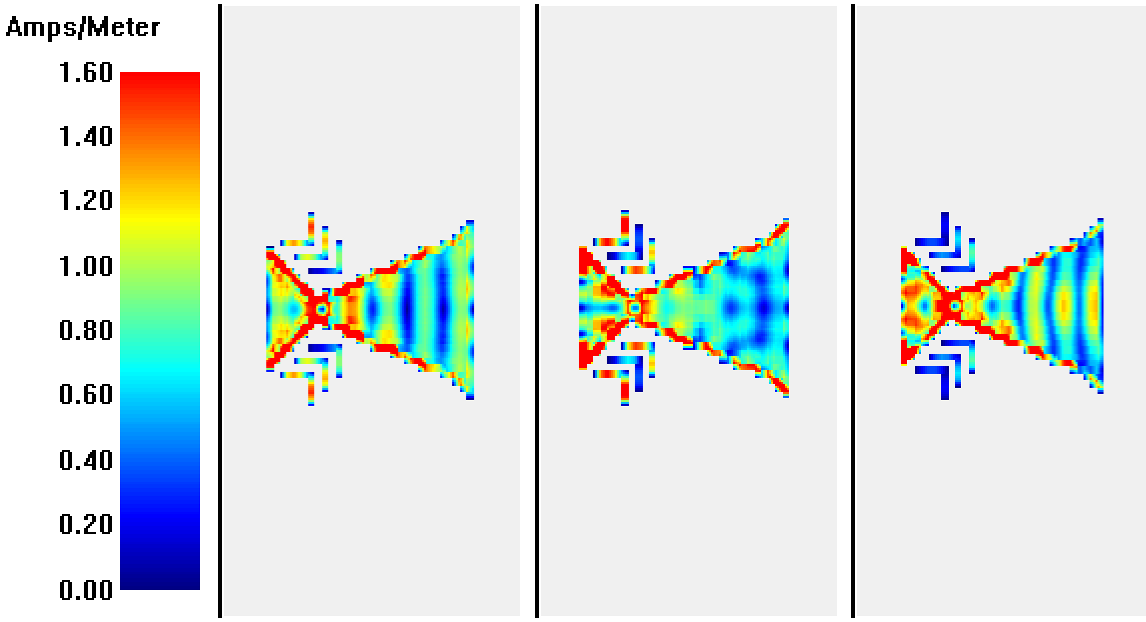

Fig. 7. Current distribution on the antenna at 12.38GHz, 13.88GHz, and 15.12GHz, respectively.

4. Conclusions

In this paper, a dual-band microstrip patch antenna is designed and simulated. Modifications on the patch geometry helped a lot to maintain and improve the specified design parameters such as; return loss, input impedance, and gain. The next work would be an ultra wide-band antenna between 11–16 GHz by decreasing the return loss under –10 dB level, around the 13 GHz. Radiation pattern beamwidth enhancement and fabrication of the antenna are the other future goals.

References

1 Sonnet Software, version 12.56, www.sonnetsoftware.com, 2009.

2 D. E. Anagnostou, G. Zheng, M. T. Chryssomallis, J. C. Lyke, G. E. Ponchak, J. Papapolymerou, C. G. Christodoulou, "Design, Fabrication, and Measurements of an RF-MEMS-Based Self-Similar Reconfigurable Antenna", *IEEE Transactions on Antennsa and Propagation,* Vol. 54, No. 2, February 2006.

3 J. R. Panda, R. S. Kshetrimayum, "Notched Antenna with Triangular Tapered Feed Lines for Tri-Band Operation" *International Journal of Recent Trends in Engineering* ,Vol 1, No. 3, May 2009.

4 R. Pant, P. Kala, R.C. Saraswat, S.S. Pattnaik, "Analysis of Dual Frequency Equilateral Triangular Microstrip Patch Antenna with Shorting Pin", *Int. Journal of Microwave Optical Technology*, Vol. 3 No.2, April 2008.