Miniaturized Probe-Fed Elliptical Microstrip Patch Antenna for Radiolocation Applications

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***Abstract*—This letter presents a miniaturized probe-fed elliptical microstrip patch antenna (PF-EMPA) targeting the 8.50-10.55 GHz band for radiolocation applications. The proposed design is composed of an elliptical patch inserted into an elliptical slot. In order to achieve our goals and control the impedance matching, we adjusted the offset distance from the elliptical patch to the side of the elliptical slot. As results, this work presents the characteristics of a new microstrip patch antenna operating at 9.845 GHz (9.650 – 10.222 GHz) providing higher gain value (more than 6 dBi), and an impedance matching bandwidth of around 5.75%. The performance of the structure is simulated by electromagnetic simulator CST Microwave Studio. Details of the obtained results are presented and discussed.**

Keyword-Elliptical, microstrip patch antenna, slot, probe-fed, radiolocation

I. Introduction

In rapidly expanding market for miniaturization of wireless devices, the antenna engineers have investigated a flurry of interest in microstrip patch antennas. This is mainly due to the attractive features of microstrip antennas, which are, namely, low in profile, easy for mass production, compact in structure, light in weight, conformable to the hosting surfaces, and well suited for integration with the electronic system [1–3]. Microstrip patch antenna consists of a very thin metallic strip etched on a grounded dielectric substrate [3]. To reduce the size of the microstrip antenna and overcome its limitation of narrow impedance bandwidth, many methods have been commonly proposed and investigated by using: cavities [4–5], irises [6], folded structures [7], and multi layers [8–9].

In the structure presented in this letter, an elliptical patch inserted into an elliptical slot has been used to design a miniaturized probe-fed elliptical microstrip patch antenna (PF-EMPA) targeting the 8.50 - 10.55 GHz band for radiolocation applications. Details of the simulated results exhibiting the characteristics of the studied antenna are presented and discussed.

II. Description of Antenna

The schematic and dimensions of the proposed Probe-Fed Elliptical Microstrip Patch Antenna are shown in Fig. 1. The developed prototypes are printed on a FR-4 dielectric substrate with a relative dielectric constant ε_r = 4.3 and a thickness of 1.575 mm (*h*). The bottom of the dielectric is completely covered by foil and grounded. The ground plane dimensions are *L* mm by *W* mm and the metal cladding is *t* = 0.018. The *x* and *y* axes of the elliptical patch are denoted with R_1 and L_1, respectively, while R_2 and L_2 are the axes of the elliptical slot.

The offset distance from the elliptical patch to the side of the elliptical slot is denoted as *d*. The patch is fed by a 50 Ω coaxial probe of a 0.9-mm diameter at the point (x = 0 mm, $y = L_1 - L_2 + d$). The studies carried out in this paper have shown that the adjustment of the distance (*d*) can readily control the impedance matching. The performance of the studied antenna is rigorously simulated using CST Microwave Studio.

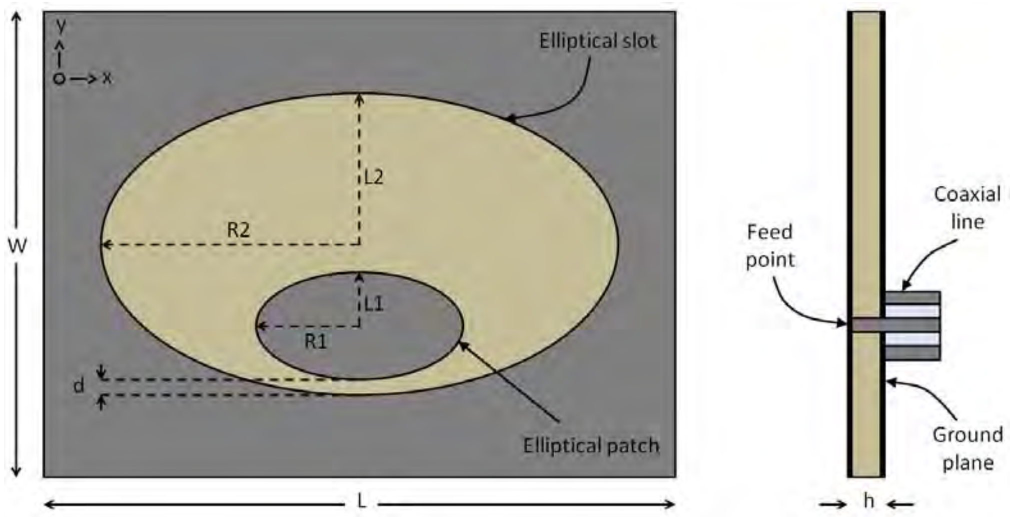

Fig. 1. Design parameters for the proposed configuration

III. Simulated Results and Discussion

Several designs have been successfully implemented. Fig. 2 shows simulated return loss of the proposed Probe-Fed Elliptical Microstrip Patch Antenna with *d* = 0 mm (denoted as prototype I here), 1 mm (prototype II), 2 mm (prototype III), 4 mm (prototype IV), and 6 mm (prototype V) with the dimensions of the structure fixed at *L* = 40 mm and *W* = 35 mm.

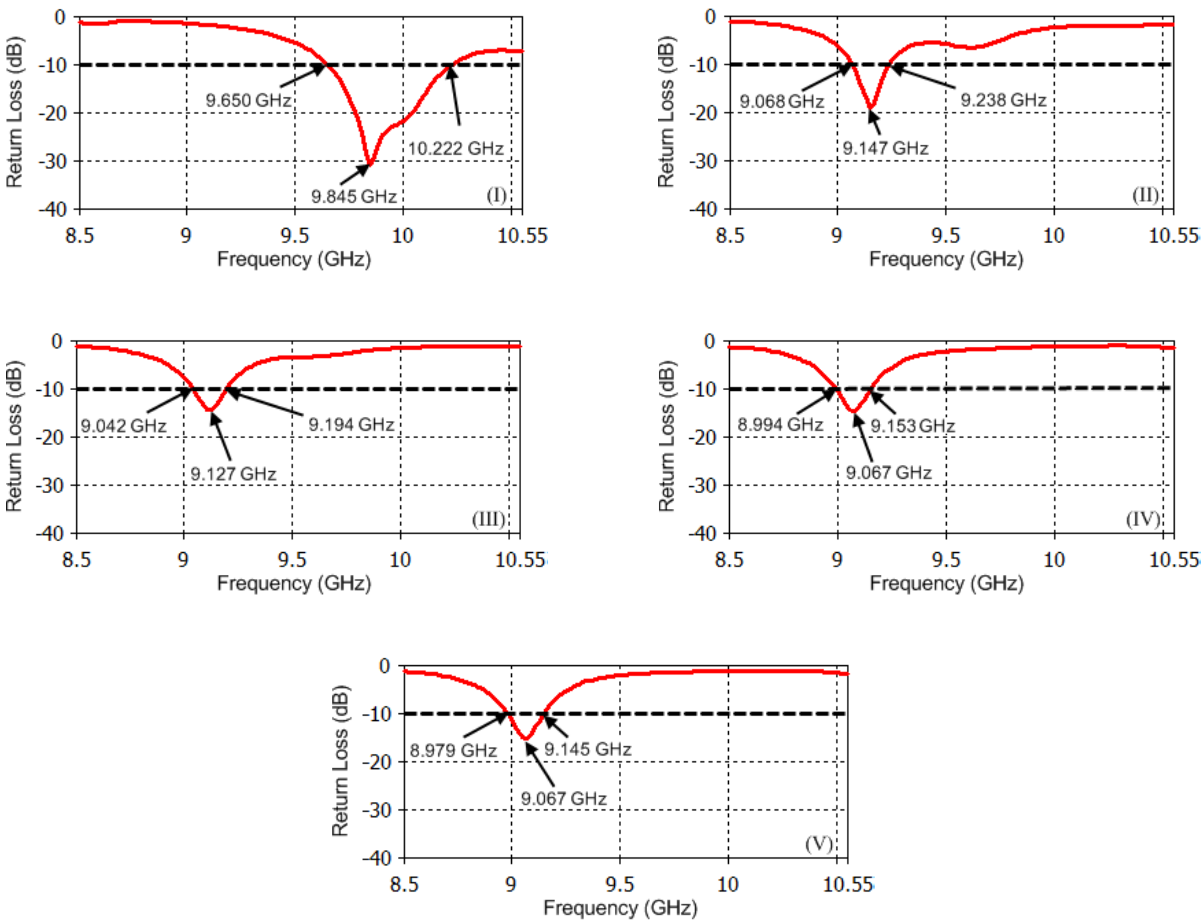

Fig. 2. Simulated return loss of Prototype I, II, III, IV, and V; R_2 = 16 mm, L_2 = 12 mm, R_1 = 8 mm, L_1 = 6 mm. Prototype I: *d* = 0 mm. Prototype II: *d* = 1 mm. Prototype III: *d* = 2 mm. Prototype IV: *d* = 4 mm. Prototype V: *d* = 6 mm.

The corresponding performances are listed in Table I. It is first noted that the center operating frequency (f_c), defined here to be the frequency with minimum return loss in the operating bandwidth, is observed to be 9.845 GHz (prototype I), 9.147 GHz (prototype II), 9.127 GHz (prototype III), and 9.067 GHz (prototype IV and V). The simulated matching frequency band for -10 dB reflection coefficient and the maximum radiation gain are 9.650 – 10.222 GHz (6.278 dBi at 9.845 GHz) for prototype I, 9.068 – 9.238 GHz (6.559 dBi at 9.147 GHz) for prototype II, 9.042 – 9.194 GHz (6.975 dBi at 9.127 GHz) for prototype III, 8.994 – 9.153 GHz (7.405 dBi at 9.067 GHz) for prototype IV, and 8.979 – 9.145 GHz (7.471 dBi at 9.067 GHz) for prototype V, respectively.

TABLE I
Performances of the Five Antenna Prototypes (I, II, III, IV and V)

	d (mm)	fc (GHz)	PF-EMPA bandwidth	Antenna gain (dBi)
Prototype I	0	9.845	5.75%	6.278
Prototype II	1	9.147	1.85%	6.559
Prototype III	2	9.127	1.66%	6.975
Prototype IV	4	9.067	1.75%	7.405
Prototype V	6	9.067	1.83%	7.471

So, it can be seen that, while the developed prototypes (II, III, IV, and V) provide an impedance matching bandwidth not exceeding 1.85%, the prototype I provides much wider impedance matching bandwidth of around 5.75% (9.650 to 10.222 GHz).

Moreover, it can also be seen that, when the offset distance (*d*) from the elliptical patch to the side of the elliptical slot is decreased, the center operating frequency (f_c) and the impedance matching bandwidth are both increased, and the antenna gain is decreased. For the gain and efficiency enhancement of the present proposed design, the technique of the multi-layered laminated conductors [9] can be applied.

Finally, the radiation patterns of the present design in the x-z and y-z planes are also simulated and plotted in Figs. 3, 4, 5, 6 and 7. From the results obtained, it is observed that the radiation patterns in the orthogonal planes are almost unidirectional for the five antenna prototypes.

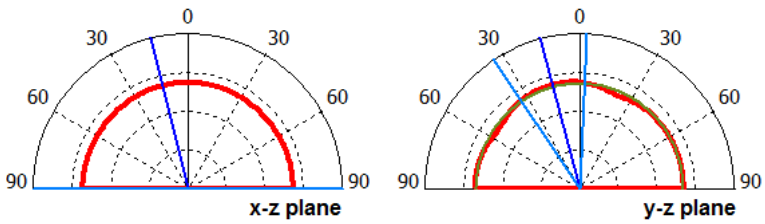

Fig. 3. Simulated radiation patterns of Prototype I at 9.845 GHz.

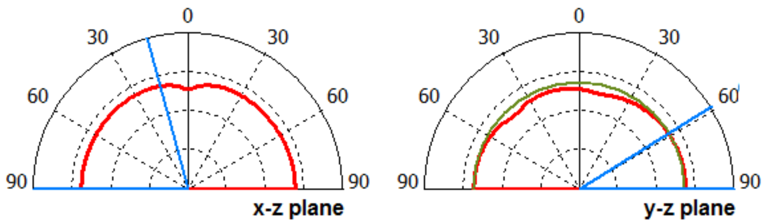

Fig. 4. Simulated radiation patterns of Prototype II at 9.147 GHz.

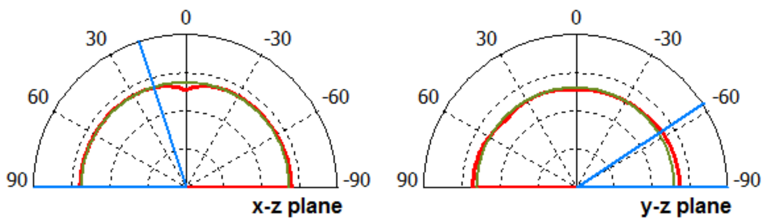

Fig. 5. Simulated radiation patterns of Prototype III at 9.127 GHz.

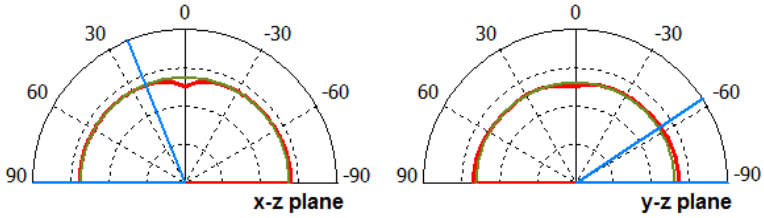

Fig. 6. Simulated radiation patterns of Prototype IV at 9.067 GHz.

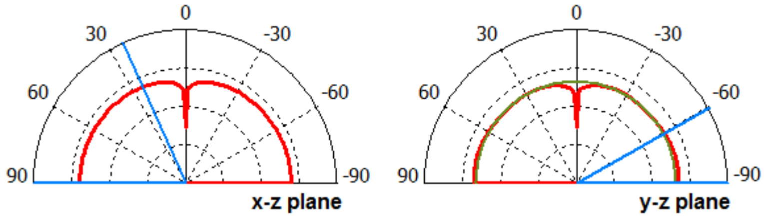

Fig. 7. Simulated radiation patterns of Prototype V at 9.067 GHz.

IV. CONCLUSION

In this paper, a novel miniaturized elliptical microstrip patch antenna having simple topology and excited by a coaxial probe, for radiolocation (8.50 – 10.55 GHz) applications is proposed. The return losses coefficient and the radiation patterns of the suggested antenna design are presented. As results, this antenna has an impedance matching bandwidth of around 5.75% (between 9.650 and 10.222 GHz). The maximum radiation gain obtained is 6.278 dBi at 9.845 GHz.

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