A 1.9−13.5 GHz Low-Cost Microstrip Antenna

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***Abstract*—In this paper, a low-cost ultra-wideband microstrip antenna is presented. The antenna is based on a 1.6-mm-thick FR4 substrate, is microstrip-line fed and has a partial ground plane. The return loss is more than 10 dB in the 1.9−13.5 GHz frequency range. Possible applications include 3G, Wi-Fi, WiMAX, and UWB applications. The gain results and pattern plots of the antenna are included in the paper.**

***Index Terms*—Microstrip antennas, PCB antennas, UWB.**

I. Introduction

Printed microstrip antennas have received increasing attention in satellite and communications applications because of their low profile, small size, light weight, low cost and ease of fabrication [1]. Their simple feed methods, especially microstrip-line and coplanar waveguide (CPW) feeds, make them compatible with wireless communication integrated circuitry.

Microstrip antennas, however, have inherently narrow bandwidths and, in general, are half-wavelength structures operating in the TM_{01} and TM_{10} fundamental resonant mode [2]. Techniques to overcome the problem of narrow bandwidth and shrink the size of microstrip antennas were discussed in [3].

The PCB antenna presented in [4] operates over the 3.4−11 GHz band, taken for $|S_{11}| < -10$ dB. The authors used three techniques for good impedance matching: slots made to the rectangular patch, a tapered connection between the rectangular patch and the feed line, and a partial ground plane flushed with the feed line. Partial ground planes were also used in [5], where patches of elliptical and modified elliptical shapes were used and the antenna was top-loaded. Therein, the authors reported an impedance bandwidth of 8.2 GHz in the 2.4−10.6 GHz range, but for VSWR < 2.5. The bandwidth is much smaller for VSWR < 2, especially for the design with the small ground plane.

In this paper, we present a microstrip-line-fed PCB antenna based on a modified circular patch, and a partial ground plane. The obtained impedance bandwidth is 1.9−13.5 GHz for $|S_{11}| < -10$ dB, making this antenna suitable for applications spanning 3G, 802.11a/b/g/n, Bluetooth, wireless CCTV and video links, WiMAX, and applications in the UWB 3.1−10.6 GHz band.

II. Antenna Configuration

The antenna geometry is shown in Fig. 1. The FR4-based board is 1.6 mm in thickness. The feed line is 22-mm long and 3-mm wide. The radius of the modified circular patch is 19.2 mm. The cropped edges of the patch are 30-mm apart. The ground plane is 5-cm wide and is flushed with the feed line. The part of the patch bounded by the cropped edges acts like a rectangular patch, which is relayed to the feed line via a "tapered" connection, thus providing better impedance matching. The remaining round-edged part also helps to improve the bandwidth.

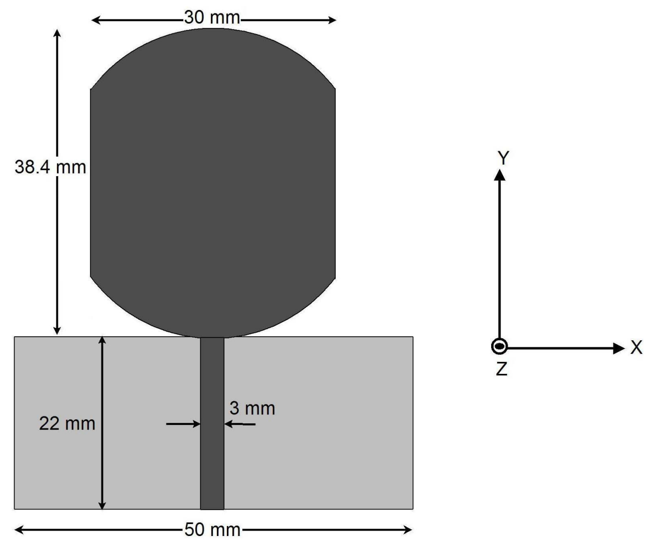

Fig. 1. Antenna Structure.

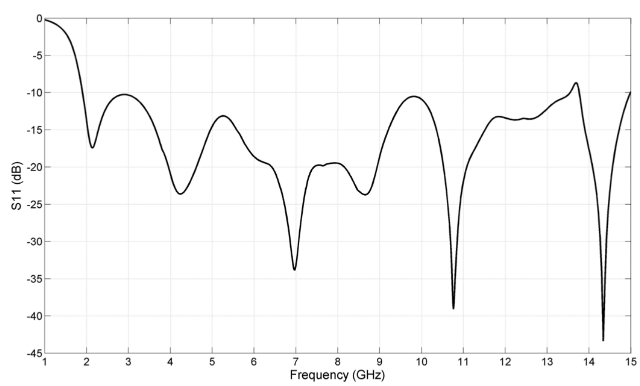

Fig. 2. Simulated return loss of the antenna.

III. Results and Discussion

The antenna was designed and simulated using ADS Momentum [6], which is based on the method of moments. The computed return loss in the 1−15 GHz frequency range is shown in Fig. 2. A return loss below −10 dB is witnessed over the 1.9−13.5 GHz band. The actual return loss of the antenna fabricated on a 5×7 cm^2 substrate was measured using Agilent's E5071B network analyzer, which operates in the

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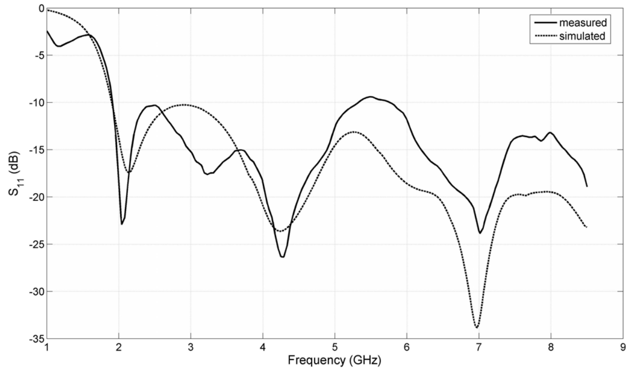

Fig. 3. Comparison of simulated and measured S_{11}.

300 KHz−8.5 GHz frequency range. A comparison between computed and measured S_{11} in the range 1−8.5 GHz is shown in Fig. 3. At lower frequencies, good agreement is observed between simulation and actual results. The actual return loss is higher at frequencies in excess of 5 GHz.

The computed radiation patterns in the X−Z and Y−Z planes, for 1.9, 2.4, 3.5, 5, 8 and 11 GHz, are depicted in Fig. 4. It is important to note that ADS Momentum assumes an infinite substrate. This justifies the nulls present in the X−Z radiation patterns for the $\pm 90^0$ elevation angles . In reality, the patterns in the X−Z plane are omnidirectional. The simulation patterns are consistent and vary little over the frequency band, especially for frequencies below 10 GHz. The maximum gain of the antenna is given in Table I for a group of frequencies. The gain variation is less than 1 dB between 1.9 and 4 GHz, and less than 0.5 dB between 10 and 12 GHz. The gain dropped to about 0.5 dB at 8 GHz.

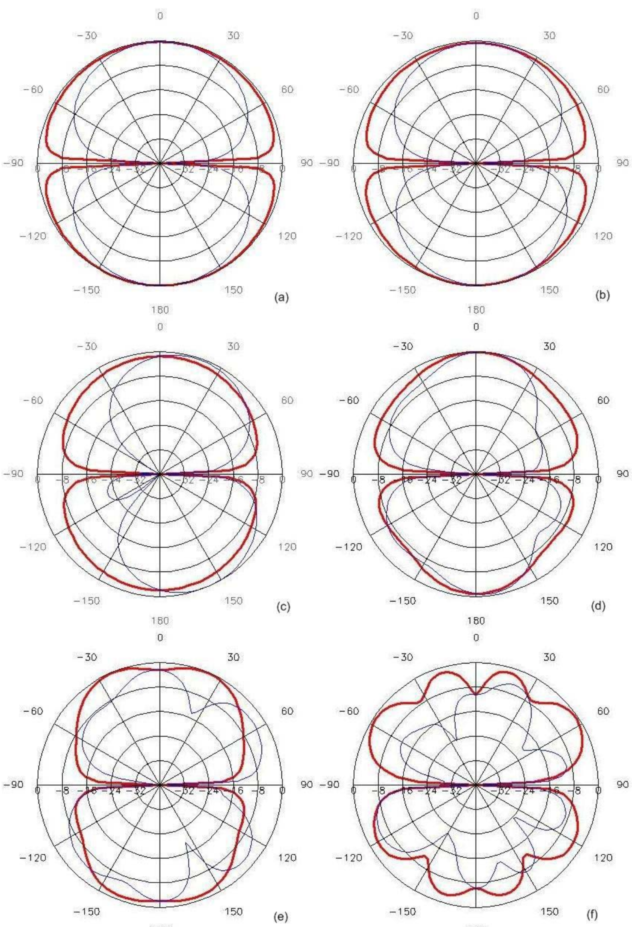

Fig. 4. Normalized radiation patterns of the antenna in X-Z plane (thick line) and Y-Z plane (thin line): (a) 1.9 GHz (b) 2.4 GHz (c) 3.5 GHz (d) 5 GHz (e) 8 GHz (f) 11 GHz.

TABLE I
ANTENNA GAIN.

Frequency (GHz)	Gain (dB)
1.9	2.88
2.1	3.12
2.4	3.51
3.0	3.29
3.5	3.62
4.0	3.76
5.0	1.07
6.0	1.84
8.0	0.53
10.0	5.72
12.0	5.28

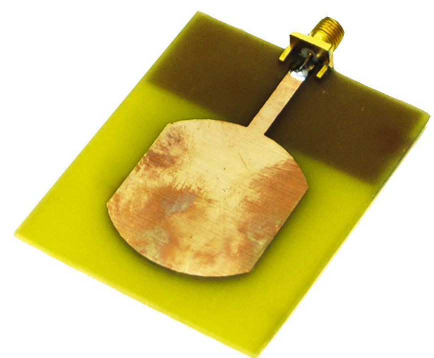

Fig. 5. Photo of the antenna fabricated on a 5×7 cm^2 substrate.

IV. CONCLUSION

In this paper, we presented a low-cost PCB antenna covering the 1.9−13.5 GHz frequency span. The antenna was fabricated on a 1.6-mm-thick FR4 substrate with dimensions 5 cm × 7 cm. The return loss was measured in the 1−8.5 GHZ range and showed a reasonable agreement with the simulation result. The radiation patterns in the X−Z plane were consistent across the antenna's band. The variation in the maximum gain was less than 3 dB in the 1.9−6 GHz range and less than 6 dB in the 1.9−11 GHz range. The demonstrated antenna can be used for many applications including 3G, Wi-Fi, WiMAX, as well as UWB applications.

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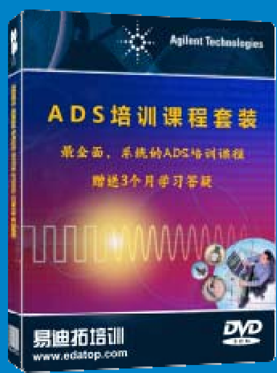

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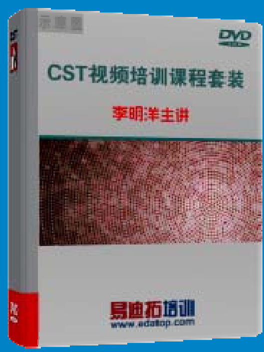

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