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Design of Multilayer Microstrip Patch Antenna Using T-probe for UWB Communications

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Abstract. In this letter, we introduce a multilayer microstrip patch antenna for ultra-wideband communications. The structure of the antenna is nearly the same with the traditional microstrip patch antenna except the feeding method. By using T-probe and multilayer structure. The result shows that the impedance bandwidth (VSWR $\leq$ 2) of the proposed antenna is 6.40 GHz (5.12 GHz to 11.52 GHz), which is equivalent to 76.93%. The gain of the antenna is almost 6.5dB across the operating bandwidth.

Keywords: Microstrip patch antenna; UWB; feeding method; multilayer.

1 Introduction

Ultra-wideband (UWB) communication systems attract great attention in the wireless world because of their advantages, including high speed data rate, extremely low spectral power density, high precision ranging, precision, low cost, and low complexity since the Federal Communication Commission (FCC) allowed 3.1–10.6 GHz unlicensed band for UWB communication [1]. Particularly, in practical applications, owing to the coexistence of UWB systems with other wireless standards, such as WLAN (5.15–5.35 and 5.725–5.825 GHz), downlink of X-band satellite communication systems (7.25–7.75 GHz) and ITU (8.025–8.4 GHz), The UWB antenna is essential for providing wideband wireless communications based on the use of very narrow pulses on the order of nanoseconds, covering an ultra-wide bandwidth in the frequency domain, and over short distance at very low spectral power densities. In addition, the antennas required to have a non dispersive characteristic in time and frequency, providing a narrow, pulse duration to enhance a high data throughput [2]. Different kinds of antennas suitable for use in UWB applications have proposed in past few decade, each with its advantages and disadvantages [3]. Many techniques have already been applied to design wideband antennas. For example an isolated slit inside a patch, two opened slits at the top edge of a T-shaped stub, two parasitic strips and a square ring resonator embedded in a tuning stub have been reported to design band notched antenna. Embedding of various thin slots on the antenna surface, such as L-shaped slot, T-shaped slot, fractal slot, L-probe and H-slot Patch Antenna have also been reported for achieving wide-bands [4-13].

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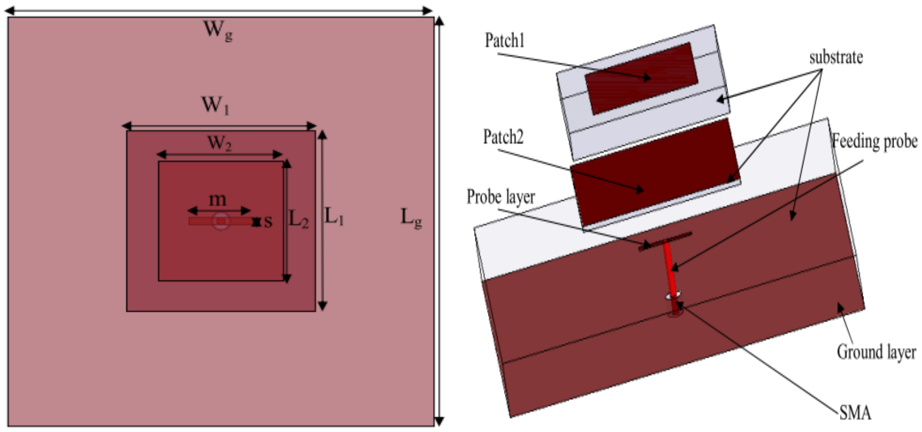
In this paper, a novel multilayer square patch antenna with wide bandwidth, broadside radiation and high gain is proposed. With the use of T-shaped probe and the multiple patches, a broad impedance bandwidth is achieved when compared with the traditional microstrip antennas. The bandwidth of the proposed antenna can achieve 76.93% with VSWR below 2 and the gain is around 6.5dB across the operating bandwidth. Details of the proposed design are presented and discussed in this paper. The proposed antenna design and performances are analyzed by using Ansoft High Frequency Structure Simulator (HFSS).

2 Antenna Design

Figure 1 shows the geometries and dimensions of the proposed antenna. The antenna consists of three layers. The first two layers respectively have a square patch printed on their top surface. The third layer has a printed T-strip on its top surface and a ground plane on its bottom surface. The dielectric constants of all layers are the same, which are Roger RT/Droid5880 with ε_r =2.2. The shape of patch 1 and patch 2 is square. Both of them are physically symmetrical around the center of the patch. The vertical portion of the T-shaped probe is made by a copper rod with radius of 0.5mm. It is connected to a 50Ω SMA launcher.



(a)Top view (b) Side view

Figure. 1. Geometry of the proposed antenna. W_g=L_g=54, W_1= L_1=24, W_2= L_2=16, m=8, s=1, h_1=6, h_2=0.6, h_3=3 (in mm).

3 Simulation Results

All of the simulations are performed by software HFSS. Figure 2 shows the reflection coefficient of the proposed antenna. The obtained result shows that the bandwidth at -10 dB of this antenna is in the frequency range from 5.12GHz to 11.5GHz, which covers

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the bandwidth of the WLAN2, 5.8GHz-band RFID, X-band and ITU. Figure 3 shows the voltage standing wave ratio (VSWR) of the proposed antenna.

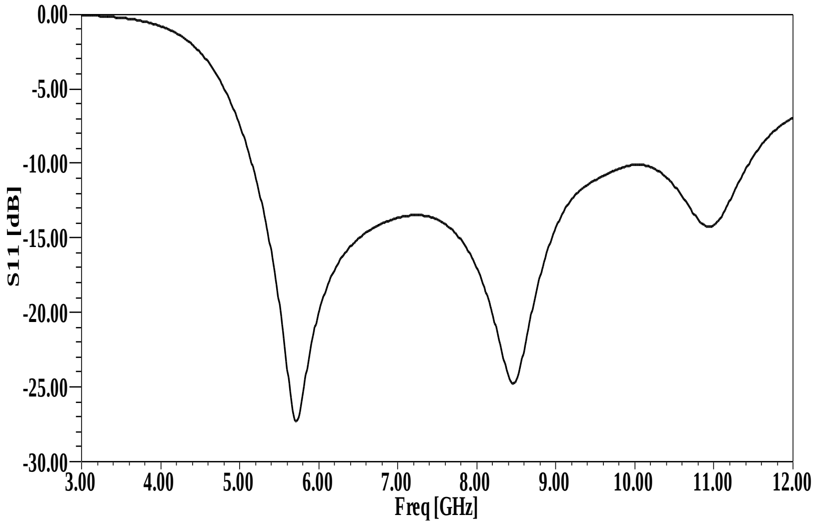

Figure. 2. Reflection coefficient of the proposed antenna.

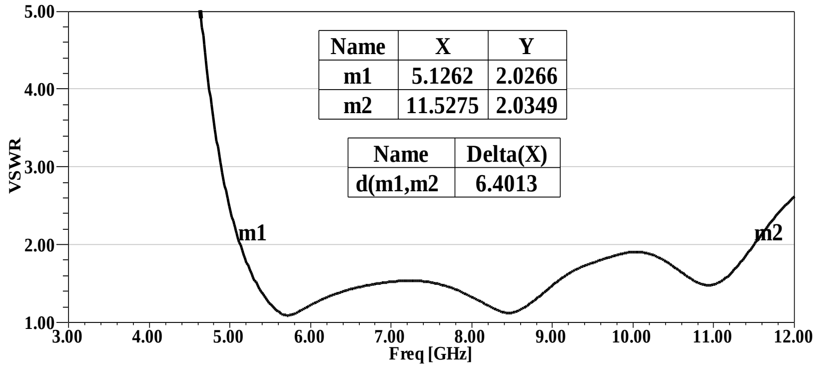

Figure. 3. The VSWR of the proposed antenna.

The simulation results in Fig.4 show the real and imaginary parts of antenna input impedance. Across the matching band, the real part is approximately 50Ω and the imaginary part varies close to the zero value as a result of capacitive and inductive effects. This result means that the antenna will exhibit near linear phase characteristics.

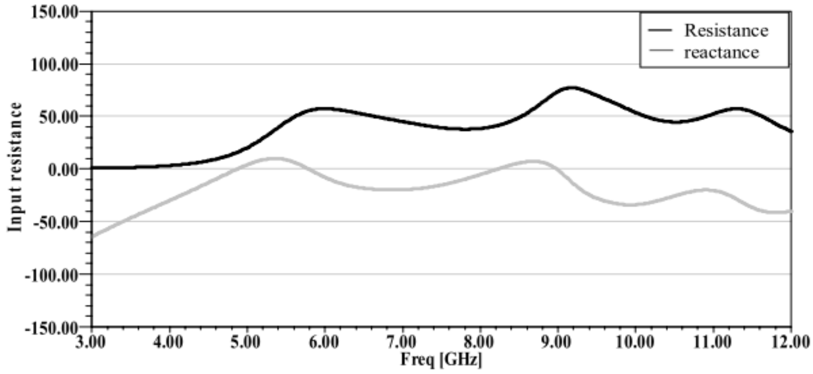

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Figure. 4. Real and imaginary part of antenna input impedance.

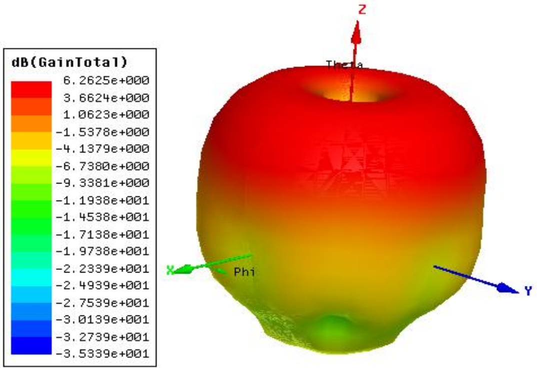

Figure. 5. 3D Radiation pattern of the radiating patch at 8.45 GHz.

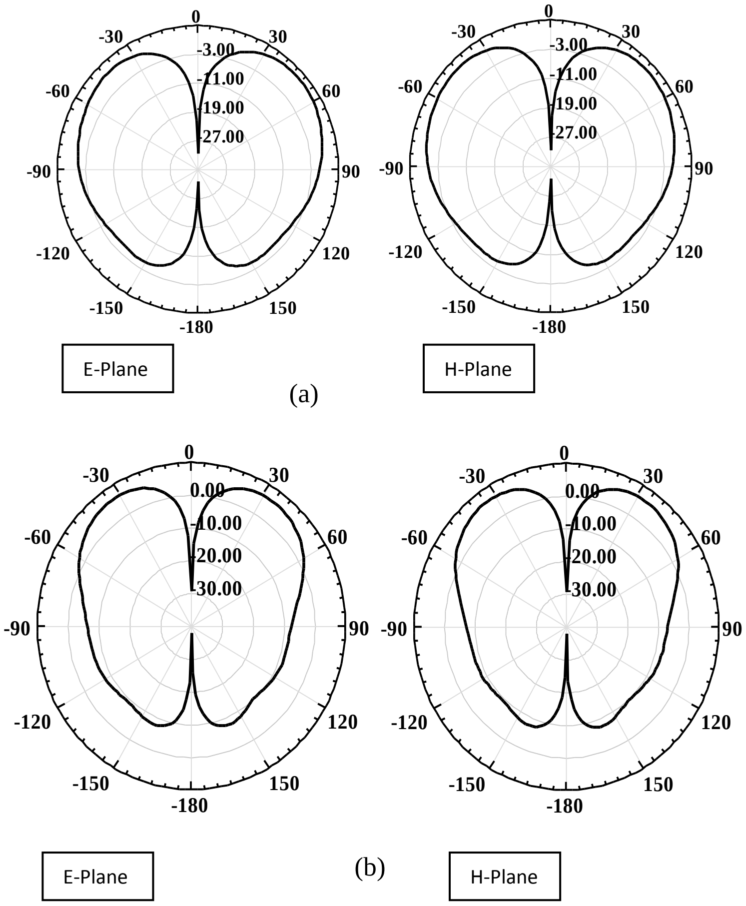

Figure. 6. Radiation patterns at frequency of E- and H-plane (a) 5.71GHz, (b) 8.45GHz.

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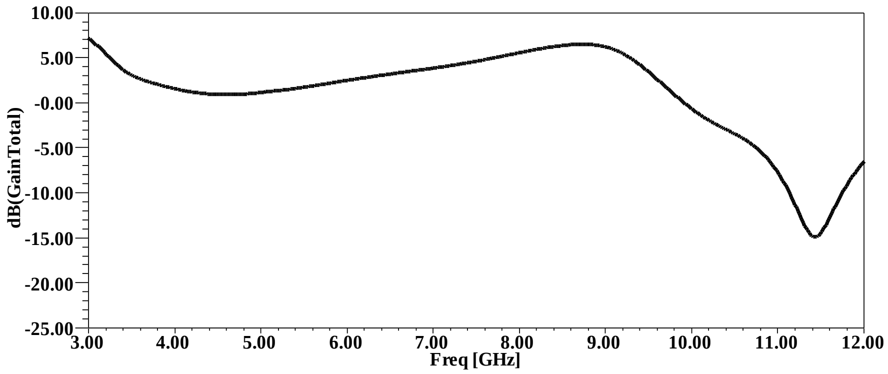

Figure. 7. Simulated result of Gain.

Figure 5 shows the 3D radiation pattern of the proposed antennas. Figure 6 shows the E-plane and H-plane radiation patterns of the proposed antenna at two resonance frequencies of 5.12 and 8.45GHz respectively. It can be observed that at low frequencies both the E-plane and H-plane radiation patterns are approximately bidirectional and the antenna has a main beam in the broadside direction.

At lower frequencies both the E-plane and H-plane radiation patterns are about the same as that of a patch antenna. As frequency increases, higher order current modes are excited and the radiation patterns becomes slight directional. However a stable and symmetric radiation patterns are observed over the operating band of the proposed antenna.

Figure 7 depicts the simulated gain against the frequency of the proposed antenna. The peak Gain is 6.5dBi.

4 Conclusion

Design concept of a novel ultra wideband antenna, together with the simulated results, are proposed and presented. The antenna has bi-directional radiation patterns and average peak gain of about 6.5dB within an impedance bandwidth of 5.12-11.5GHz for return loss lower than -10dB. Furthermore, it has a balanced structure and simple feed structure with T-probe, thus it can be integrated with other differential-driving RF components directly, since differential circuits and components are becoming more dominant in the future RF and microwave systems. Also the antenna is compact and can cover the whole frequency band of 5.8GHz-band RFID systems, WLAN, ITU, X-band satellite communication systems and European standard UWB systems, it should be a promising candidate for such applications.

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