J Electr Eng Technol.2015; 10(3): 1081-1085
http://dx.doi.org/10.5370/JEET.2015.10.3.1081

ISSN(Print) 1975-0102
ISSN(Online) 2093-7423

A Pair Dipole Antenna with Double Tapered Microstrip Balun for Wireless Communications

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Abstract – In this paper a printed pair dipole antenna with double tapered microstrip balun for wireless communications is proposed. The proposed antenna consists of a pair arm of different sizes that is branched microstrip line and microstrip line with the ground plane on opposite side of the dielectric substrate plane. The proposed antenna is matched between the ground plane to the microstrip line by double tapered microstrip balun. This antenna obtains multi-band radiation frequency band. The impedance bandwidths for a reflection coefficient of VSWR$\leq$2 are about 1.01 GHz (2.35~3.336 GHz), 1.56 GHz (4.7~6.26 GHz) and 1.15GHz (6.85~8.0[GHz]). Additionally, the measurement peak gain is about 3.6 dBi. The proposed antenna is able to support wireless communication applications.

Keywords: A pair dipole antenna, Multi-band frequency, Tapered microstrip

1. Introduction

Recently, there has been rapid development in wireless communications. Regarding connectivity, a considerable amount of data transmissions between information appliances with fast and secure transmissions to procure wireless inactions without cable take place in the bandwidth of wireless communication systems. Accordingly, wide and multiband antennas are required [1, 2]. Printed dipole antennas are highly suitable for integration onto a circuit board of communication devices, leading to attractive features such as a reduction of the required system volume and a decreased fabrication cost of the final product [3, 4]. The antenna should be in planar form, lightweight, and compact so that it can easily be embedded in the cover of a communication device [5, 6]. In this paper, we proposed a novel design of a printed two pair dipole antenna. The proposed antenna is fed by a microstrip line, and impedance is matched by adjusting the width and height of the tapered microstrip [4-7]. This antenna has characteristics of three-band resonance frequency and a wide bandwidth. Prototypes of the proposed antenna were designed for wireless communication in the WLL (wireless local loop), WLAN (wireless local area network) (IEEE 802 11b/a) bands, and for DSRC (dedicated short-range communications) operations [8, 9]. The simulation and evaluation was carried out using the HFSS software. The simulated and measured results of the antenna design are presented and discussed.

2. Configuration and Design

Generally, the dipole antenna consists of two terminals or poles into which radio frequency current flows. This current and the associated voltage causes and electromagnetic or radio signal to be radiated [10, 11]. Being more specific, a dipole is generally taken to be an antenna that consists of a resonant length of conductor cut to enable it to be connected to the feeder. For resonance the conductor is an odd number of half wavelengths long. In most cases a single half wavelength is used, although three, five wavelength antennas are equally valid. Geometry and dimensions of the proposed antenna shows Fig. 1. The proposed antenna is printed on the Tefron substrate of relative permittivity 5.2 with a thickness of 1.52 mm. The fed method of this antenna uses a microstrip line of 50 Ω, thus making it an easily feed method. The structure of the two different sized dipole arms are printed on opposite side of substrate, as shown in Fig. 1. The top side consists of branched microstrip line. The bottom side

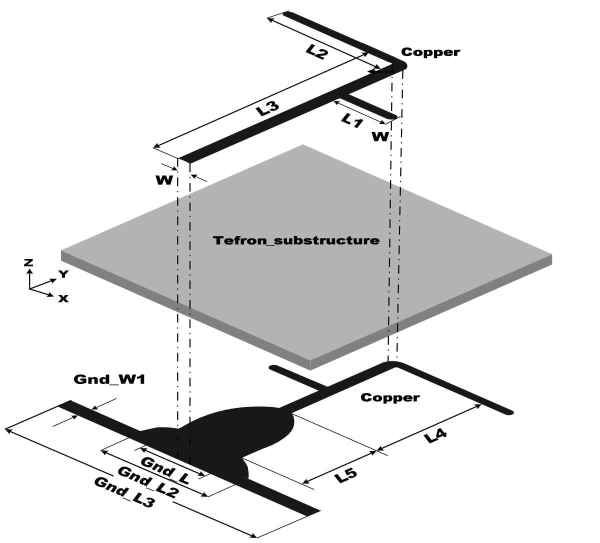

Fig. 1. Geometry of the proposed antenna.

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Received: April 25, 2014; Accepted: November 17, 2014

Table 1. The design parameters value of proposed antenna [mm].

Parameter	Value	Parameter	Value
L1	10.4	W	3.3
L2	22.8	Gnd_L1	9
L3	40.3	Gnd_L2	18
L4	31	Gnd_L3	54
L5	6	Gnd_W1	3.3

consists of branched microstrip line with dual tapered ground plane. The design parameters of the proposed antenna are presented in Table 1. The each pair dipole arm printed in both sides on the dielectric substrate. Here, L1 and L2 is the length of each dipole arm; while L3 and L4 are the lengths of the streams of the proposed antenna, respectively. In addition, Gnd_L1, Gnd_L2, and Gnd_L3 are the tapered widths, L5 is length of the tapered at the ground plane. Here, W is the width of a microstrip feed line of the proposed antenna.

The microstrip feed line and the ground plane is printed on opposite sides on the dielectric substrate plane. The width of line L1 and L2 is 3.0 mm, respectively. The design parameters of the proposed antenna are presented in Table 1.

3. Results and discussion

The pair dipole, microstrip feed line and double tapered balun of the proposed antenna is printed both sides on dielectric substrate plane, as shown Fig. 1. The wave length of center frequency of 5.23 GHz is about 32mm, in this paper. The reflection coefficient for the L2/L1 ratio was plotted by means of a simulation, as shown in Fig. 2. The length of L1 was changed from 10.4 to 12.6 mm. Here, the length of L2 was held at 22.8 mm. As result, when L1 was 10.4mm, the reflection coefficient was most suitable and the bandwidth reached its maximum value. Additionally, L2 is the long dipole of the antenna. When the value of L1 was increased, the second radiation vanished. Fig. 3 shows the reflection coefficient for variable distance between the L2 to L1 by analyzing a simulation. The distance was changed from 9 to 18 mm by step 3mm. As result, when distance of L2 and L1 was 15mm, the bandwidth of reflection coefficient had a stable and a maximum value. The second resonance characteristic went bed when distance was shorting, as shown Fig. 3. The distance of between radiator element appeared the most good gain characteristics in case of 0.6 ~0.7λg as a generally array antennas. Therefore, as the distance get shorter that resonance characteristic go bed.

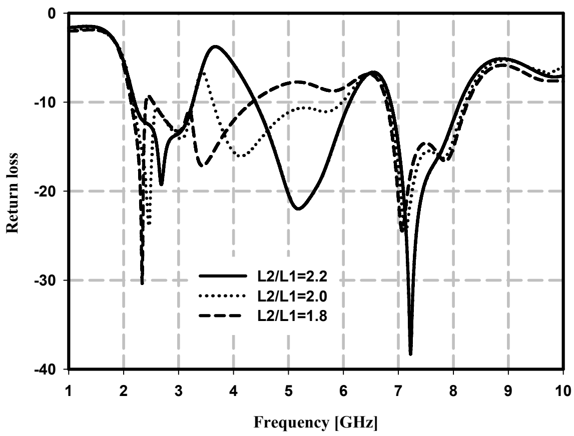


Fig. 2. Simulated reflection coefficient to the L2/L1 ratio of the proposed antenna.

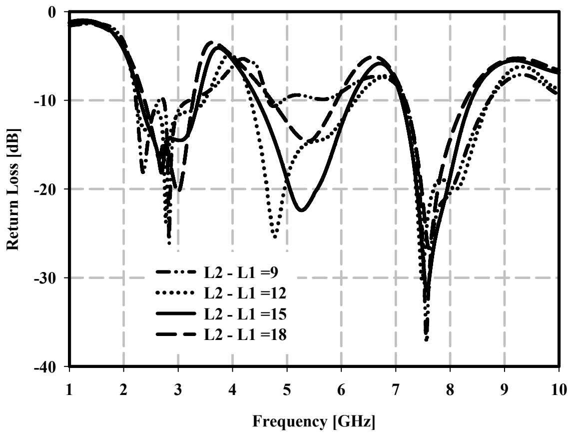
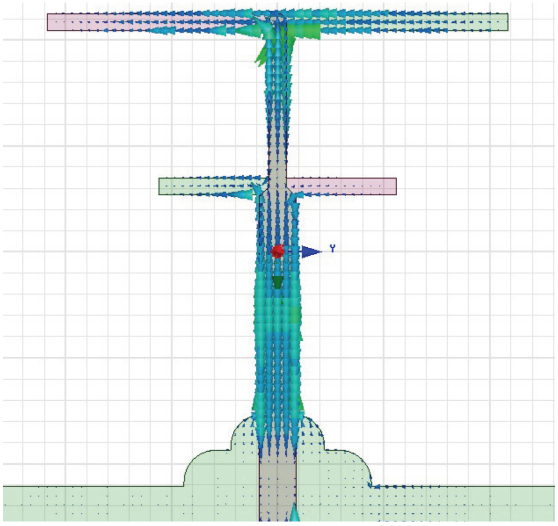


Fig. 3. Simulated reflection coefficient for variable distance between L2 to L1 of a pair dipole.

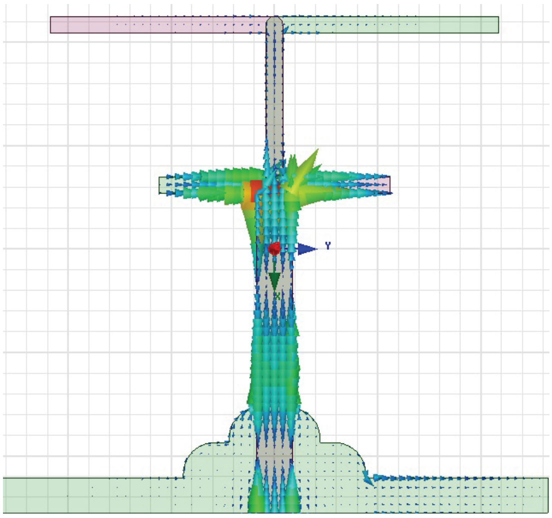
Fig. 4 shows surface current distribution each resonance band of 2.6, 5.2, 7.14 GHz. Fig. 4 (a) is plot the resonance frequency at 8.14 GHz. While the proposed antenna shows to appear a lots of surface current to long dipole, short dipole appear a few surface current. On the other hand of Fig. 4 (b) there appear surface current to short dipole, long dipole appear few surface current. Fig. 4 (c) shows to appear resonance three times at stream of microstrip feed line, also shows same appearance long dipole. The simulated and measured reflection coefficient of the proposed antenna shows in Fig. 5. As shown in Fig. 5, the simulated reflection coefficient agrees well with the measured return loss. Also, the simulated input impedance of a Smith chart shows in Fig. 6. The input impedance matches very well at the excited part, as shown in Fig. 6.

A photograph of the proposed antenna is shown in Fig. 7. The rear side and the front side of the photograph show in Figs. 7 (a) and (b). Fig. 7 (b) shows the reverse side of the antenna.

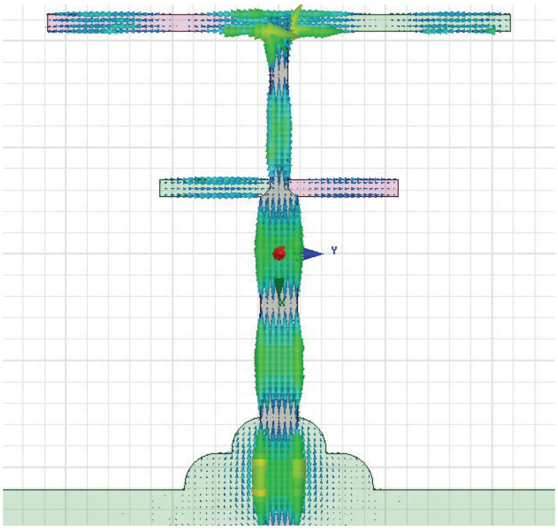
As shown in Fig. 8, the E-plane and the H-plane radiation patterns of the proposed two-pair dipole are measured at the resonant frequencies of 2.6, 5.2 and 7.14 GHz. The measured radiation patterns at the first, second, and third resonant frequencies are shown in Fig. 8. As generally estimated, the radiation patterns at these three resonant frequencies are similar to those of the conventional printed dipole antenna. The tapered microstrip matching by



(a) surface current at 2.6 GHz



(b) surface current at 5.2 GHz



(c) surface current at 7.14 GHz

Fig. 4. Current distribution of the proposed antenna.

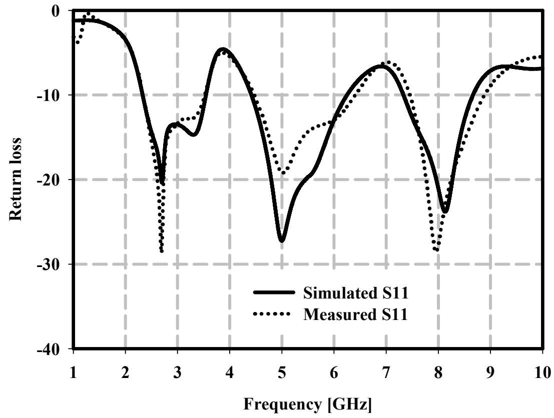


Fig. 5. The measured and simulated reflection coefficient of the proposed antenna.

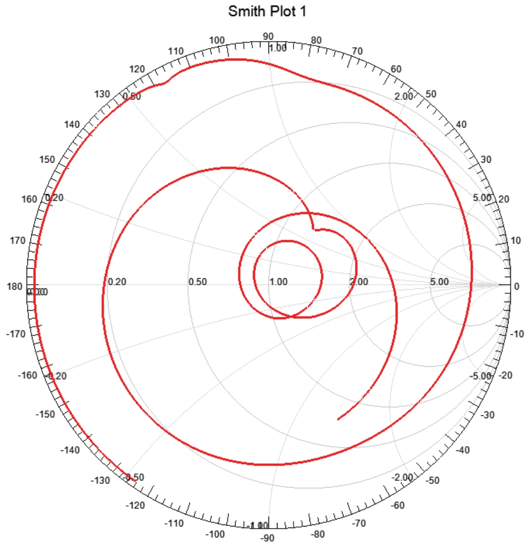
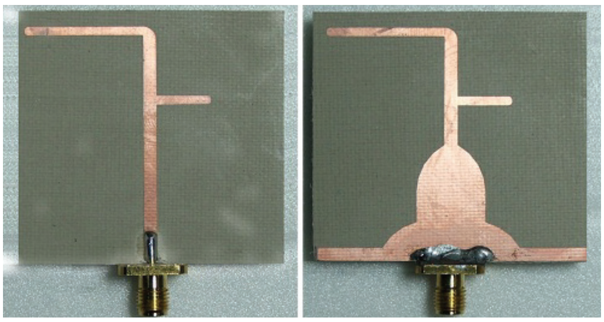


Fig. 6. Simulated impedance on Smith chart of the proposed antenna.



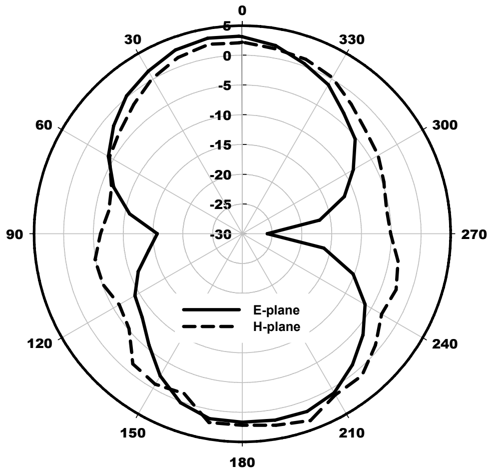
(a) front side (b) rear side

Fig. 7. Photograph of manufactured antenna.

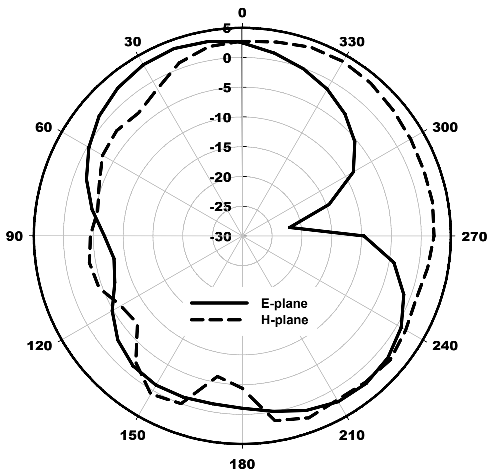
the ground plane caused the radiation pattern to tilt the right side, as shown in Fig. 8 (a) and (b). The proposed antenna had a pick gain of approximately 3.6 dBi. The measured pick gains of proposed antenna are presented in Table 2.

Table 2. The measured pick gains.

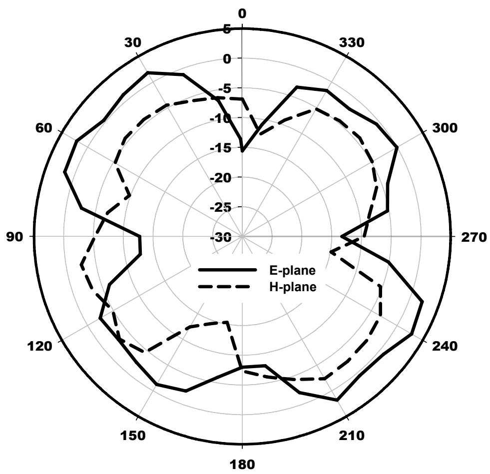
gain	2.6 GHz	5.2 GHz	7.14 GHz
Measured value [dBi]	3.6	3.6	2.8



(a) 2.6 GHz



(b) 5.2GHz



(c) 7.14GHz

Fig. 8. Measurement radiation patterns at each frequency of the proposed antenna.

4. Conclusion

A printed pair dipole antenna for application in wireless communications proposed in this paper. The proposed antenna is introduced to a double tapered microstrip balun that obtained characteristics a wideband, three-band resonance frequency. It is designed for wireless communication for WLL, WLAN (IEEE 802 11b/a) and DSRC band operations. The results shown the impedance bandwidth for reflection coefficient of below 10dB is about 1.01GHz (2.35~3.336[GHz]), 1.56GHz (4.7~6.26[GHz]) and 1.15GHz (6.85~8.0[GHz]), at respectively radiation band. Also, the measurement peak gain 2.6 and 5.2 GHz is about 3.6 dBi. The proposed antenna is able to support wireless communication applications.

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