Regular Article

A Hybrid of T-Dipole and Quasi-Yagi Antenna for Dual-band WLAN Access Point

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Abstract– **In this paper, a hybrid of T-dipole and quasi-Yagi antenna is presented for using in dual-band Wireless Local Area Network (WLAN) access point. The antenna is made up of combination of T-dipole and quasi-Yagi antenna structures, which are distinctly designed to operate at 2.4 and 5.5 GHz frequency bands. A simply integrated balun that consists of a curved microstrip line and a circular slot to allow broadband characteristic is used to feed the antenna. The final antenna design presents measured bandwidths ($RL \leq -10$ dB) of 2.35 – 2.55 GHz and 4.30 – 6.56 GHz which cover completely the two bands of WLAN. Simulated and measured results of peak gain and radiation patterns in both E- and H-plane validate potential of the design.**

Keywords– **Integrated balun, quasi-Yagi, T-dipole, wireless local area network (WLAN).**

1 Introduction

In the last two decades, the 2.4 GHz (2.4 – 2.484 GHz) and 5.5 GHz (5.15 – 5.95 GHz) frequency bands have been widely used for the Wireless Local Area Network (WLAN) communication standards. Due to the presence of many shadowing areas as inside high buildings or tunnels, a large number of access points (APs) is needed to achieve ubiquitous coverage of WLAN systems. An AP is commonly attached on the wall or ceiling to provide coverage in a specified area. Therefore, the antenna for WLAN AP requires not only dual-band operation but also an insignificant back-radiation. Several antennas [1]–[3] were reported for dual-band applications, including the printed dipole antennas [1], [2] or slot-monopole antenna [3]. However, these antennas have omni-directional radiation patterns, hence cannot prevent the radiated wave from propagating to undesired directions.

In recent years, both T-dipole and quasi-Yagi antennas have been widely employed in microwave and millimeter-wave applications owing to their broadband, simplicity, ease of fabrication, and low cost. While T-dipole antennas can be fed by various types of balun with [4]–[6] or without [4], [7], [8] via holes, quasi-Yagi antennas can be fed by alternative feeding lines, including microstrip line [9], coplanar waveguide [10], coplanar stripline [11], and slotline [12]. Especially, quasi-Yagi antennas have highly directional and end-fire radiation pattern, which are promisingly suitable for WLAN APs. The main propose of this paper is to introduce a hybrid of T-dipole and quasi-Yagi antenna that is fed by a simply integrated balun consisting of a curved microstrip line and a circular slot. The T-dipole and quasi-Yagi antenna structures are distinctly designed to operate at 2.4 GHz and 5.5 GHz bands. The proposed antenna has a truncated ground and a parasitic director to improve its radiation pattern at the lower and upper bands, respectively.

2 Antenna design and characteristics

Figure 1 shows the geometry of a hybrid of T-dipole and quasi-Yagi antenna. The antenna was designed on both sides of a 70 × 50 mm Rogers RO4003 substrate with a dielectric constant of 3.38 and a thickness of 0.508 mm. As can be seen, the antenna comprises of an integrated balun feeding, two printed dipoles, a parasitic strip, and a ground plane. The balun is composed of a curved microstrip line and a circular

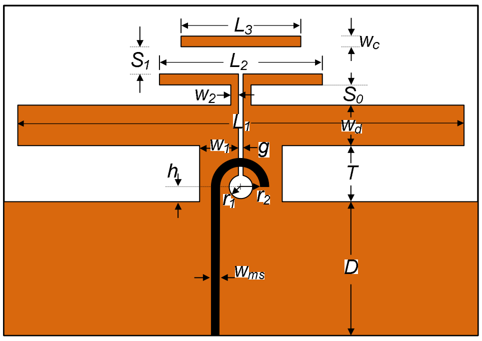

Figure 1. Geometry of the antenna.

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slot. The curved microstrip line was placed on the back side of the substrate, and comprised of a 50 Ω feeding line and a half of ring both with $W_{m}s = 1.14$ mm. The circular slot was etched on the printed dipoles with the same center of the ring. Initial lengths of the dipoles L_1 and L_2, and parasitic strip L_3 were approximately a half of the effective wavelength (i.e., $\lambda_{eff}/2$) at 2.45, 4.8 and 6.2 GHz, respectively. In this design, the ground plane will act as a reflector with a greater length than the larger dipole. The larger dipole was located at $T = 8$ mm away from the ground plane. The two dipoles were printed on the top side of the substrate with a spacing of $S_0 = 3$ mm. The spacing between the smaller dipole and the parasitic strip was $S_1 = 4$ mm. The antenna was optimized using the full-wave electromagnetic simulator Microwave Studio (MWS by Computer Simulation Technology – CST) to achieve dual-band characteristics and stable radiation pattern (i.e., moderate gain and high front-to-back ratio).

The T-dipole structure was separately designed for operating at 2.4 GHz band, from which Figure 2 shows the reflection coefficient of the antenna as a function of the dipole length (L_1). We can see that, as L_1 increases from 54 to 78 mm (in increment of 12 mm) the resonance of 2.4 GHz band decreases, and $L_1 = 66$ mm provides the widest bandwidth at 5.5 GHz band. These indicate that the length of the larger dipole mainly determines the resonant frequency of lower bands.

In the proposed antenna structure, the larger dipole, smaller dipole, and parasitic strip act as the reflector, driver, and director of the quasi-Yagi antenna, respectively. Figure 3 shows the reflection coefficient of the antenna as a function of the driver length L_2. As L_2 increases from 22 to 26 mm (in increments of 2 mm), the 2.4 GHz band hardly changes while the lower resonance of the 5.5 GHz band decreases and the higher one remains almost the same. This indicates that the length of the driver mainly determines the lower resonance of the 5.5 GHz band.

Figure 4 shows the reflection coefficient of the antenna as a function of the director length L_3. As L_3 increases from 16 to 19 mm (in increments of 1.5 mm), the 2.4 GHz band does not change while the higher resonance of the 5.5 GHz band decreases and the lower one changed insufficiently. This indicates that the length of the director mainly determines the higher resonant frequency of the 5.5 GHz band.

Figure 5 shows the reflection coefficient of the antenna as a function of the spacing between the driver and director (S_1). Increments of 2 mm of this space from 2 to 6 mm induced significant changes in the reflection coefficient in the high-frequency region of the 5.5 GHz band but negligible changes in the low-frequency region and the 2.4 GHz band. This indicates that the spacing between the driver and the director mainly affects the antenna characteristics in the high-frequency region of the 5.5 GHz band.

As mentioned above, the T-dipole and quasi-Yagi antennas were distinctly designed for 2.4 GHz and 5.5 GHz, however, an existing influence between two.

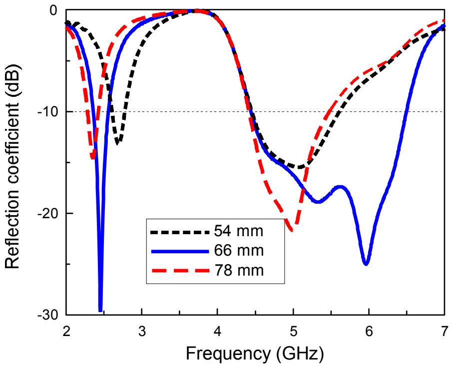


Figure 2. Reflection coefficient as a function of L_1.

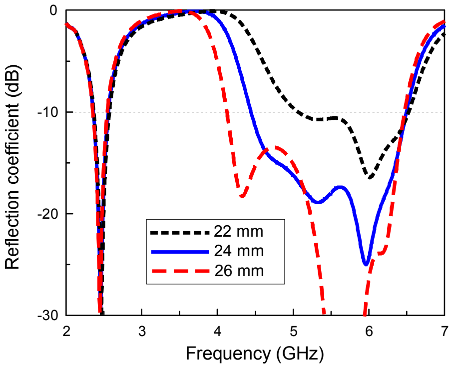


Figure 3. Reflection coefficient as a function of L_2.

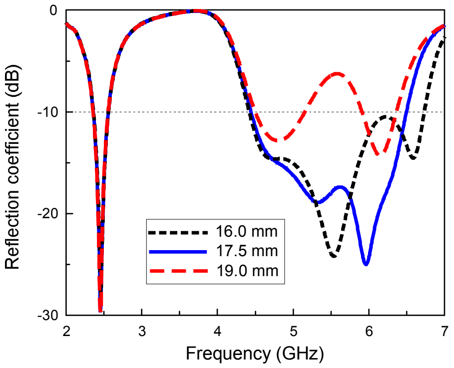


Figure 4. Reflection coefficient as a function of L_3.

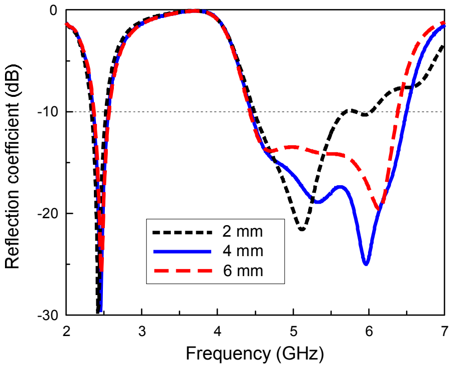


Figure 5. Reflection coefficient as a function of S_1.

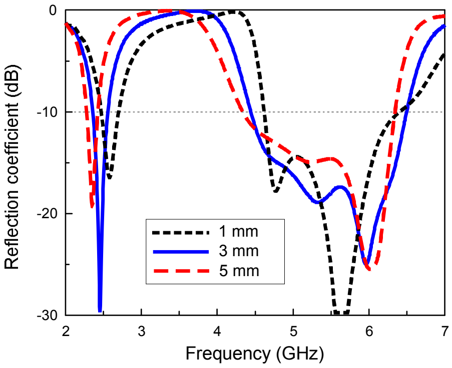


Figure 6. Reflection coefficient as a function of S_0.

This can be seen from Figure 6, which shows the reflection coefficient of the antenna as a function of the spacing between the large and small dipoles (S_0). As S_0 was increased from 1 to 5 mm (in increments of 2 mm), the resonance of the 2.4 GHz band decreased while the center frequency of the 5.5 GHz band insignificantly changed. This indicates that a judicious choice of the spacing (S_1) is very important for dual-band operation of the proposed antenna.

The antenna was fabricated using a standard etching technology on Rogers RO4003 substrate with a 20 μm copper thickness, and a subminiature type-A (SMA) connector was used as a microstrip-to-coaxial line transition (not included in the simulations). An Agilent N5230A network analyzer was first calibrated with an Agilent 3.5 mm 85052B calibration kit and then used to measure the prototype shown in Figure 7. As shown in Figure 8, the measured reflection coefficient of the optimized antenna is in a very good agreement with the simulation. The measured bandwidth was 2.35 – 2.55 GHz and 4.30 – 6.56 GHz for the −10 dB reflection coefficient while the simulated bandwidth was 2.36 – 2.56 GHz and 4.45 – 6.49 GHz. This bandwidth completely covers the specification for WLAN operation in the 2.4 GHz (2.4 – 2.484 GHz) and 5.5 GHz (5.15 – 5.95 GHz) bands.

The radiation patterns and gain of the proposed antenna were measured with an Agilent E8362B network analyzer. Two identical standard horn antennas (one for transmitting and one for receiving) were first connected to two ports of the network analyzer for calibration. The distance between the transmitting and receiving antennas was 10m. The receiving antenna was then replaced with the hybrid of T-dipole and quasi-Yagi antenna. In the measurement process, the transmitting antenna was fixed, while the receiving antenna was rotated from −180° to 180°, with an angular increment of 1°. Figure 9 shows 2.45, 5, 5.5, and 6 GHz radiation patterns of the antenna and showed a good agreement between the measurements and simulations. The patterns are quite symmetric and stable for both of lower and upper bands. At the frequency of 2.45 GHz, the measurements resulted in a front-to-back ratio of 14 dB and a half-power beamwidth (HPBW) of 66° and 162° along E- and H-plane patterns, respectively. At 5.5 GHz band, the measurements resulted in a front-to-back ratio of > 25 dB, HPBWs of 42° – 67° and 148° – 182° along the E- and H-plane, respectively. As shown in Figure 10, a slight difference between the measured and simulated gain could be attributed to a misalignment between curved microstripline and the circular slot of the balun and effect of the SMA connector. Additionally, the measurement resulted in the peak gains of 5.83 and 7.44 dBi for the 2.4 GHz and 5.5 GHz bands, respectively.

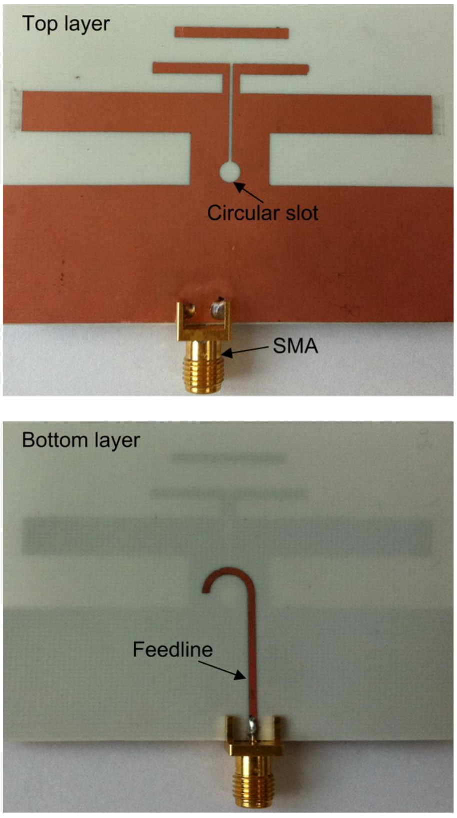


Figure 7. Fabricated antenna.

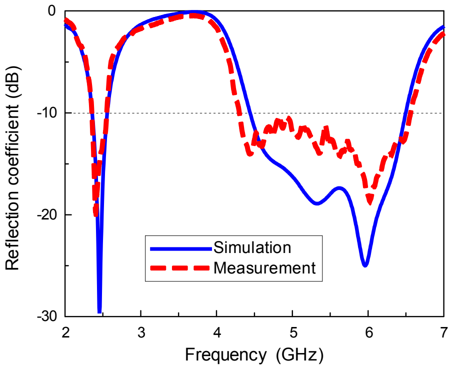
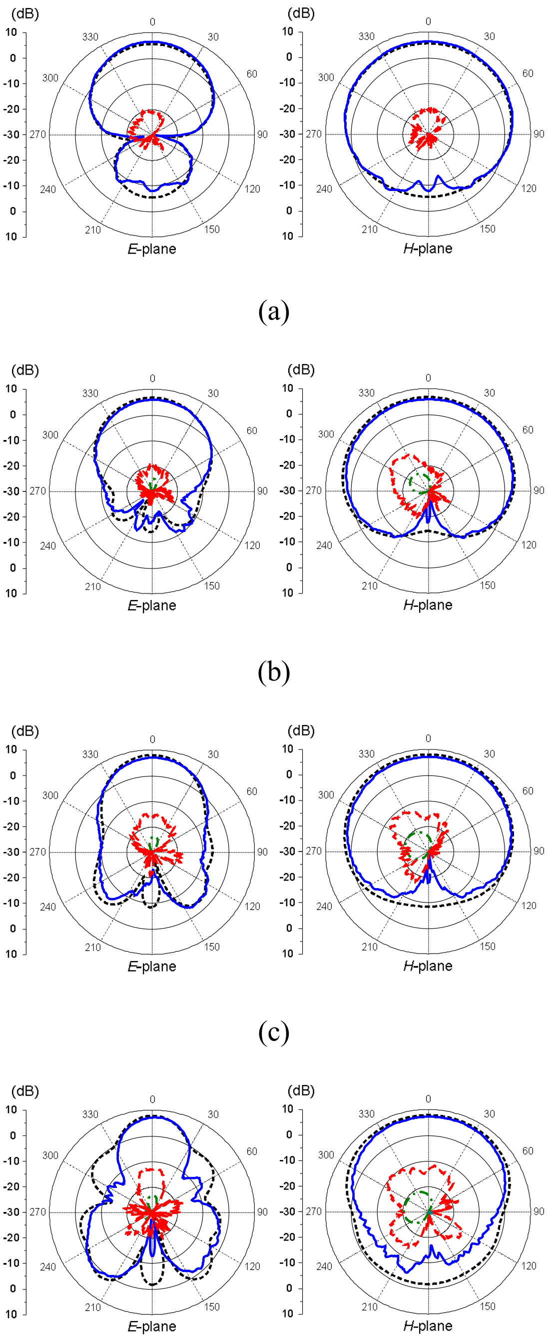


Figure 8. Measured and simulated reflection coefficient.



(a)

(b)

(c)

(d)

Figure 9. (a) 2.45, (b) 5.0, (c) 5.5, and (d) 6.0 GHz radiation patterns of the antenna.

3 Conclusions

Hybrid of T-dipole and quasi-Yagi antenna with single feed introduced for use in the dual-band WLAN access points. T-dipole and quasi-Yagi antenna are designed to operate at 2.4/5.5 GHz bands, respectively. The single feed is a simple integrated balun with a curved microstripline and a circular slot. The antenna has an impedance matching bandwidth of 2.355 – 2.565 GHz and 4.4 – 6.6 GHz for the –10 dB reflection coefficient. The peak gains are 5.83 and 7.44 dBi for the lower and upper bands, respectively. This simple structure, dual-band, and quite stable radiation pattern make the proposed antenna can be widely used in WLAN access points.

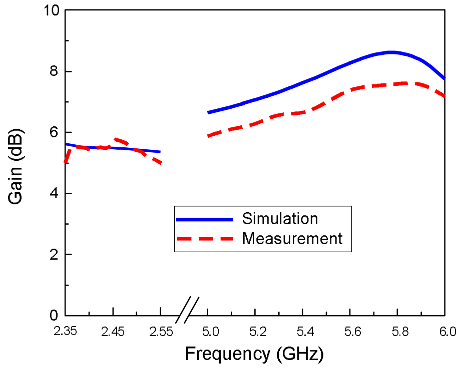


Figure 10. The gain of the proposed antenna.

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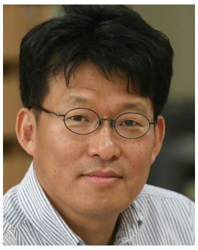

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