Directional triple-band planar antenna for WLAN/WiMax access points

R.L. Li, X.L. Quan, Y.H. Cui and M.M. Tentzeris

A directional triple-band planar antenna is proposed for WLAN/WiMax access point applications. The triple-band planar antenna consists of a top-loaded dipole for the 2.4 GHz band, two longer dipoles for the 3.5 GHz band and two shorter dipoles for the 5 GHz band. All the dipoles are printed on the same substrate. The triple-band antenna achieves a directional radiation pattern at all the three frequency bands with an antenna gain of 7.5 dBi for the lowest band, 8.5 dBi for the middle band, and 9–10 dBi for the highest band.

Introduction: For WLAN/WiMax communications, the operating frequency is available at different bands, including the 2.4 GHz band (2.4–2.5 GHz), the 3.5 GHz band (3.4–3.6 GHz) and the 5 GHz band (5.1–5.9 GHz). Therefore a triple-band antenna may be needed for a wireless access point. Over the past few years, a number of triple-band antennas have been proposed for WLAN/WiMax applications [1–8]. But all these triple-band antennas were developed for user terminals, such as mobile handsets [2] or laptop computers [7]. For a user terminal, the antenna is normally required to have an omnidirectional radiation pattern, which leads to a lower antenna gain (typically ~2 dBi). For wireless access point applications, a directional antenna with a higher gain (e.g. 7–10 dBi) is sometime needed, such as for a ceiling mount wireless access point. In this Letter, we propose a directional triple-band planar antenna which achieves a gain of 7.5 dBi in the 2.4 GHz band, 8.5 dBi in the 3.5 GHz band and 9–10 dBi in the 5 GHz band.

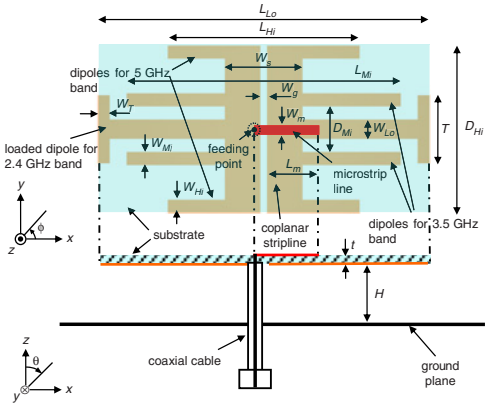

Fig. 1 *Configuration of directional triple-band antenna*

Table 1: Optimised geometric parameters for directional triple-band antenna

Parameter	Value	Parameter	Value
L_{LO}	52 mm	W_s	12 mm
L_{HI}	30 mm	W_g	1 mm
D_{Hi}	26 mm	W_m	1.5 mm
D_{Mi}	7 mm	W_{Hi}	2 mm
T	10.5 mm	W_{Mi}	2 mm
L_m	8.5 mm	W_T	2 mm
L_{Mi}	43 mm	W_{LO}	3 mm
H	12 mm	t	0.5 mm

Antenna configuration: The configuration of the proposed directional triple-band antenna is illustrated in Fig. 1. The triple-band antenna consists of a top-loaded dipole for the 2.4 GHz band, a pair of longer dipoles for the 3.5 GHz band and a pair of shorter dipoles for the 5 GHz band. The top-loaded dipole for the lowest band has a total length of $L_{Lo} = 0.42\lambda_{2.45}$ while the pair of the longer dipoles for the middle band has a length of $L_{Mi} = 0.49\lambda_{3.5}$ and the pair of shorter dipoles for the highest band has a length of $L_{Hi} = 0.55\lambda_{5.5}$, where $\lambda_{2.45}$, $\lambda_{3.5}$ and $\lambda_{5.5}$ are the free-space wavelengths at 2.45, 3.5 and 5.5 GHz, respectively. Therefore the top-loaded dipole and the two pairs of longer dipoles and shorter dipoles act as a single half-wave dipole antenna in the 2.4 GHz band and a two-element half-wave dipole array in the 3.5 and 5 GHz bands, respectively. The two pairs of longer and shorter dipoles have a separation of $D_{Mi} \simeq 0.08\lambda_{3.5}$ and $D_{Hi} \simeq 0.48\lambda_{5.5}$, respectively, and are connected by a coplanar stripline. All these dipoles are printed on the bottom side of a thin RT/Duroid 5880 substrate with a dielectric constant $\varepsilon_r = 2.2$ and a thickness $t = 0.5$ mm. The printed dipoles are placed ($\sim 0.1\lambda_{2.4}$) above a ground plane (100 × 60 mm) for a directional radiation pattern and excited by a coupling microstrip line printed on the top side of the substrate through a 0.084 inch semi-rigid coaxial cable. The directional triple-band antenna was optimised using CST MicroStripes 7.5. The optimised values for all geometric parameters of the antenna are listed in Table 1.

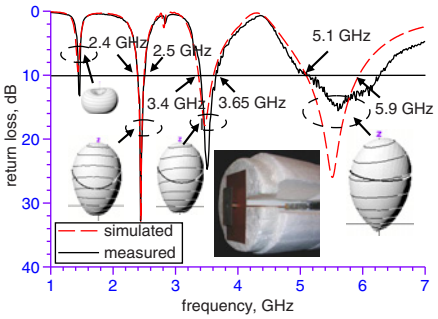

Fig. 2 *Return loss of directional triple-band antenna*

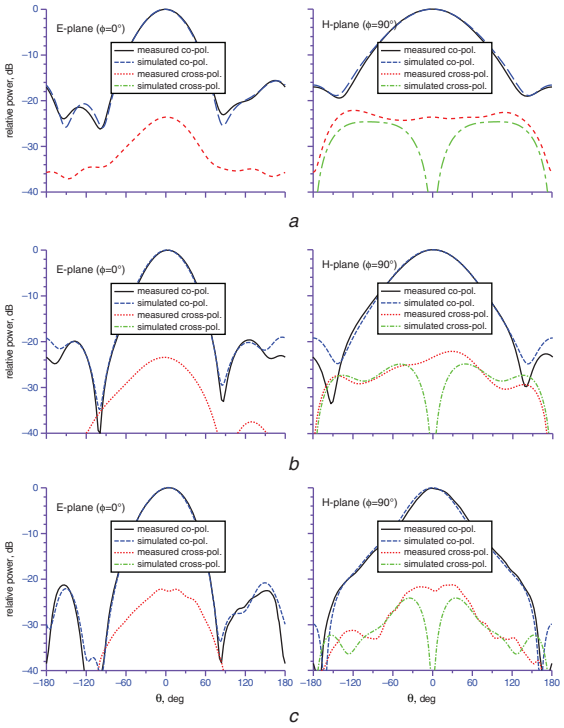

Fig. 3 *Radiation patterns of directional triple-band antenna*

a At 2.45 GHz
b At 3.5 GHz
c At 5.5 GHz

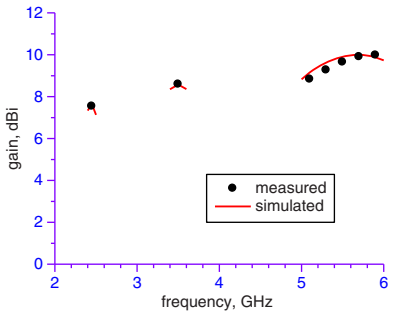

Fig. 4 *Gain of directional triple-band antenna*

Results: The simulated return loss (RL) is plotted in Fig. 2. Good impedance matching is achieved in the 2.4 GHz band (RL > 10 dB from 2.4 to 2.5 GHz), the 3.5 GHz band (RL > 10 dB from 3.4 to 3.6 GHz), and the 5 GHz band (RL > 10 dB from 5.1 to 5.9 GHz). An additional resonance appears around 1.4 GHz. This resonance is due to the feeding coaxial cable which acts as a vertical top-loaded monopole at this frequency but makes little contribution to the 2.4, 3.5, and 5.5 GHz bands. A prototype has been fabricated and measured. The measured RL has been compared with the simulation result and good agreement is observed. The radiation patterns at 2.45, 3.5, and 5.5 GHz are presented in Fig. 3. Good directional radiation patterns are observed for all three frequency bands. Note that the radiation pattern at 1.4 GHz is omnidirectional (see the inset of Fig. 2), which confirms the monopole mode. The antenna gain is shown in Fig. 4. The gain is about 7.5 dBi for the 2.4 GHz band, 1 dB lower than that for the 3.5 GHz band (8.5 dBi) and 1.5–2.5 dB lower for the 5 GHz band (9–10 dBi). The higher gains in the middle and highest bands are due to the two-element dipole arrays for the 3.5 and 5 GHz bands. This characteristic is desirable because radio signals experience a higher path loss at a higher frequency, thus requiring a higher gain.

Conclusions: A directional triple-band planar antenna is presented. The triple-band antenna consists of a top-loaded dipole for the lowest frequency band, two longer dipoles for the middle frequency band and two shorter dipoles for the highest frequency band. All dipoles are printed on a thin substrate and are excited by a coupling microstrip line. The triple-band antenna has a high-gain directional radiation pattern in the 2.4, 3.5, and 5 GHz bands, and thus may find applications in wireless access points for WLAN/WiMax communications.

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One or more of the Figures in this Letter are available in colour online.

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