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DUAL ISM-BAND GAP-FILLER MICROSTRIP ANTENNA WITH TWO Y-SHAPED SLOTS FOR SATELLITE INTERNET SERVICE

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ABSTRACT: *This article describes a dual-band gap-filler microstrip antenna with nearly equal gain and similar radiation patterns in the 2.4-GHz and 5.8- GHz ISM satellite Internet service bands. The proposed antenna has two Y-shaped slots on the microstrip patch and is fabricated on an RO4003 substrate with a dielectric constant of 3.38 and a thickness of 0.508 mm. The dimensions of the antenna are 50 mm × 47.5 mm × 6.5 mm, and it is fed by a coaxial cable. The measured bandwidths of the antenna are 2.376–2.492 GHz and 5.425–6.055 GHz for a voltage standing wave ratio of less than 2. At 2.42 GHz, the antenna has a broadside radiation pattern with a half-power beamwidth (HPBW) of 70° in the* x-z *plane and 80° in the* y-z *plane. At 5.75 GHz, it has a HPBW of 65° in the* x-z *plane and 75° in the* y-z *plane. The measured gain is 8.37 dB in the 2.4-GHz ISM band and 8.38 dB in the 5.8 GHz ISM band.* © 2010 Wiley Periodicals, Inc.

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Key words: *microstrip antenna; dual band; satellite internet service; gap filler*

1. INTRODUCTION

In recent years, satellite internet service has been widely investigated for use on high-speed trains. It offers stable wireless internet service without time or space limitations, but is hindered when the train is passing through a tunnel, which blocks direct access to the satellite signal. A tunnel is a typical shadowing area, in which a gap filler is required for better communication between the satellite and the wireless terminal of the Korean high-speed train network [1–3].

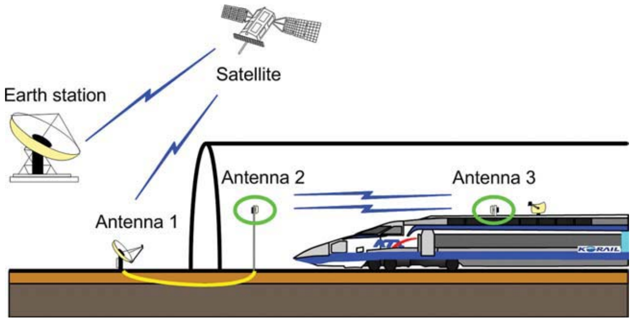

Figure 1 Gap filler system for the satellite internet service. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

A gap filler system requires three antennas: one installed outside the tunnel (Antenna 1), one installed inside the tunnel (Antenna 2), and one installed on the train (Antenna 3). Satellite internet service consists of a forward link from an earth station to the satellite, from the satellite to the gap-filler, from the gap-filler to the portable terminal of a mobile user, and a return link from the portable terminal of the mobile user to the gap filler, from the gap filler to the satellite, from the satellite to the earth station as shown in Figure 1. The forward link requires a 72-MHz bandwidth for communication and broadcasting, and the return link requires a 36-MHz bandwidth for communication. Hence, the combined bandwidth of both links is 108 MHz, and the required total bandwidth (including guard band) is about 150 MHz. The current wireless local area network (WLAN) bands are 2.4–2.483, 5.15–5.35, and 5.725–5.825 GHz. Of these, the ISM bands that require no permission for industrial, scientific, and medical purposes are the 2.4 GHz band (IEEE 802.11b) and the 5.8 GHz band (IEEE 802.11a). A gap filler must use both bands (802.11a/b) because of the required total bandwidth. Thus, a dual-band antenna is necessary. Moreover, the antennas installed in the tunnel and on the high-speed train must have

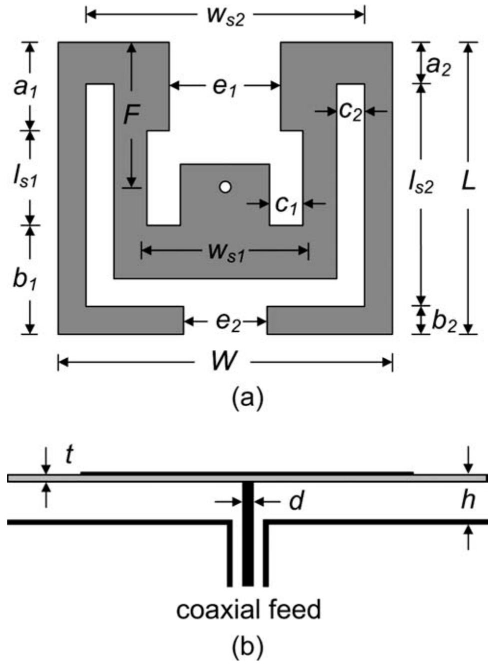

Figure 2 Antenna structure, (a) top view and (b) side view

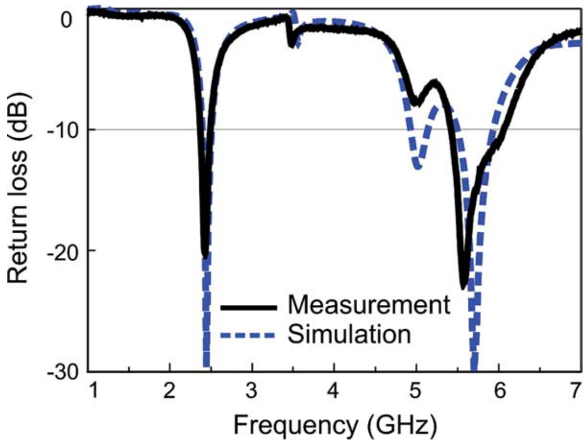

Figure 3 Return loss of the optimized antenna. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

similar radiation patterns to achieve optimum communication and the high gain needed in each of the frequency bands to offset the multipath fading effect of the tunnel environment [4]. Hence, the antenna for the gap filler must operate in both the 802.11a/b bands with high gain and similar radiation patterns.

Microstrip patch antennas have been widely used because of their modest cost, light weight, low profile, and ease of fabrication. Dual-frequency operation can be obtained by putting slots on the microstrip patch [5] or by placing shorting pins at appropriate locations on the patch [6, 7]. However, when the higher resonant frequency is more than twice that of the lower frequency, the radiation pattern at the higher frequency becomes distorted due to the higher-order resonant modes. In this article, a dual-band microstrip antenna is introduced that has nearly equal gain and similar radiation patterns in the 2.4-GHz and 5.8-GHz ISM satellite Internet service bands.

2. ANTENNA CONFIGURATION AND CHARACTERISTICS

Figure 2 shows the proposed antenna structure, which is obtained by adding a small inverse Y-shaped slot to a rectangular patch with a large Y-shaped slot. Air ($\varepsilon_r = 1$) exists between the substrate supporting the patch and the ground plane. The substrate is RO4003 with a dielectric constant of 3.38 and a thickness of 0.508 mm. A coaxial cable with an inner conductor diameter of $d = 0.92$ mm is attached at $F = 24.5$ mm from the end of the patch. The dimensions of the patch are $L = 47.5$ mm

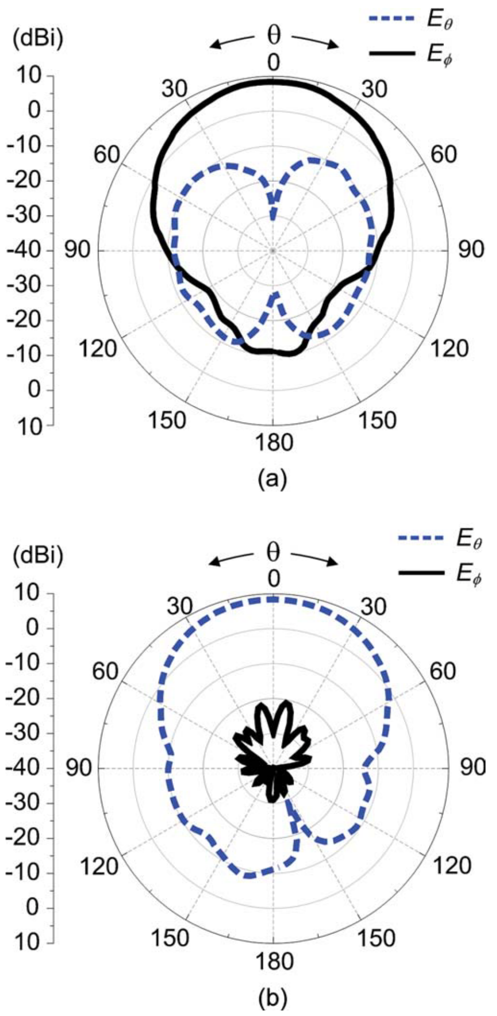

Figure 4 Radiation patterns at 2.42 GHz, (a) *x-z* plane and (b) *y-z* plane. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

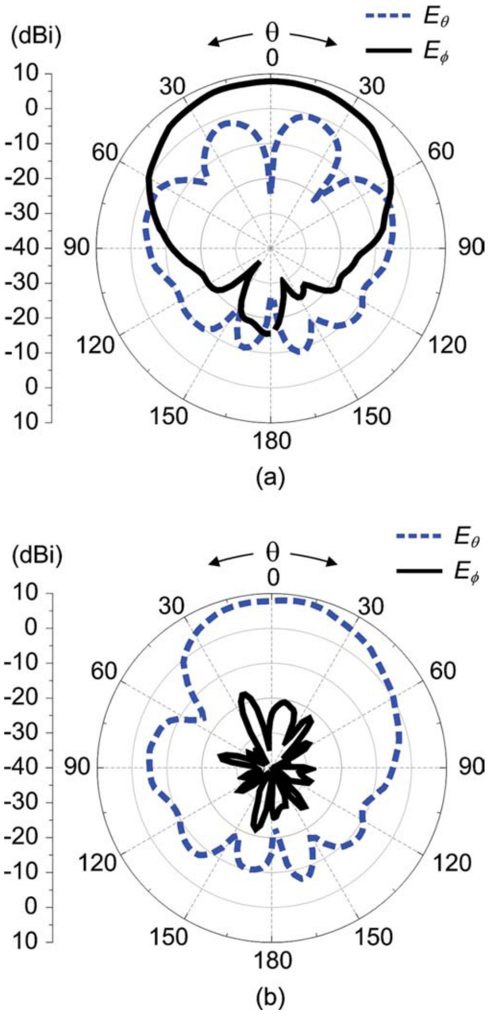

Figure 5 Radiation patterns at 5.75 GHz, (a) *x-z* plane and (b) *y-z* plane. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

and $W = 50$ mm, and it is placed at a height of $h = 6.5$ mm above the ground plane. The width and length of the small inverse Y-shaped slot are $w_{s1} = 23.5$ mm and $l_{s1} = 14.5$ mm, and the widths of the arm and leg are $c_1 = 5.5$ mm and $e_1 = 22.5$ mm, respectively. The respective width and length of the large Y-shaped slot are $w_{s2} = 46$ mm and $l_{s2} = 38$ mm, and the respective widths of the arm and leg are $c_2 = 3.5$ mm and $e_2 = 15$ mm. We optimized the design parameters with respect to the widths of the Y-shaped slots and the length, location, and position of the feed. The small Y-shaped slot generates a higher resonant frequency, while the large Y-shaped slot generates a lower resonant frequency. The simulated and measured return loss characteristics of the antenna are shown in Figure 3. The simulated bandwidths of the antenna are 2.388–2.499 GHz and 5.489–5.924 GHz, and the measured bandwidths are 2.376–2.492 GHz and 5.425–6.055 GHz.

The measured radiation patterns of the antenna in the *x-z* plane and *y-z* plane are shown in Figures 4 and 5, respectively, for the central frequencies of 2.42 and 5.75 GHz of the two bands. At 2.42 GHz, the antenna has a broadside radiation pattern with a half-power beamwidth (HPBW) of 70° in the *x-z* plane and 80° in the *y-z* plane. At 5.75 GHz, a HPBW of 65° in the *x-z* plane and 75° in the *y-z* plane are obtained. The measured gains are 8.37 and 8.38 dBi at the center frequencies of 2.42 and 5.75 GHz, respectively.

3. CONCLUSIONS

A description is given of a dual ISM-band gap filler microstrip antenna with nearly equal gain and similar radiation patterns for application to satellite internet service. The antenna operates in the 2.4-GHz and 5.8-GHz ISM bands. A large Y-shaped slot on the microstrip patch generates the lower resonant frequency, while a small inverse-Y-shaped slot generates the higher resonant frequency. The measured bandwidths of the antenna are 2.376–2.492 GHz and 5.425–6.055 GHz for a voltage standing wave ratio of less than 2. The measured gains are 8.37 and 8.38 dBi for the lower and upper bands, respectively.

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THREE TO TWO CURVE FRACTAL FOLDED DIPOLE ANTENNA FOR RFID APPLICATION

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ABSTRACT: *A 3/2 curve fractal dipole antenna was proposed for radio-frequency identification application, with mirror and photonic bandgap structure. Some properties of the antenna, such as return loss and bandwidth have been simulated and investigated. The results show that the absolute bandwidths of antenna are up to 0.28 GHz and 0.41 GHz at 2.4 GHz and 5.8 GHz, respectively accordingly the relative bandwidths up to 9.76% and 6.87%. With a prototype fabricated, we also verified the good performance of the antenna through the comparison of measured and simulated results.* © 2010 Wiley Periodicals, Inc. Microwave Opt Technol Lett 52: 1827–1830, 2010; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.25324

Key words: *dipole antenna; 3/2 curve fractal; PBG; wideband; RFID*

1. INTRODUCTION

Fractal was originally coined by Mandelbrot in 1975 from the latin fractus, derived from the original inspiration for an in-depth study of the patterns of nature [1]. In recent years, it is possible to develop new types of antennas using fractal structure rather than Euclidean geometry for traditional antennas. For the

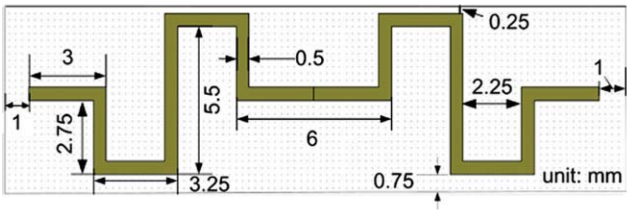

Figure 1 Basic fractal dipole antenna structure. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

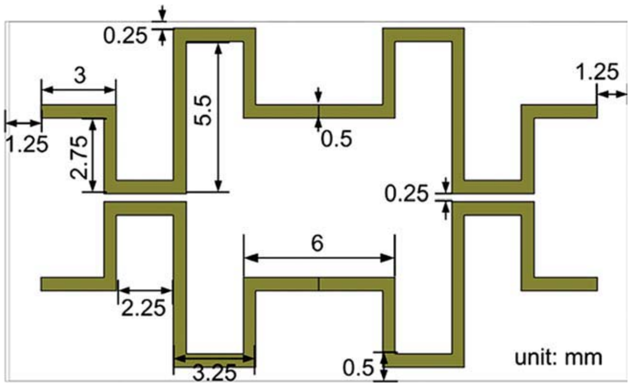

Figure 2 Fractal dipole antenna with mirror structure. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]