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LETTER

A wideband planar surface wave antenna for the WLAN router

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Abstract

In this paper, a wideband planar surface wave antenna for the 5 GHz wireless local area network (WLAN) router applications is proposed. The antenna is excited by a center-fed circular patch with an annular ring patch (ARP) and a thin dielectric slab with periodic circular patches (PCPs) is loaded on the circular patch radiator. A prototype of the 0.3-mm-thick (0.06λ) antenna was constructed and tested to evaluate its suitability for reducing router thickness. The impedance bandwidth of the antenna was 23.6% (5.7–7.1 GHz) and its average gain was 5.91 dB. The radiation pattern of the antenna was nearly omnidirectional.

Keywords: WLAN; Surface wave antenna; Wideband; Monopole-like pattern; Planar antenna

1. Introduction

The wireless local area network (WLAN) is a short-distance wireless technology used for communications between the client devices such as personal computer, laptop and PDA. The frequencies allocated to WLANs are 5.15–5.35 and 5.725–5.825 GHz in the United States and 5.15–5.35 and 5.470–5.725 GHz in Europe according to the standard of IEEE (802.11a) [1,2]. Although several kinds of antennas for laptops and other portable devices have been introduced [3], the study of omnidirectional planar antennas for WLAN router applications has never been investigated. Omnidirectional dipole antennas are widely used in home and office WLAN routers. Dipole antennas are easily constructed, and are formed by elements placed back to back for a total length of $\lambda/2$. A $\lambda/4$ grounded monopole with a radiation pattern similar to a dipole for WLAN router applications is unnecessarily thick because of its length. A planar omnidirectional antenna would reduce this thickness.

Many kinds of omnidirectional planar antennas have been studied. Mongia et al. [4] and Guha et al. [5] designed a dielectric resonator antenna with a monopole-like radiation pattern. However, dielectrics make antennas thick, and they are expensive. Another method of obtaining monopole-like radiation is to use a microstrip. The simplest such antenna is a circular patch antenna, which radiates symmetrically around the normal z-axis with a null in the broadside direction typically of -30 dB [6]. Although Ravipatl et al. [7,8] realized a miniaturization of the circular patch antenna using the slots and shorting via holes, this suffered from reduced bandwidth. The other method of designing antennas with monopole-like radiation is to use a periodic structure. In [9–11], surface wave antennas (SWAs) with monopole-like radiation patterns and low-profile configurations were designed using thin ground slabs with periodic patch loadings. However, these antennas cannot be used for 5 GHz WLAN applications because of their narrow bandwidth. Wideband

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antennas with monopole-like radiation have been studied [12], but even though wide bandwidth can be obtained by adding a square ring patch, the resulting antenna is so thick due to the air gap that it cannot be used on WLAN routers. The antenna air gap also increases the difficulty of fabrication.

In this paper, we propose a wideband planar SWA with an omnidirectional radiation pattern for use in a WLAN router. The antenna is excited by a center-fed circular patch to which an annular ring patch (ARP) is added to enhance the bandwidth. A thin dielectric slab with periodic circular patches (PCPs) is loaded on the circular patch to produce monopole-like radiation [10]. The proposed antenna has an omnidirectional radiation pattern, a bandwidth of 23.6%, and a gain of 5.91 dB.

2. Configuration of the surface wave antenna

The surface wave antenna is defined as an antenna which radiates from discontinuities in the structure that interrupt a bound wave on the antenna surface in [13]. For the surface wave, the radiation takes place only at nonuniformities, curvatures, and discontinuities. Discontinuities can be either discrete or distributed. Generally, a surface wave antenna is a slow wave structure whose phase velocity is equal to or less than the speed of light in free space and endfire or near-endfire radiators. The surface wave can occur by placing periodic circular patches arrayed on the dielectric slab which is an upper layer of the center-fed circular patch. In the dielectric slab with PCPs, a TM surface wave is excited and propagates along the slab until it diffracts at the edge of the ground plane.

The geometry of the wideband planar SWA is illustrated in Fig. 1. The antenna consists of two circular dielectric layers with dielectric constant $\varepsilon_r = 2.5$, thickness $h = 1.524$ mm and a radius of 75 mm. The proposed antenna is useful in WLAN router applications because it is very thin. Fig. 1(a) shows the top layer loaded with PCPs, where $g_2 = 4$ mm and $r_2 = 10$ mm. The PCPs are arranged in a circle in order to improve the omnidirectional property of the antenna. Fig. 1(b) shows the bottom layer consisting of a circular patch with a radius of $r_1 = 19.5$ mm and an ARP with $w = 10$ mm. The gap, g_1, between the circular patch and ARP is 3 mm. The circular patch loses less energy via radiation than the rectangular patch and thus provides a larger quality factor [14]. The ARP on the same layer as the circular patch enhances the bandwidth. Fig. 1(c) shows a side view of the antenna. A coaxial probe is connected to the center of the inner circular patch for feeding.

In the slab with PCPs, the surface wave propagates and diffracts at the edge of the ground plane. Thus, the antenna has not only a monopole-like radiation pattern but also good impedance matching [11]. Fig. 2 shows the simulated return loss curves of the four types of antenna. Here, CPA is the conventional circular patch antenna and CPA_{ARP} is the CPA

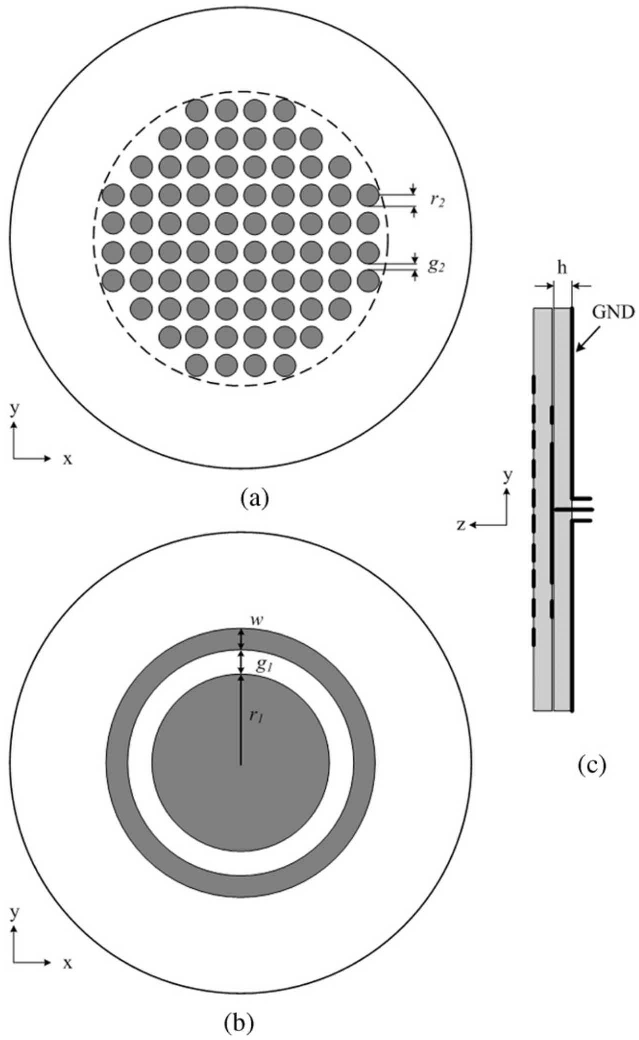

Fig. 1. Geometry of the wideband planar SWA. (a) Top layer, (b) bottom layer and (c) side view of the antenna.

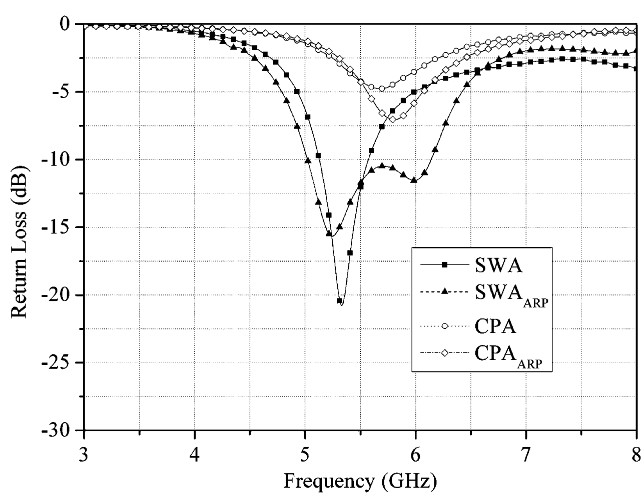

Fig. 2. Simulated return losses of four types of antenna: CPA, CPA_{ARP}, SWA and SWA_{ARP}.