Profile Miniaturization and Bandwidth Enhancements of Crossed Dipoles on Artificial Magnetic Conductor Surfaces

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***Abstract* - This paper presents single-feed circularly polarized (CP) crossed dipole antennas on finite-sized artificial magnetic conductor (AMC) surfaces that show profile miniaturization and bandwidth enhancement. The antennas include a single-band radiator on a single-band AMC, a tri-band radiator on a single-band AMC, and a dual-band radiator on a dual-band AMC. The presence of the finite AMC surface results in generation of extra resonances for the radiating structures. These extra resonances can be favorably used to improve the performance of the antenna.**

***Index Terms* — Circular polarization, crossed dipole, artificial magnetic conductor, extra resonance.**

I. Introduction

A circularly polarized (CP) crossed dipole antenna is a common choice for many of today's wireless communication systems. The crossed dipole can be excited by either a dual feed [1] or single feed [2] to generate CP radiation. A crossed dipole is typically backed by a metallic surface in order to produce the desired unidirectional radiation pattern [3], [4]. The main problem with an antenna equipped with a metallic reflector is often addressed by placing a quarter-wavelength space between the radiating element and the reflector to obtain optimal antenna characteristics. This can be circumvented by using an artificial magnetic conductor (AMC) surface instead of the metallic reflector. The AMC, which generally consists of a lattice of metal plates on a grounded dielectric substrate, with [5] or without [6] grounding vias, can mimic a perfect magnetic conductor (PMC) over a certain frequency band. More interestingly, the presence of the finite-sized AMC causes extra resonances of the radiating structures. This has been validated for both linearly polarized [7], [8] and CP radiators [9], [10].

This paper presents several low-profile, multiband CP antennas that are matched to a single 50-Ω source and have high radiation efficiencies. The antennas are successfully implemented by combining single-band [11], dual-band [12], and tri-band [13] crossed dipoles with finite AMC surfaces. The presence of the finite AMC surface results in generation of extra resonances for the radiating structures, and these are favorably used to enhance the antenna performances.

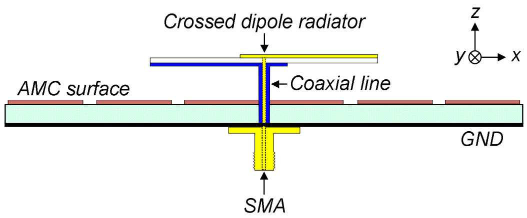

Fig. 1. Cross sectional view of the crossed dipole on an AMC surface.

II. Antenna Design and Characteristic

Fig. 1 shows a cross sectional view of the proposed antennas. Each antenna essentially consists of a crossed dipole radiator, a coaxial line, and an AMC surface. The crossed dipoles were suspended above the AMC surface, which consists of a lattice of metal plates on a grounded dielectric substrate without grounding vias. The characteristic impedance of the coaxial line was 50 Ω, and the coaxial line passed through the center of the AMC reflector to feed the radiator.

Fig. 2 shows a fabricated sample of the single-band crossed dipole on a single-band AMC surface. It exhibits dual-band operation that was obtained by utilizing the original band of the radiator and the first extra band caused by the surface waves propagating on the finite AMC reflector. The antenna with an overall size of ~0.3485 λ_o × 0.3485 λ_o × 0.0471 λ_o at 1.23 GHz yields an impedance bandwidth of 1.202–1.706

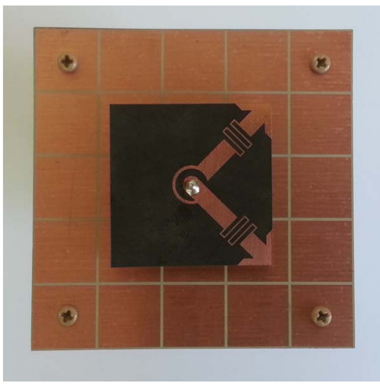

Fig. 2. Single-band crossed dipole on a single-band AMC structure.

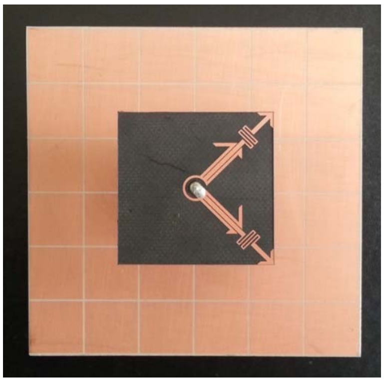

Fig. 3. Tri-band crossed dipole on a single-band AMC structure.

GHz for the $|S_{11}|$ < –10 dB and 3-dB axial ratio (AR) bandwidths of 1.205–1.240 GHz (GPS L2 band) and 1.530–1.625 GHz (GPS L1 band). The proposed antenna was right-hand CP (RHCP) in both bands and yielded gains of 5.60 and 5.31 dBic and radiation efficiencies of 95% and 96.5% at the GPS L1/L2 frequencies, respectively.

Fig. 3 shows a fabricated sample of the tri-band crossed dipole on a single-band AMC surface. The AMC was designed to act as a PMC over the 2.4-GHz band, but performed like a perfect electric conductor over the 5.2- and 5.8-GHz bands. The extra band generated by the surface waves propagating on the AMC was also suitably utilized to produce an improvement of the 3-dB AR bandwidth at the lower band. The fabricated prototype with an overall 2.4-GHz frequency size of approximately 0.576 $\lambda_o \times 0.576\ \lambda_o \times 0.14\ \lambda_o$ has $|S_{11}|$ < –10 dB bandwidths of 2.21–2.62 GHz, 5.02–5.44 GHz, and 5.62–5.96 GHz and 3-dB AR bandwidths of 2.34–2.58 GHz, 5.14–5.38 GHz, and 5.72–5.88 GHz. Additionally, the antenna system has a unidirectional RHCP gain pattern, high radiation efficiency, and stable operation over all three operating bands.

Fig. 4 shows a fabricated sample of the dual-band crossed dipole on a dual-band AMC surface. The extra bands caused by the finite AMC surface were generated and consequently were utilized to improve the 3-dB AR bandwidths at both bands. The final design with an overall 2.4-GHz frequency size of $0.576\lambda_0 \times 0.576\lambda_o \times 0.088\lambda_o$ results in impedance bandwidths of 2.20–2.60 GHz and 4.90–5.50 GHz for $|S_{11}|$ < –10 dB, 3-dB AR bandwidths of 2.30–2.50 GHz and 5.05–5.35 GHz, as well as highly efficient unidirectional radiation patterns.

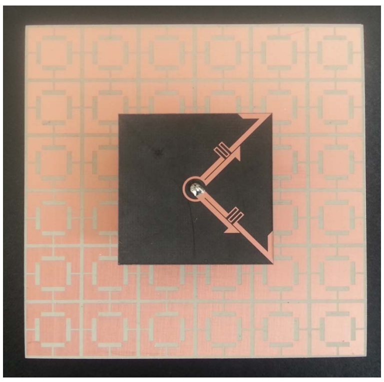

Fig. 4. Dual-band crossed dipole on a dual-band ACM structure.

III. CONCLUSION

Three kinds of crossed dipole antennas that use an AMC surface have been introduced and show 3-dB AR bandwidth improvement and profile miniaturization. The bandwidth improvement was obtained by utilizing the original bands of the radiators and the additional bands generated by the finite AMC reflector. All antennas exhibited good RHCP radiation with high front-to-back ratios and high radiation efficiencies. These features will allow the proposed antennas to be widely used in many different kinds of wireless communication systems such as GPS, WLAN, RFID, and WiMAX.

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