

A Coupled-mode Omni-directional Circularly Polarized Buried Antenna

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Buried antennas, especially omni-directional circular polarized antennas, have been widely utilized in various Internet of Things (IoT) applications such as agriculture, drainage management, and navigation. Since many of these applications use communication protocols in UHF bands, such as LoRa AS923 (920-925MHz) and NB-IoT B8 (885-960 MHz), a wideband antenna is essential to support multi-protocol operations. Therefore, developing a compact yet highly efficient omni-directional circularly polarized (CP) buried antenna is of great significance. This study introduces a novel coupled-mode omni-directional circularly polarized buried antenna (CPBA), which consists of a non-radiative metal patch loaded dielectric resonator (resonator 1) and a vertically coupled four-metal-ring loaded radiative metal patch resonator (resonator 2) within a top-opened metal cylindrical cavity.

A perspective view of the proposed antenna is depicted in Fig. 1(a), featuring an internal diameter of the cylinder cavity of 130 mm and a height of 38 mm. The antenna operates within the frequency band of 850-1030 MHz. Dielectric resonator 1 with $\epsilon_r = 19.6$ and $\tan\delta = 5 \times 10^{-6}$ operates with dual orthogonal TM_{01} modes. Adjacent to the top open-end, resonator 2 supports dual orthogonal radiative TM_{01} modes. Changing the vertical distance between the two resonators allows the coupling between their corresponding parallel TM_{01} modes to be adjusted, generating two orthogonal linear polarization radiating waves. This configuration enables the antenna to achieve wideband omni-directional circular polarization. The desired left-hand CP (LHCP) or right-hand CP (RHCP) can be attained by adjusting the phase difference of the two outputs of the branch-line coupler network feeding the dual TM_{01} modes of resonator 1. The feeding network shares the same ground as resonator 1. Using the dual TM_{01} modes of resonator 2 as the radiating modes enhances radiation efficiency, as the electric field of these modes aligns perpendicular to the cavity's periphery or the electric field of the buried antenna is perpendicular to the lossy soil near the interface.

A prototyped CPBA is electromagnetically designed and comprehensively measured within an emulated lossy soil environment in an anechoic chamber whose setup is illustrated in Fig. 1(b). Comparison between the simulated and measured metrics such as total gain, reflection coefficient, total efficiency, axial ratio (AR), and radiation patterns is presented in Figs. 1(c) and 1(d), showing excellent agreement. The impedance matching bandwidth of $|S_{11}| < -15$ dB and 3-dB AR reveal an overlap bandwidth of 19.6% within the designated frequency band. The CPBA achieves over 60% measured radiation efficiency, with an average gain exceeding 4.8 dBi. The omni-directional radiation patterns (LHCP) displayed in Fig. 1(d) demonstrate low back radiation due to the lossy soil, whereas the broadside radiation remains unaffected. This observation validates the suitability of the proposed CPBA for buried applications.

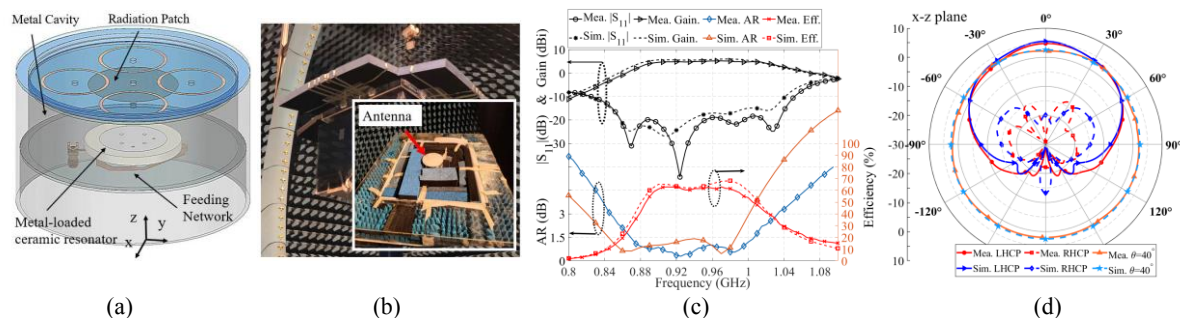


Figure 1. (a) The structure of the proposed CPBA; (b) measurement setup of emulated lossy soil environment in an anechoic chamber with a spherical near-field scanner; (c) simulated and measured metrics; (d) radiation patterns.