A Novel “Green” Inkjet-Printed Monopole Antenna Topology for Concurrent RFID and Cellular Communications

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Abstract

In this paper, a novel “green” inkjet-printed monopole antenna topology for integrated RFID-reader and cellular communication functionalities is presented. The antenna is loaded with a parasitic strip to fulfil the design requirements for the required dual-band operation. The design characteristics of the antenna are verified for paper-based substrates through extensive simulated parametric analysis and optimization.

Introduction

Nowadays, the mobile phone is the most widely used device for communication worldwide. On the other side, RFID technology importance for applications such as automotive/logistics tracking, biomedical sensing, item tracking, retail management and security is increasing dramatically [1]. In the future, the convergence of RFID and cell phones is inevitability and future developments following this trend are expected. Currently, the most widely adopted system worldwide for cellular phones is Global System of Mobile Communications (GSM) adopted primary in Europe and Asia. The cell phones within a few years are expected to incorporate RFID chips to enable Near-Field-Communication (NFC). The use of RFID readers on RFID–enabled cell phones will have a tremendous impact on the business proposition of mobile telephony enabling the users not only communicate via phone, but also access services and buy products simply by holding their own device close to an RFID tag.

Dual-mode, low-cost, conformal, lightweight antennas that can be easily fabricated in mass quantities are highly required for future RFID-enabled cell phones. In this paper, a novel monopole antenna topology comprising of a Z-shaped monopole antenna loaded with a parasitic strip is proposed. A Z-shaped antenna was presented in the past as a candidate RFID antenna [2] and parasitic elements are commonly used for the bandwidth enhancement of printed antennas. The proposed antenna will be fabricated on the lowest-cost, most environmentally-friendly material, paper using inkjet-printing technology, setting the foundation for the implementation of a truly “green” RF module [3]. The proposed antenna was designed and simulated using the 3D Simulator Ansoft HFSS.

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Antenna Design

A paper substrate (thickness 0.254mm, relative permittivity 3.4 and loss tangent 0.08) with overall dimensions 105mm (width) x 130mm (length), including the feeding line is used. The proposed antenna is fed by a CPW transmission line, because of its easy integrability on the paper substrate due to its planar and its single-metallization layer structure. The antenna topology is composed of a planar Z-shaped rectangular monopole and a folded parasitic strip, as illustrated in Fig. 1. The Z-shaped radiating element of the monopole antenna has width 50mm, length 56mm and a spacing of h=11mm from the ground plane. Two rectangular slots are embedded into the radiating element from both side edges with lengths of l_1=37mm and l_2=38mm, resulting in a meander-like antenna with a strip width of 12mm. The parasitic strip is chosen to have the same width of 12mm and a spacing i=6mm from the z-shaped antenna, which is half of the strip width. Finally, the parasitic element's functionality is further enhanced by two additional vertical folded strips, with a length of 36mm and off-symmetric horizontal spacing from the main Z-shaped antenna.

The proposed antenna must meet not only the requirements for RFID tags, but also the design goals for a mobile phone antenna: "global-operability" UHF [USA (902–928 MHz), Europe (865–868 MHz)] RFID band, GSM-900 and GSM-1800 operation, omnidirectional radiation pattern, impedance matching with RFID enabled mobile phone circuitry, long read range, and compact size, thus eventually leading to a tradeoff-based design [4]. Maximizing the size of the ground plane increases the directivity of the antenna, because the ground acts as a radiating element and also shields it from the rest electronic circuitry; however it increases the profile of the antenna. In order to ensure maximum power transfer, the lengths of the two slots are optimized so that the antenna has conjugate input impedance to the tag's load chosen to be ($37.3 + j65.96\Omega$) in our design, at the tag's operating frequency 904.5MHz. The use of the parasitic element is imperative to introduce a second resonance at the 1800MHz GSM frequency band. The parasitic strip's spacing from the main Z-shaped antenna and the slots of the Z-antenna were fine tuned to improve the antenna's radiation pattern.

Simulation Results

Fig. 2 shows the simulated frequency response of Return Loss of the proposed topology. It can be seen that there is a resonance at 905MHz with a –10dB impedance bandwidth of 126MHz (834–960MHz) and another resonance at 1843MHz with a –10dB impedance bandwidth of 79MHz (1809–1888MHz).

The radiation characteristics of the proposed antenna have also been investigated and are depicted in Fig. 3. The simulated radiation patterns for the x-z plane and y-z plane at the resonant frequency 905MHz are illustrated at Fig. 3. At the RFID-GSM band, the antenna produces omnidirectional, monopole-like radiation characteristics. Fig. 3 also shows the corresponding radiation patterns at

1843MHz. The radiation pattern on the x-z plane features some degradation, but it's almost omnidirectional. A non uniform radiation pattern is displayed on the y-z plane, because the main radiating element acts as the reflector for the half-wavelength parasitic strip at 1843MHz. This is created since the Z-shaped antenna has a non-uniform width due to its rectangular slots. However the omnidirectional radiation pattern on the x-z plane satisfies the requirements for cellular operation at the GSM-1800 band.

Conclusion

A novel "green" Z-shaped printed monopole antenna loaded with a parasitic element for concurrent RFID and cellular communications applications has been proposed. The antenna performance was simulated and optimized to achieve the required design requirements, enabling the realization of a "green", inkjet-printed RFID-enabled cellular antenna.

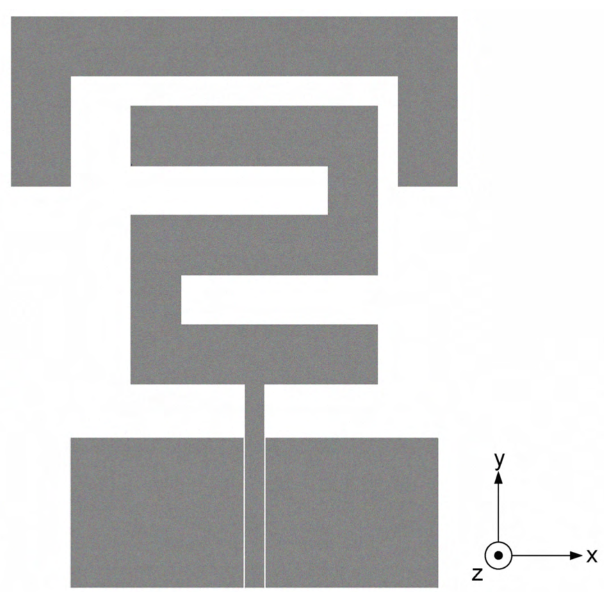

Fig. 1 Z-shaped printed monopole antenna with folded parasitic element geometry

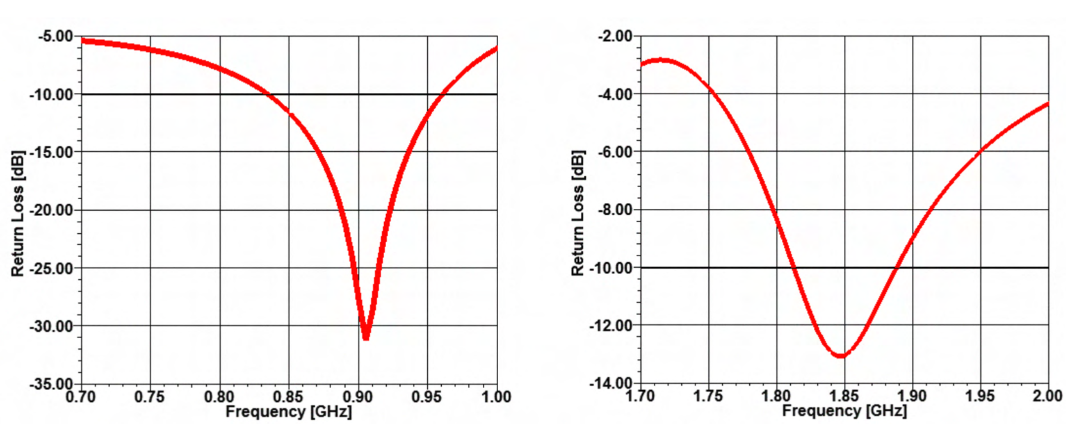

Fig. 2 Simulated Return Loss: (Left) RFID-GSM-900 band, (Right) GSM-1800 band

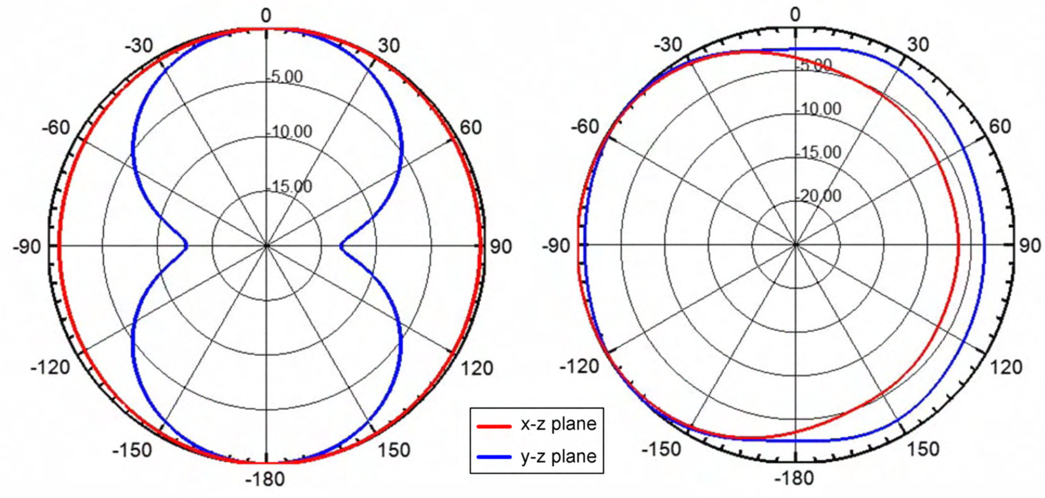

Fig. 3 Simulated radiation patterns of the proposed antenna topology for the x-z and y-z planes at the corresponding resonant frequencies: (Left) 905MHz, (Right) 1843MHz

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