# A Novel Green Multi-antenna Topology for Concurrent 4G Cellular and RFID-enabled Wireless Sensor Data Bundling

Zissis Konstas[1], Anya Traille[1], Konstantinos Katsibas[2], and Manos M. Tentzeris[1]

[1]*School of ECE, Georgia Institute of Technology*
*Atlanta, GA 30332, USA*
*{zkonstas@@.gmail.com, atraille@ece.gatech.edu}*
[2]*COSMOTE Mobile Telecommunications S.A.*
*95-97 Kifisias Ave., 15124, Athens, Greece*
*kkatsimpas@cosmote.gr*

***Abstract*— A novel "Z-shaped" antenna optimized for RFID 860-960MHz and 4G 2.3-2.4 GHz is presented. The antenna is printed on paper substrate, providing the advantages of being lightweight, conformal, flexible and environmentally friendly. The proposed approach could enable the efficient data bundling of RFID-enabled wireless sensors utilizing the high-data-speed of 4G technologies. It could provide the basis of one of the first "green" technology platforms that are highly required for the development of ubiquitous telemedicine and "Internet of things" applications.**

## I. Introduction

The mobile phone, initially used for basic voice communication and text messaging, has evolved to 4G with a significant increase in data speed and a capacity for real-time high quality multimedia support [1]. RFID technologies, on the other hand, has brought about the capability of identification, location, and real-time tracking of moving products, animals and persons within intermediate distant range. This could be very useful for a wide range of applications such as manufacturing, retail, animal tracking, inventory logistics, and security access control [2]. Integrating RFIDs into mobile phones would allow people, events and objects of the physical world to be automatically bi-directionally linked to the digital world of high speed/high capacity data transmission enabling the first true "Internet of Things" applications. It has to noted that the cell phone, functioning as a reader would be able to acquire mass amounts of information about the users surrounding environment such as advertisements, consumer products, personal items and location. The phone, functioning as an RFID tag would be able to access services such as mobile payments where the phone behaves as a credit card linked to a particular bank account. Realizing conformal and wearable antennas and coupling with 4G high-data-speed technologies could enable the use of the phone as a wireless RFID-enabled sensing platform with numerous applications in the health industry, bio-diagnostics and telemedicine by facilitating real-time communication between patients – especially senior and handicapped ones - and health professionals regarding health information, medications and appointments.

In order to facilitate the convergence of RFID with new 4G mobile phones, a novel dual-mode antenna operating in the RFID 860-960 MHz and 4G (LTE advanced 2.3-2.4 GHz) is presented in this paper. The proposed design features many cost/performance optimization features, including low cost, light weight, conformality and easy fabrication [3]-[5]. Environmentally friendliness [4] is also important for mass produced electronics, making "green" electronics necessary for mass-amount electronic commodities applications, such as cellular phones and wireless sensors.

## II. Antenna Design

The antenna geometry is illustrated in Figure 1. The paper substrate (thickness 0.254mm, $\varepsilon r$ = 3.4 and tan $\delta$ = 0.08) used to fabricate the proposed antenna has overall dimensions 85mm (width) x 110mm (length), including the feeding line. A CPW transmission line is selected to feed the antenna, because of its easy integration onto the paper substrate due to its planar and its single-metallization layer structure. The antenna configuration is composed of two strips, a long Z-shaped [6] and a shorter folded strip, in order to provide different current paths, so as to produce dual resonant modes. Both strips have a width of 10mm and are attached to the feeding line at a spacing of 8mm from the ground plane.

The Z-shaped strip has a total (corrugated) length of 140mm and introduces the resonant mode at the 0.9GHz frequency band. The folded strip is incorporated to the antenna to introduce a 2.4GHz frequency band resonance. Its length is 40mm which is close to $\lambda$/4 at this frequency band.

The proposed antenna should fulfill several requirements: "global-operability" in the UHF RFID band [USA (902–928 MHz), Europe (865–868 MHz)] and operation in the 4G frequency band (2.3-2.4 GHz), omnidirectional radiation pattern, impedance matching with RFID enabled circuitry, long read range, and compact size. 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 width and the lengths of both strips are optimized so that the antenna has conjugate input impedance to the tag's load chosen to be (37 + j65 Ω) in our design, at the tag's operating frequency 904.5MHz.

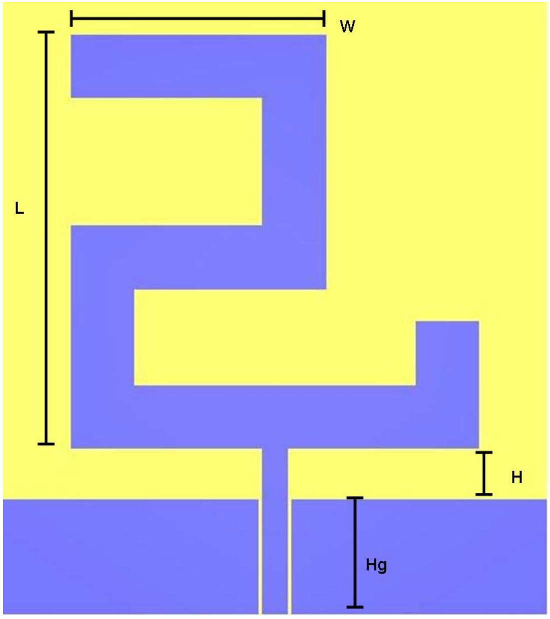


Fig. 1 Proposed antenna geometry.

## III. SIMULATION RESULTS

The performance of the proposed topology was simulated using Ansoft HFSS. The frequency response of the Return Loss is depicted in Figure 2. It is observed that the antenna is resonant at 906MHz with a –10dB impedance bandwidth of 100MHz (846–946MHz) and at 2322MHz with a –10dB impedance bandwidth of 484MHz (2114–2598MHz), thus satisfying the dual band requirements for RFID and 4G cellular operation, potentially allowing for the integration of the WiFi 2.4 GHz band.

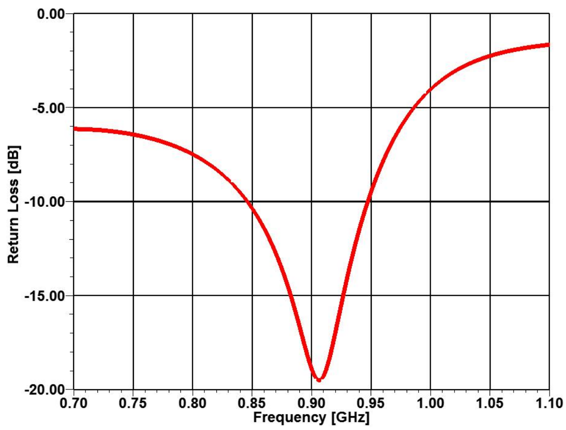


Fig. 2 Simulated Return loss for RFID-900MHz.

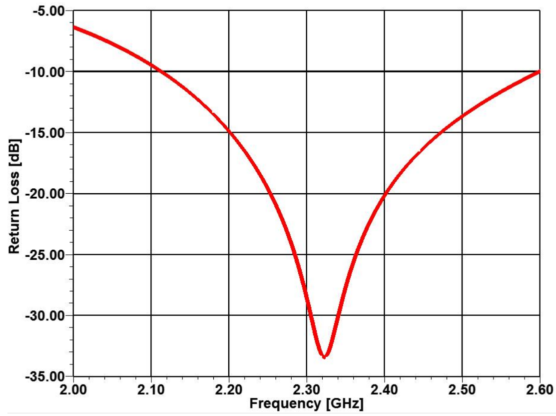


Fig. 3 Simulated Return loss for 4G-2.4GHz band.

The radiation characteristics of the proposed antenna have also been investigated. The simulated radiation patterns for the x-z plane and y-z plane at the resonant frequency of 906MHz are presented at Fig. 3. At the RFID band, the antenna features omni-directional, monopole-like radiation characteristics. Fig. 3 also displays the corresponding radiation patterns at 2322MHz (4G cellular operation). It is evident that the radiation pattern on the x-z plane is almost omnidirectional, while a non uniform radiation pattern is observed on the y-z plane. This results because the Z-shaped strip acts as a reflector for the folded strip at 2322MHz. In the conference, we will present numerous approaches to address this issue.

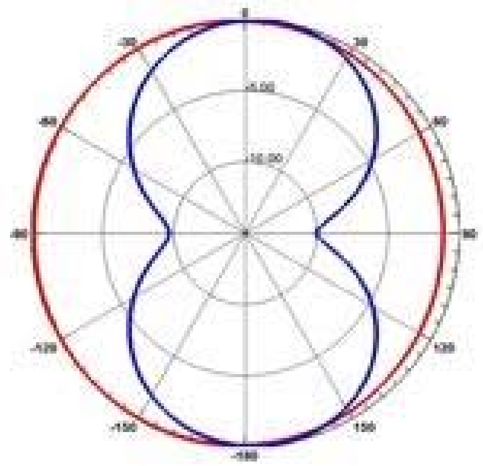

Fig. 4 Simulated radiation pattern for the X-Z and Y-Z planes at 906 MHz.

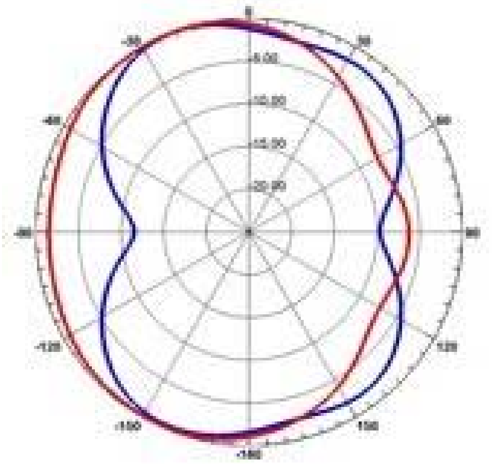


Fig. 5 Simulated radiation pattern for the X-Z and Y-Z planes at 2322 MHz.

## IV. Conclusions

A novel antenna for the efficient data bundling of RFID-enabled wireless sensors is presented for a dual-mode operation around the UHF RFID and the 4G frequency bands. This antenna is low-cost inkjet-printed on a paper substrate and features a "green" conformal characteristic, that could enable the first truly ubiquitous wireless telemedicine and "Internet of things" applications.


## Acknowledgment

The authors would like to acknowledge the support of Georgia Electronic Design Center, Interconnect Focus Center (IFC) SRC and National Science Foundation under contract ECS-0801798.


## References


[1] http://www.mobilein.com/what_is_4GCellular.htm

[2] K. Finkenzeller, RFID Handbook: Fundamentals and Applications in Contactless Smart Cards and Identification, 2nd edition, John Wiley and Sons: New York, 2003.

[3] L. Yang, A. Rida, R. Vyas and M. M. Tentzeris, "RFID Tag and RF Structures on Paper Substrates using Inkjet-Printing Technology," IEEE Transactions on Microwave Theory and Techniques, vol. 55, no. 12, part 2, pp. 2894-2901.

[4] A. Rida, L. Yang, R. Vyas and M. M. Tentzeris, "Conductive Inkjet-printed Antennas on Flexible, Low-Cost, Paper-Based Substrates for RFID and WSN Applications", IEEE Antennas and Propagation Magazine, Vol.51, No.3, pp.13-23, June 2009.

[5] K. V. S. Rao, P. V. Nikitin and S. Lam, "Antenna design for UHF RFID tags: A review and a practical application," IEEE Transactions on Antennas and Propagation, vol. 53, no. 12, pp. 3870-3876, Dec. 2005.

[6] Z. Konstas, A. Rida, R. Vyas, K. Katsibas, N. Uzunoglu and M. M. Tentzeris, "A Novel "Green" Inkjet-Printed Z-Shaped Monopole Antenna for RFID Applications," 3rd European Confefrence on Antennas and Propagation (EuCAP 2009), 23-27 March 2009, Berlin, GERMANY.