Wideband Antenna for 4G MIMO Applications

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ABSTRACT— A small, wideband, multiple-input-multiple-output (MIMO) antenna is presented for 4G Long Term Evolution (LTE) applications. The proposed antenna consists of a vertically polarized wideband stepped slot, as well as a horizontally polarized narrowband, uniform slot, integrated on a single substrate and fed by two ports. A prototype of the proposed antenna was designed, fabricated and measured. The stepped slot antenna achieves an enhanced bandwidth of 122% from 0.77 GHz to 3.12 GHz, covering the 2G, 3G and 4G bands. The narrowband slot achieves a bandwidth of 35% from 2.11 GHz to 3.01 GHz, covering the 4G band frequencies only. The isolation between the two slots is greater than 21 dB over the entire band of interest. The radiation pattern of the wideband slot in the horizontal plane is omnidirectional in nature while the narrowband slot exhibits a bi-directional radiation pattern in the horizontal plane. The proposed antenna is suitable for indoor, ceiling-mount, micro-cell 4G LTE applications.

Keywords: 4G, LTE, MIMO, wideband

1. INTRODUCTION

The fourth generation (4G) of mobile technology has faster data rates than the preceding third generation (3G) technology. Data rates of 100 Mb/s can be expected for high mobility users whilst low mobility users will experience data rates up to 1 Gb/s [1]. It is speculated that approximately 70% of the demand for high speed data services originates from indoor environments [2]. Although the latest 4G technology has been released, 2G and 3G technology is still widely in use and the availability of a single wideband antenna suitable for all the frequency bands; 2G, 3G and 4G (with multiple-input multiple-output (MIMO) capabilities in the 4G band) would be highly advantageous.

A number of antennas for 4G applications are available. These antennas comply with the requirements for the 4G frequency band with MIMO capabilities but are not operational in the 2G and 3G frequencies bands [3], [4]. Wideband antennas which achieve the bandwidth requirements (2G, 3G and 4G) are not suitable for 4G applications due to their lack of MIMO capabilities [5], [6]. Wideband MIMO antennas [2] suitable for 2G, 3G and 4G applications tend to be large with complex manufacturing processes and some exhibit non-ideal radiation patterns [7].

In this paper a compact indoor ceiling mount antenna covering the 2G, 3G and 4G bands, with MIMO capability for the 4G band is presented. The design entails a simple and low cost fabrication procedure. The proposed antenna will find application in indoor, ceiling-mounted micro-cells. The novelty of the design presented is seen in the wideband operation of the antenna, with MIMO capabilities in the 4G band, in conjunction with its advantageous radiation patterns for indoor application and simple manufacturing process.

2. ANTENNA GEOMETRY AND DESIGN

The geometry of the proposed antenna is shown in Fig. 1. The antenna comprises of a wideband stepped slot, and a narrow band uniform slot. The wideband slot is functional over a wide band covering the 2G, 3G and 4G bands while the second slot covers only the 4G band. The wideband slot is vertically polarized whilst the narrowband slot is horizontally polarized. The opposing polarizations ensure maximum isolation between the two slots.

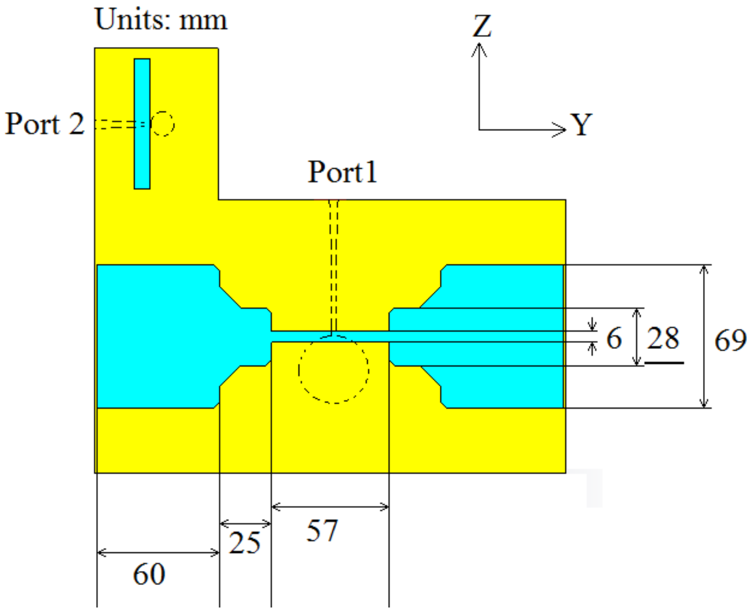

Fig. 1. Schematic of optimized antenna geometry.

A) Wideband Antenna

In order to achieve a sufficiently wide bandwidth, a stepped slot antenna was implemented. As can be seen from Fig. 1, a total of three steps were introduced into the wideband slot. Each step is responsible for introducing a resonance in its corresponding band, viz. 790MHz to 960MHz; 1700MHz to 2200MHz and 2300MHz to 2 700MHz. These steps drastically improve the impedance bandwidth of the design. The introduction of a 45 degree chamfer between selected steps improved the radiation patterns of the design whilst maintaining a good reflection coefficient over the entire band. A circular stub microstrip-to-slotline transition was implemented to feed the slot.

B) Narrowband Antenna

The second slot antenna was designed to be operational from 2.3GHz to 2.7GHz such that it would be functional for 4G MIMO applications. The slot is approximately half a wavelength at the centre frequency of the band. A circular stub microstrip-to-slotline transition was implemented as feed for the uniform slot.

3. EXPERIMENTAL VALIDATION

A prototype antenna was measured in a compact range as illustrated in Fig. 2. The simulated and measured reflection coefficients of slot 1 and slot 2 are presented in Fig. 3. A strong correlation between simulated and measured results is observed. The reflection coefficient remains below -10dB from 0.77 GHz to 3.12 GHz for the wideband slot and 2.11 GHz to 3.01 GHz for the narrow band slot. An isolation of 21 dB or more was maintained from 0.5 GHz to 4 GHz between the two ports.

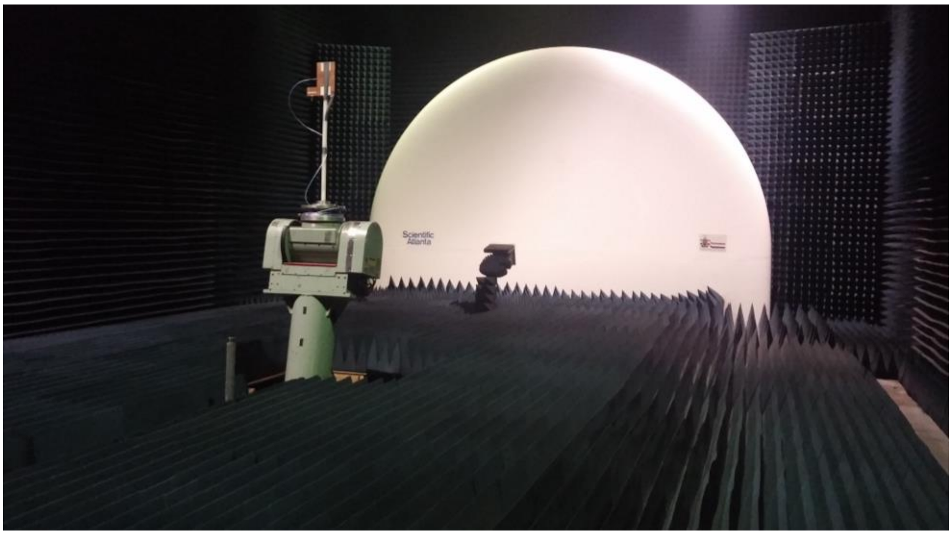

Fig. 2. Antenna measured in compact range.

The simulated and measured radiation patterns in the horizontal (XY-plane) at 900 MHz, 2 GHz and 2.5 GHz are shown for the wideband slot in Fig. 4, Fig. 5 and Fig. 6, respectively. The radiation pattern of the narrow band slot at 2.5 GHz in the horizontal plane is presented in Fig. 7. Once again a strong correlation between simulated and measured data exists. The patterns of the wideband antenna all appear to be omnidirectional in nature while the narrow band antenna displays patterns which are bi-directional.

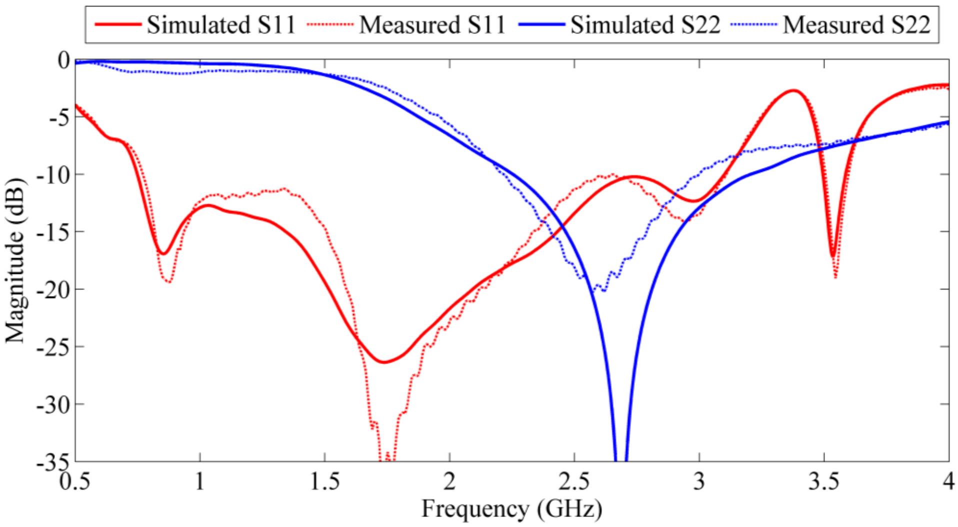

Fig. 3. Measured and simulated reflection coefficients for the wideband slot (S11) and the narrowband slot (S22)

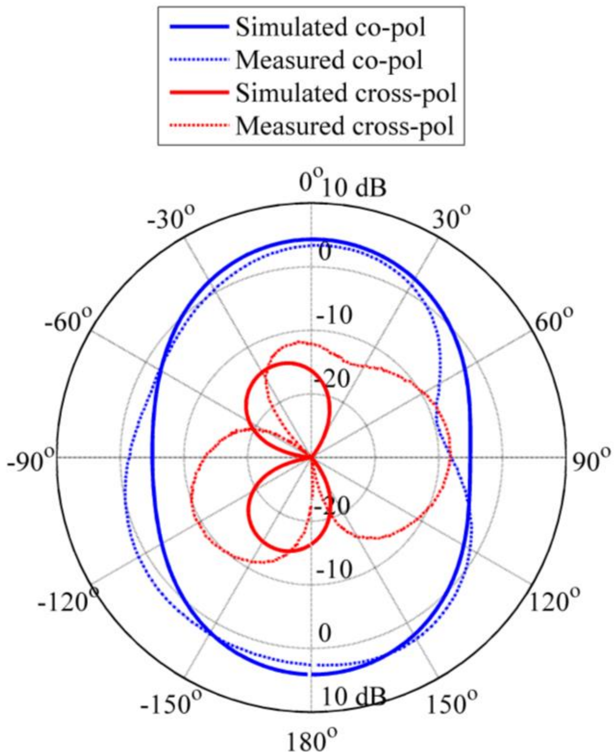

Fig. 4. Wideband slot radiation pattern in the horizontal plane at 0.9 GHz.

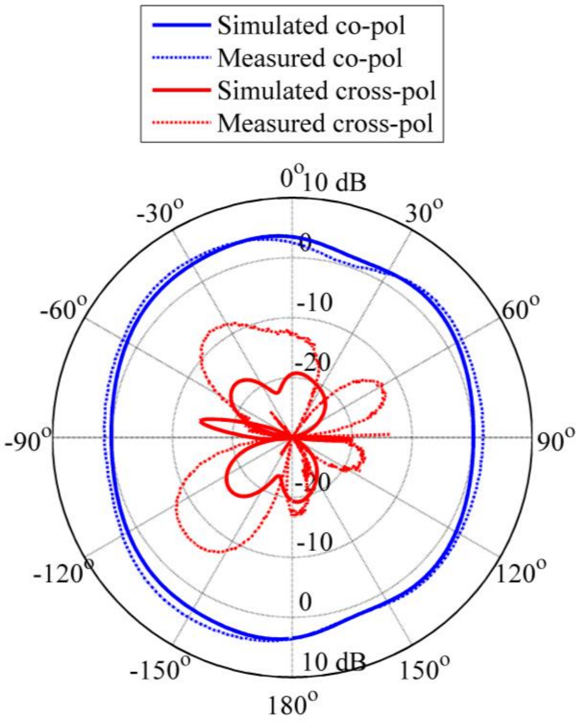

Fig. 5. Wideband slot radiation pattern in the horizontal plane 2.0 GHz.

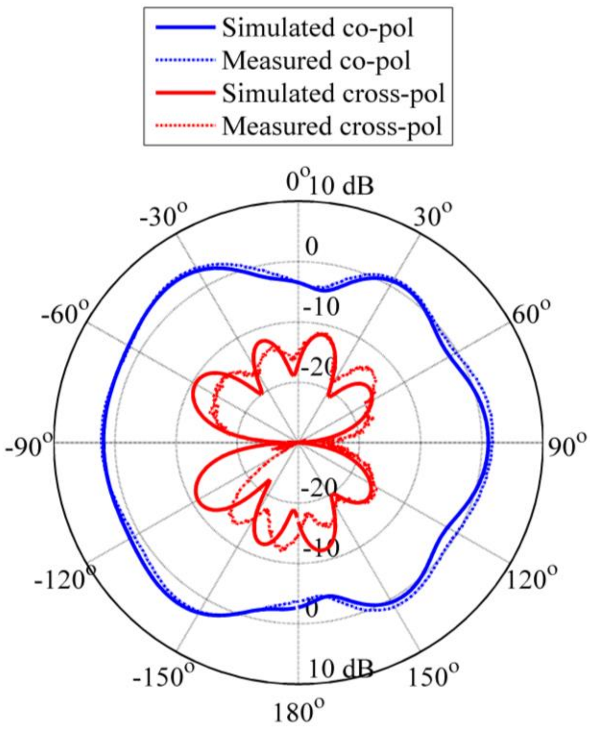

Fig. 6. Wideband slot radiation pattern in the horizontal plane at 2.5 GHz.

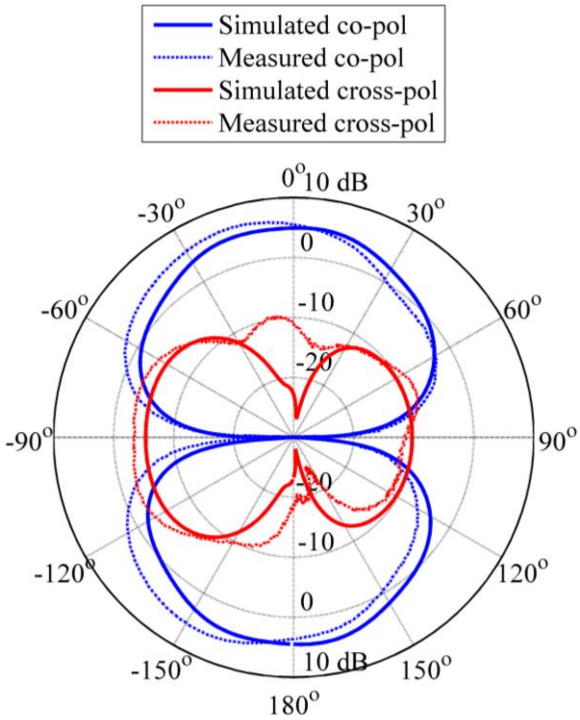

Fig. 7. Narrowband slot radiation pattern in the horizontal plane at 2.5 GHz.

The gain of the wideband slot and the narrowband slot are illustrated in Fig. 8 and Fig. 9, respectively. The maximum gain was measured in the horizontal plane. The wideband slot exhibits an average gain of 3.7 dBi over the operational band whilst the narrowband exhibits an average gain of 5.1 dBi over its operational band. The wideband slot exhibits a theoretical radiation efficiency of 81.5% or better from 0.75 GHz to 3 GHz. The uniform slot exhibits a theoretical radiation efficiency of 91.6% or better from 2.11 GHz to 3 GHz.

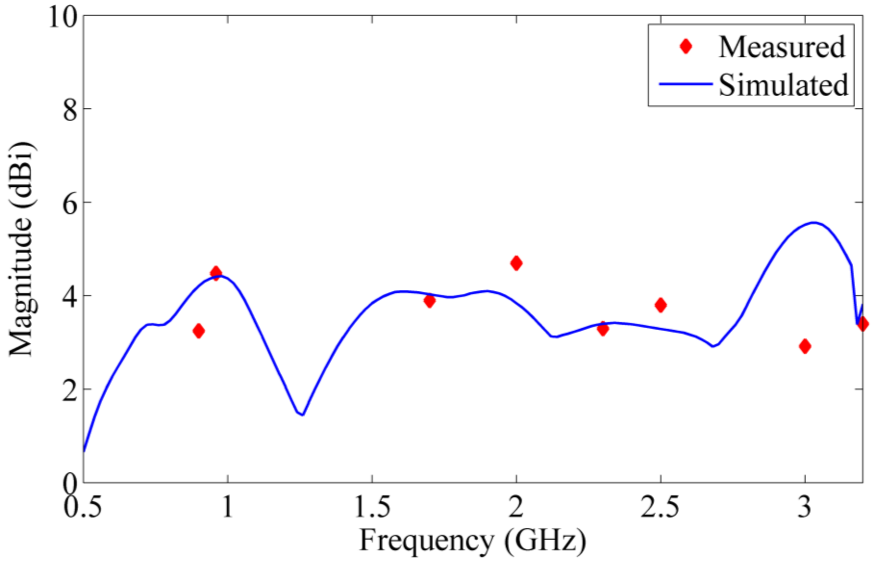

Fig. 8. Measured and simulated gain of the wideband slot.

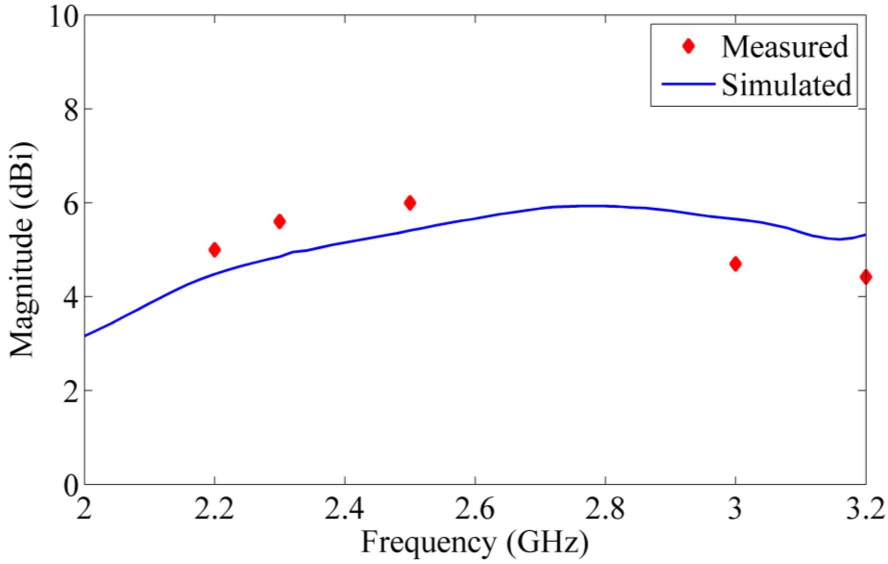

Fig. 9. Measured and simulated gain of the narrowband slot.

4. CONCLUSION

A novel wideband, vertically polarized antenna with MIMO capabilities has been presented for indoor, ceiling-mounted applications. It covers the GSM 900 and GSM 1800 bands of 2G, the UMTS 900 and

UMTS 1800 bands of 3G and the LTE 2600 band of 4G. Measured and simulated results show good correlation. The antenna meets the wideband and MIMO requirements whilst maintaining a relatively simple fabrication process.

An enhanced bandwidth of 121%, from 0.77 GHz to 3.12 GHz, is achieved by means of implementing a stepped slot antenna configuration with chamfered corners. The stepped slot is fed by a microstrip-to-slotline transition. A second slot radiator, also fed by a microstrip-to-slotline transition, with an operational bandwidth of 35% from 2.11 GHz to 3.01 GHz allows for the antenna to be MIMO in the 4G band. The wideband slot antenna is vertically polarized and has a relatively omnidirectional radiation pattern in the horizontal plane. The second slot antenna is horizontally polarized and has a bi-directional pattern in the horizontal plane. Measured and simulated results show good correlation.

REFERENCES

1. Y.Y. Yu, F. Jolani, and Z. Chen, A wideband omnidirectional horizontally polarized antenna for 4G LTE applications, IEEE Antennas and Wireless Propag Lett 12 (2013), 686-689.
2. L. Sun, W. Huang. B. Sin. Q. Sun, and J. Fan, Two-port pattern diversity antenna for 3G and 4G MIMO indoor applications, IEEE Antennas Wireless Propag Lett 13 (2014), 1573-1576.
3. F. Ahmed, Y. Feng, and R. Li, Dual wide-band four-unit MIMO antenna system for 4G/LTE and WLAN mobile phone applications, In : Loughborough Antennas and Propag Conf, Loughborough, UK, 2013, pp. 202-207.
4. A.N. Kulkami and, S.K. Sharma, A Compact Multiband Antenna with MIMO Implementation for USB Size 4G LTE Wireless Devices, In: IEEE International Symp on Antennas and Propag, Spokane, USA, 2011, pp. 2215-2218.

5. L. Zhou, Y.-C. Jiao, Y. Qi, Z. Weng, and T. Ni, Wideband ceiling mount omnidirectional antenna for indoor distributed antenna system applications, Electron. Lett 50 (2014), 253-255.

6. N.I.M. Elamin, T.A. Rahman, and A.Y. Abdulrahman, New Adjustable Slot Meander Patch Antenna for 4G Handheld Devices, IEEE Antennas and Wireless Propag Lett 12 (2013), 1077-1080.

7. E. Yetisir, C.-C. Chen, and J. L. Volakis, “Low-profile UWB 2-port antenna with high isolation, IEEE Antennas and Wireless Propag Let 13 (2009), 55-58.