

2015-04-27

A Dual Band LTE PIFA Antenna for M2M Applications

Abraham Loutridis

Technological University Dublin

Matthias John

Trinity College Dublin, matthias.john@tudublin.ie

Max Ammann

Technological University Dublin, max.ammann@tudublin.ie

Follow this and additional works at: <https://arrow.tudublin.ie/ahfrcart>



Part of the [Systems and Communications Commons](#)

Recommended Citation

A. Loutridis, M. John, & M. J. Ammann, A Dual Band LTE PIFA Antenna for M2M Applications, *Microwave and Optical Technology Letters*, vol. 57, issue 7, pp. 1655-1658, 07/2015 DOI:10.1002/mop.29185

This Article is brought to you for free and open access by the Antenna & High Frequency Research Centre at ARROW@TU Dublin. It has been accepted for inclusion in Articles by an authorized administrator of ARROW@TU Dublin. For more information, please contact arrow.admin@tudublin.ie, aisling.coyne@tudublin.ie, vera.kilshaw@tudublin.ie.

Funder: SFI

A DUAL BAND LTE PIFA ANTENNA FOR M2M APPLICATIONS

Abraham Loutridis^{1,2}, Matthias John², Max J. Ammann^{1,2}

¹ Antenna & High Frequency Research Centre,
Dublin Institute of Technology, Dublin 8, Ireland

²The Telecommunications Research Centre (CTVR)
Trinity College Dublin, Dublin 2, Ireland
abraham.loutridis@mydit.ie

ABSTRACT: A dual Planar Inverted-F-Antenna for M2M application is proposed. The antenna covers the lower LTE band (690-960 MHz) and partially the upper LTE band (1670-2067 MHz). The antenna is low cost with omnidirectional radiation characteristics. The measured total efficiency and gain are better than 58% and 0.8 dBi across the operational frequency range. A parametric study of key geometrical parameters is made.

Key words: PIFA; LTE; M2M applications.

1. Introduction

LTE (Long Term Evolution) is a radio technology for wireless data communications and an evolution of the pre-existing GSM/UMTS standards. The LTE standard was introduced to deliver greater data rates and better quality of service [1]. The variety of new M2M applications takes advantage of LTE's higher bandwidth and low latency [2]. Low profile and broadband antennas covering the LTE frequency range such as PIFAs [3-8] and monopoles [9-11] are reported as solutions for these applications. PIFA structures offer low profile omnidirectional radiation characteristics and high efficiencies addressing the requirements for M2M applications.

In this paper a dual Planar Inverted-F-Antenna for M2M applications which operates over the lower LTE band (690-960 MHz) and some of the upper band (1670-2067 MHz) is presented. The antenna provides good omnidirectionality, high efficiency and gain across the operational frequency range.

2. Antenna Design

The antenna structure and coordinate system is depicted in Figure 1. The radiating element is located on a FR-4 rectangular ground plane with dimensions 130mm x 70mm x 1.5mm and copper thickness =0.035mm. The sides of the prototyped antenna are printed on thin FR-4 layers of thickness 0.2mm ($\epsilon_r=4.3$, $\tan\delta=0.025$) with dimensions 70mm ($\approx 0.15\lambda_0$) x 19mm ($\approx 0.041\lambda_0$). The antenna can also be realized using stamped metal.

The antenna comprises two PIFAs sharing the same feed. The geometry is shown in Figure 2 with $w=11$ mm ($\approx 0.024\lambda_0$) and a small gap (0.2 mm) separating the 2

PIFAs. The shorting strip of each PIFA has a width of 0.2 mm. The antenna is fed via a 50 Ω SMA connector through the ground plane to a 5.1 mm wide feeding strip, forked at the top with a small gap (0.2 mm) to separate the 2 feeds. The antenna was modeled in CST Microwave Studio.

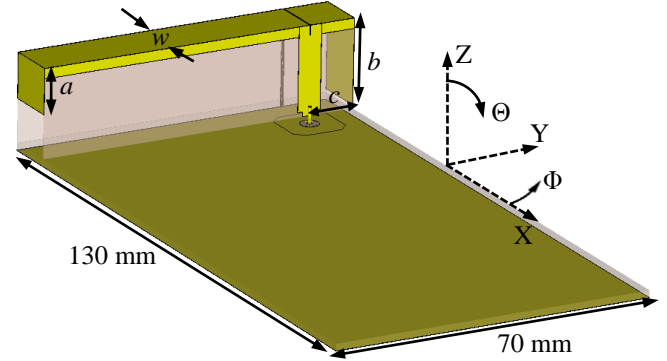


Figure 1 CST simulation model and the coordinate system.

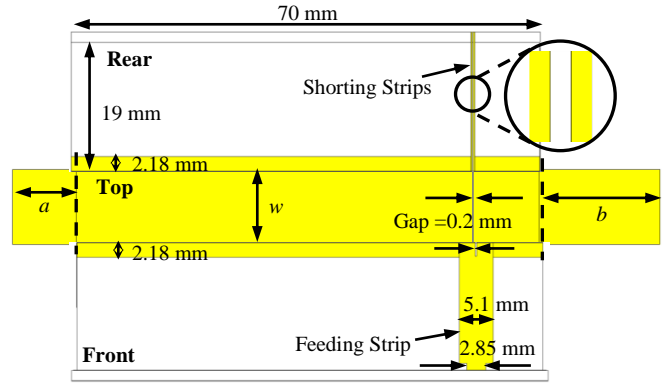


Figure 2 Antenna geometry and parameters.

3. Parameter Study

An investigation of four key geometrical parameters is made. In Figure 3 the S_{11} for various values of length (a) is shown. It is apparent that the matching and first resonant frequency is heavily dependent on this parameter as well as some effects on the second resonance. The proposed value of this parameter (a) is 9.7mm.

Figure 4 shows the effects of a variation in the folded length (b). From the obtained S_{11} results it is clear that the second resonant frequency can be controlled (impedance matching and frequency shifting) by varying the parameter b . The proposed value of the folded length (b) is 18.3 mm.

In Figure 5 the S_{11} is shown for a variation of the position of the feed and the shorting point, (c). It is clear from the plot that both resonances are strongly controlled by this parameter. As the feeding and the shorting point control the electrical length of the two PIFAs, it effects both bands. The proposed value of the parameter (c) is 9.97mm.

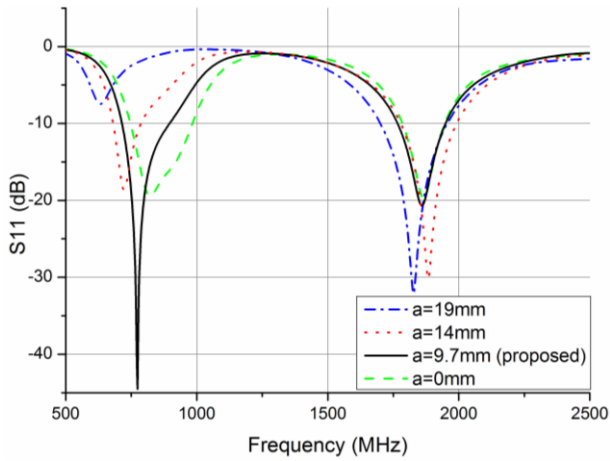


Figure 3 Simulated S_{11} variations for different values of a .

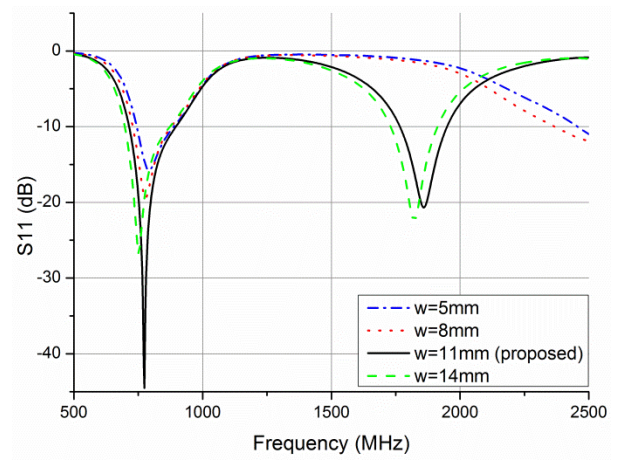


Figure 6 Simulated S_{11} variations for different values of w .

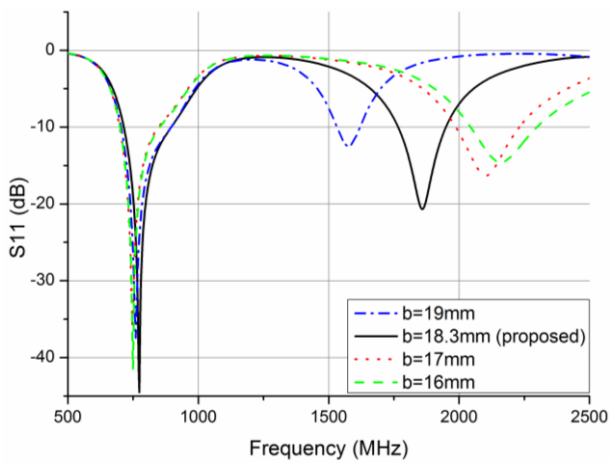


Figure 4 Simulated S_{11} variations for different values of b .

Finally in Figure 6 the variation of the width (w) of the top part of the two PIFAs is illustrated. Here the second resonance shows heavy dependence on this parameter. The proposed value of (w) is 11mm.

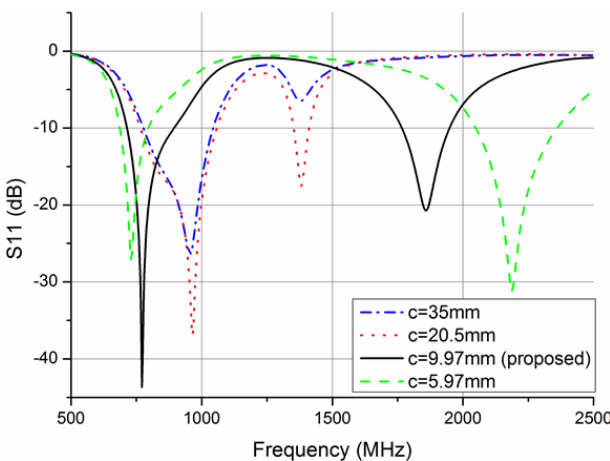


Figure 5 Simulated S_{11} variations for different values of c .

4. Results

In Figure 7 the measured and simulated S_{11} show good agreement. The antenna operates at 760 MHz with a -10 dB and -6dB impedance bandwidth of 208MHz (682-890 MHz) and 306 MHz (658-964 MHz) respectively for the lower band and at 1860 MHz with a -10 dB and -6 dB impedance bandwidth of 220 MHz (1750-1970 MHz) and 396 MHz (1671-2067 MHz) respectively for the upper band. The simulated results provide a -10 dB and -6 dB impedance bandwidth of 162 MHz (711-873 MHz) and 281 MHz (680-961 MHz) at the centre frequency of 765 MHz for the first band and a -10 dB and -6 dB impedance bandwidth of 192 MHz (1797-1989 MHz) and 341 MHz (1725-2066 MHz) at the centre frequency of 1893 MHz for the second band.

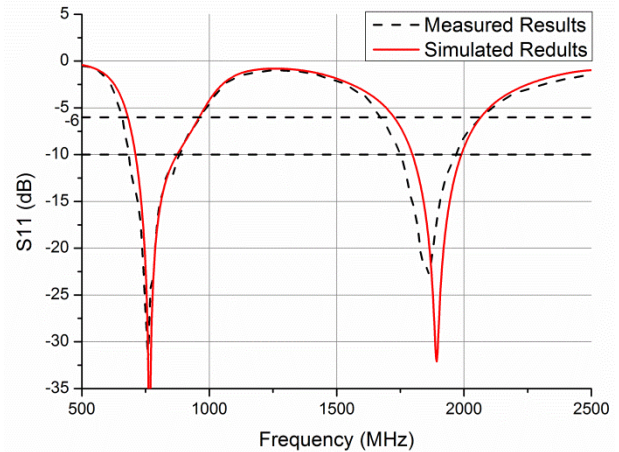


Figure 7 The measured and the simulated S_{11} .

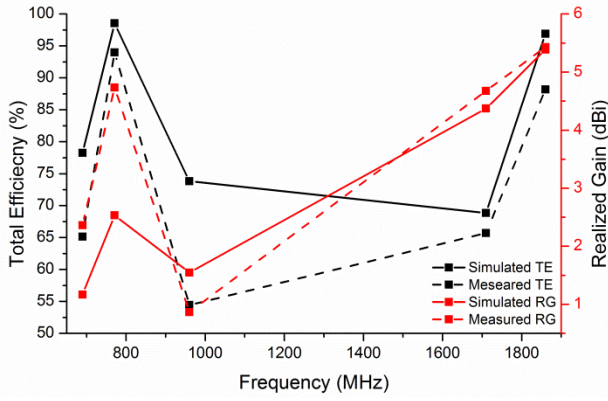


Figure 8 Measured and simulated total efficiency and realized gain.

In Figure 8 the measured and the simulated total efficiency and realized gain results are given. There is a reasonable agreement between the simulated and measured results. The total efficiency and the realized gain of the antenna were measured in Microwave Vision StarLab 18GHz and listed in Table I.

TABLE I. MEASURED AND SIMULATED TOTAL EFFICIENCY AND REALIZED GAIN.

Frequency (MHz)	Total Eff. (%)		Realized Gain (dBi)	
	Sim.	Meas.	Sim.	Meas.
690	78.2	64.8	1.2	1.9
760	98.5	83.6	2.5	3.6
960	73.8	58	1.5	0.8
1710	68.8	65.2	4.4	3.5
1860	96.9	79.8	5.4	4.1

The radiation patterns of the three planes (XY, XZ, and ZY) for 760 MHz and 1860 MHz are shown in Figures 9 to 14. All the measured patterns are illustrated against the simulated patterns in 10dB/division scaled plots.

It is observed that the Theta (θ) component provides good omnidirectional characteristics in the XY-plane for both frequencies, which is also observed in the ZY-plane for 760 MHz for the Phi (ϕ) component.

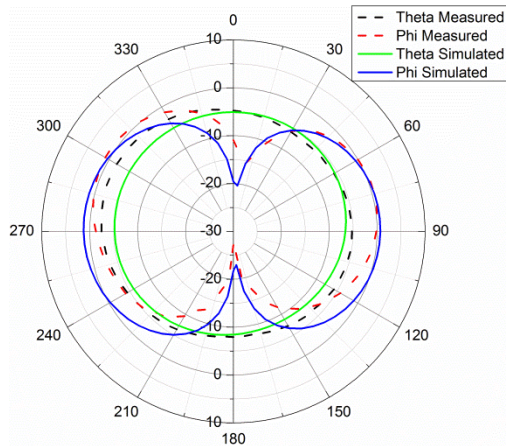


Figure 9 Measured and simulated XY-plane patterns at 760 MHz.

Moreover at 760 MHz in the ZY-plane good discrimination between the Phi (ϕ) and the Theta (θ) component is provided. There is a reasonable agreement between the measured and the simulated results.

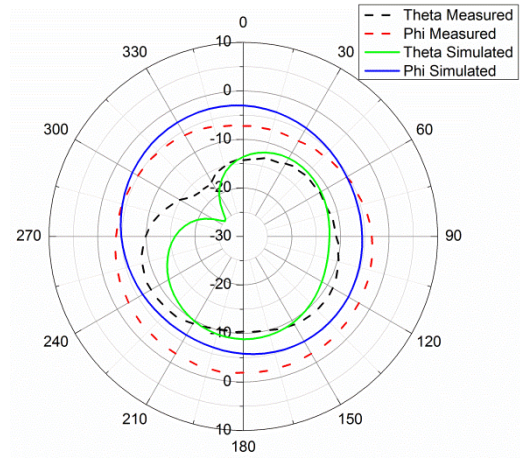


Figure 10 Measured and simulated ZY-plane patterns at 760 MHz.

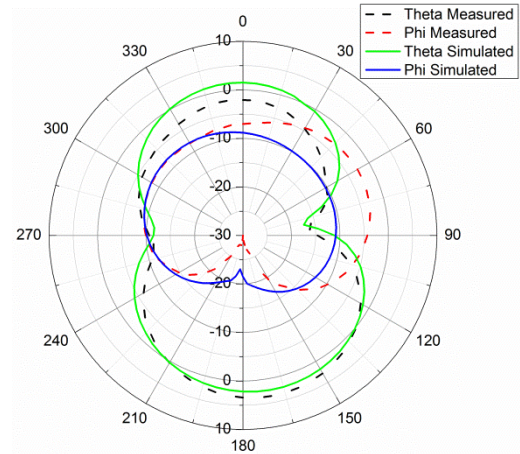


Figure 11 Measured and simulated XZ-plane patterns at 760 MHz.

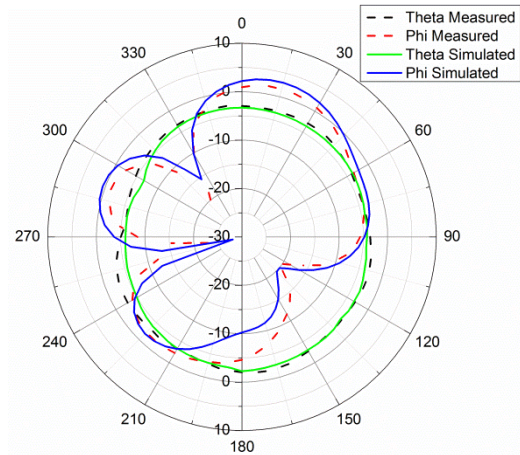


Figure 12 Measured and simulated XY-plane patterns at 1860 MHz.

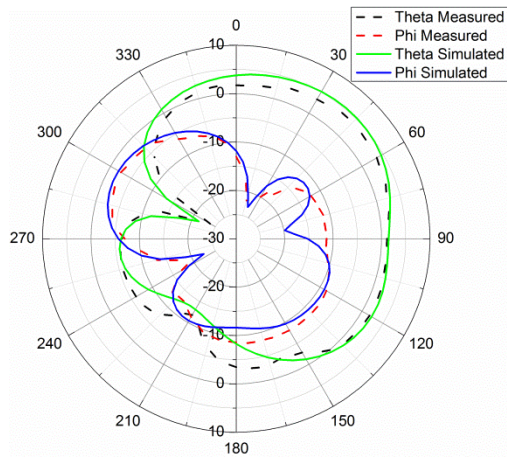


Figure 13 Measured and simulated ZY-plane patterns at 1860 MHz.

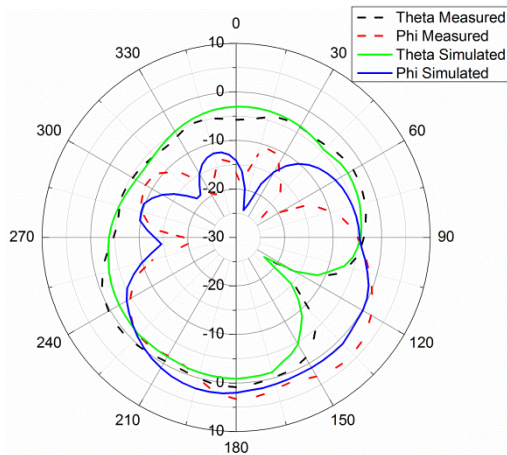


Figure 14 Measured and simulated XZ-plane patterns at 1860 MHz.

5. Conclusion

In this work, a dual Planar Inverted-F-Antenna for M2M applications is described. The antenna has a dual band operation covering the lower LTE band and partially the upper LTE band. The antenna offers good omnidirectional radiation characteristics, high efficiency and gain across the whole operation frequency range. The antenna is low cost and low profile.

6. Acknowledgements

This material is based upon works supported by the Science Foundation Ireland under Grant No. 10/CE/I1853. The authors would like to thank Microwave Vision SA-MVG for the use of their StarLab 18GHz.

References

[1] 3GPP Technical paper : UTRA-UTRAN Long Term Evolution (LTE) and 3GPP System Architecture Evolution (SAE), ftp://ftp.3gpp.org/Inbox/2008_web_files/LTA_Paper.pdf

[2] T. Potsch , S.N. Khan Marwat, Y. Zaki , C. Gorg, "Influence of Future M2M Communication on the LTE System", 6th Joint IFIP Wireless and Mobile Networking Conference (WMNC), 2013, pp. 1-4

[3] A. Loutridis, M. John, and M. J. Ammann, "Dual Band LTE Planar Inverted-F Antenna for M2M Applications", *Microwave and Optical Technology Letters*, vol. 55, issue 12, pp. 2925–2929, 12/2013.

[4] D. Kearney, M. John, and M. J. Ammann, "Miniature Ceramic PIFA for UWB Band Group 3 & 6", *IEEE Antennas and Wireless Propagation Letters*, vol. 9, pp. 28-31, 01/2010.

[5] Z. Li, Y. Rahmat-Samii, and T. Kaiponen, "Bandwidth study of a dual band PIFA on a fixed substrate for wireless communication," in *Proc. IEEE Antennas Propag. Soc. Int. Symp.*, 2003, vol. 1, pp. 435–438.

[6] D. M. Nashaat and H. A. Elsadek, "Single feed compact quad-band PIFA antenna for wireless communication applications," *IEEE Trans. Antennas Propag.*, vol. 53, no. 8, pp. 2631–2635, Aug. 2005.

[7] Li-Jun Ying, Yong-Ling Ban and Jin-Hua Chen, "Low-Profile Coupled-Fed Printed PIFA for Internal Seven-Band LTE/GSM/UMTS Mobile Phone Antenna", *IEEE Cross Strait Quad-Regional Radio Science and Wireless Technology Conference (CSQRWC)*, vol. 1, pp.418-421, 26-30 July 2011.

[8] Wei-Yu Li, Chun-Yih Wu, Kin-Lu Wong and Ming-Fang Tu, "Internal Small-Size PIFA for LTE/GSM/UMTS Operation in the Mobile Phone", *IEEE Antennas and Propagation Society International Symposium (APSURSI)*, pp. 1-4, 11-17 July 2010.

[9] G. Ruvio, and M. J. Ammann, "From L-shaped Planar Monopoles to a Novel Folded Antenna with Wide Bandwidth", *IEE Proceedings. Microwaves, Antennas & Propagation*, vol. 153, no. 5, pp. 456-460, 10/2006.

[10] G. Ruvio, and M. J. Ammann, "A Compact Wide-Band Shorted Folded Antenna", *IEEE International Workshop on Antenna Technology: Small Antennas and Novel Metamaterials*, White Plains, NY, USA, pp. 84-87, 06/03/2006.

[11] M. John, and M. J. Ammann, "Optimum Design of the Printed Strip Monopole", *IEEE Antennas & Propagation Magazine*, vol. 47, no 6, pp. 59-61, 12/2005.