# A DUAL BAND LTE PIFA ANTENNA FOR M2M APPLICATIONS

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**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 omni-directional 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 omni-directional 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 omni-directionality, 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 ($\varepsilon_r$=4.3, tanδ=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*=11mm ($\approx 0.024\lambda_0$) 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.

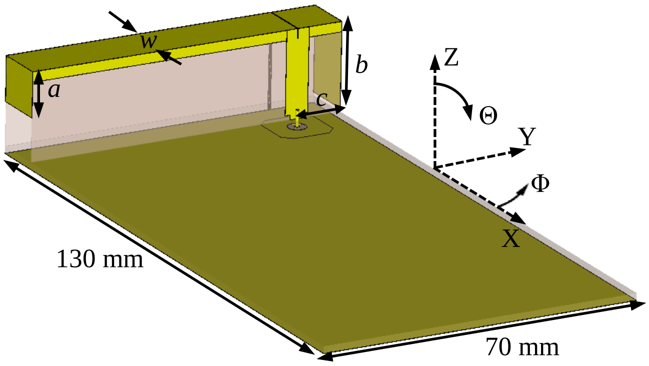


**Figure 1** CST simulation model and the coordinate system.

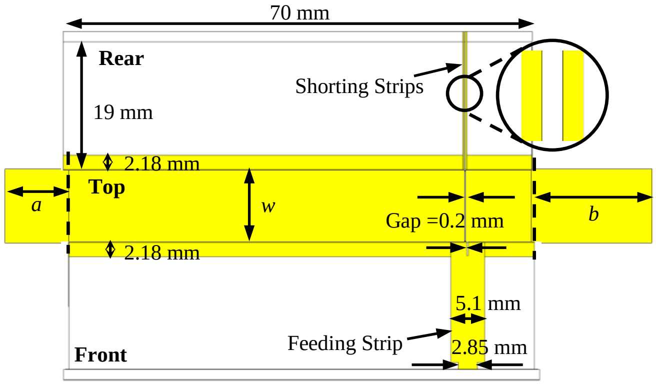


**Figure 2** Antenna geometry and parameters.

## 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.

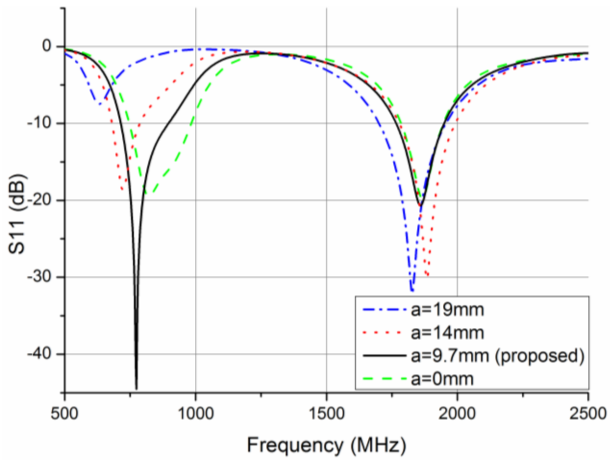


**Figure 3** Simulated $S_{11}$ variations for different values of *a*.

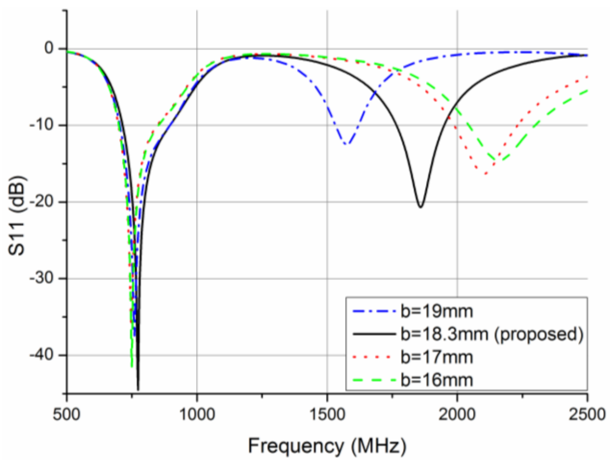


**Figure 4** Simulated $S_{11}$ variations for different values of *b*.

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.

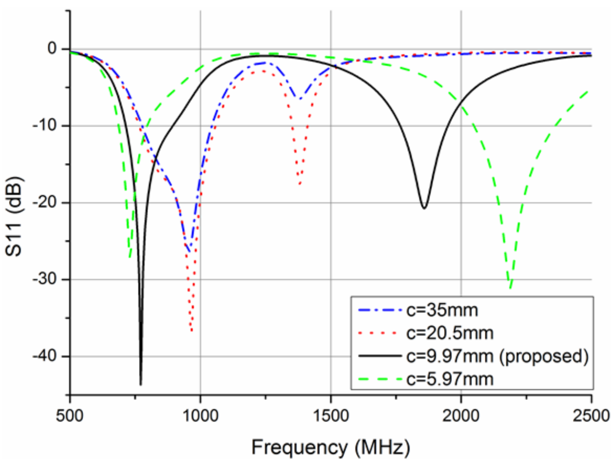


**Figure 5** Simulated $S_{11}$ variations for different values of *c*.

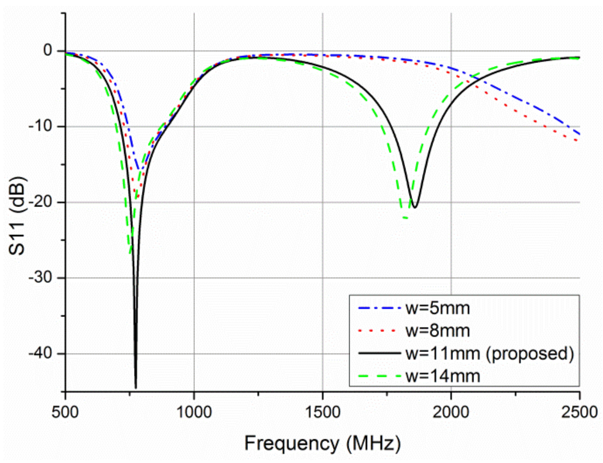


**Figure 6** Simulated $S_{11}$ variations for different values of *w*.

# 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.

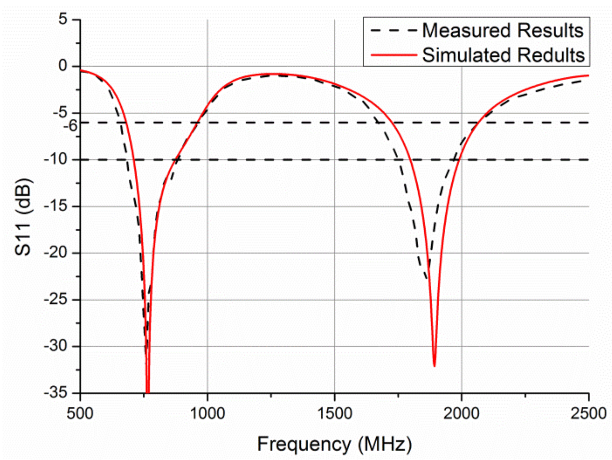


**Figure 7** The measured and the simulated $S_{11}$.

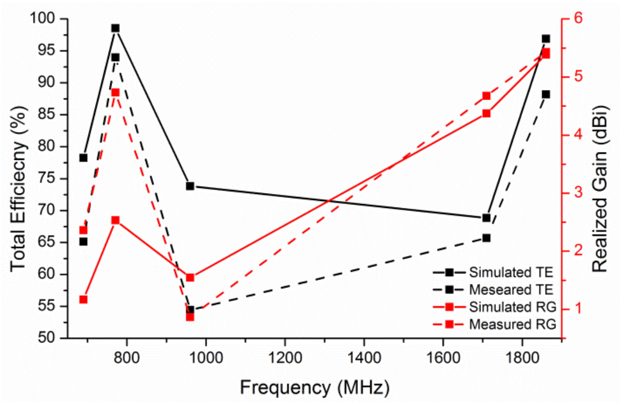


**Figure 8** **M**easured and simulated total efficiency and realized gain.

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 ($\theta$) 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 ($\varphi$) component.

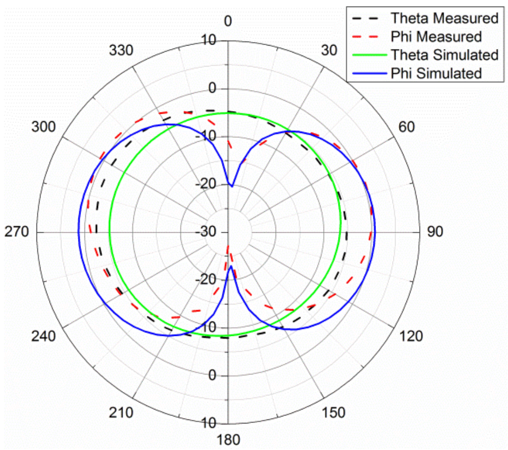


**Figure 9** Measured and simulated *XY*-plane patterns at 760 MHz.

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

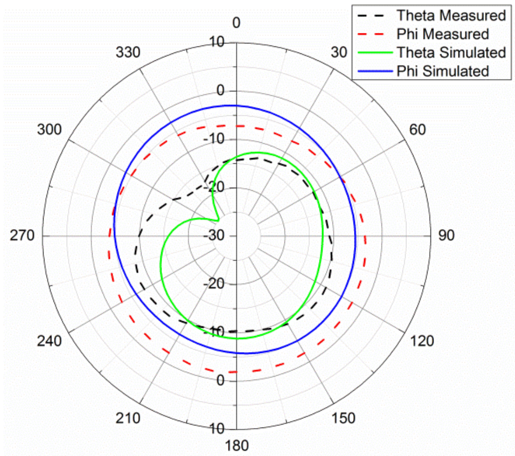


**Figure 10** Measured and simulated *ZY*-plane patterns at 760 MHz.

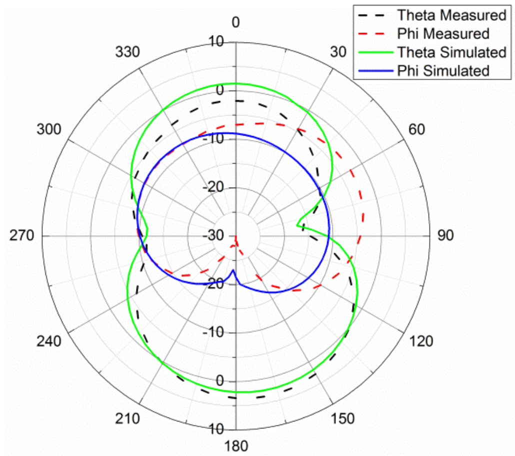


**Figure 11** Measured and simulated *XZ*-plane patterns at 760 MHz.

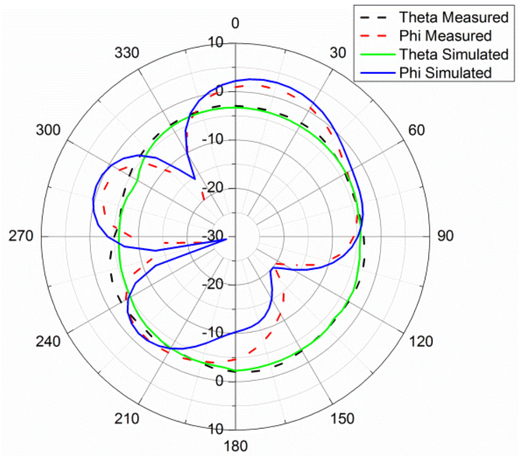


**Figure 12** Measured and simulated *XY*-plane patterns at 1860 MHz.

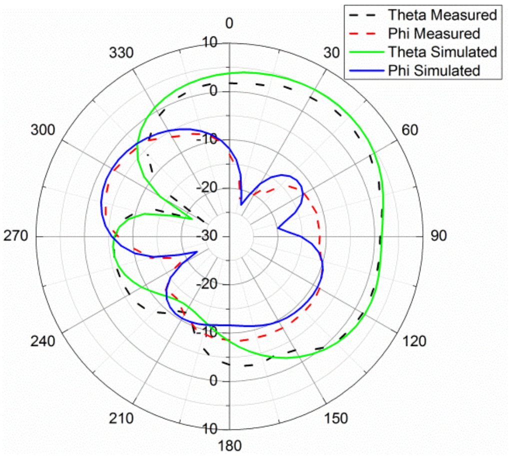


**Figure 13** Measured and simulated *ZY*-plane patterns at 1860 MHz.

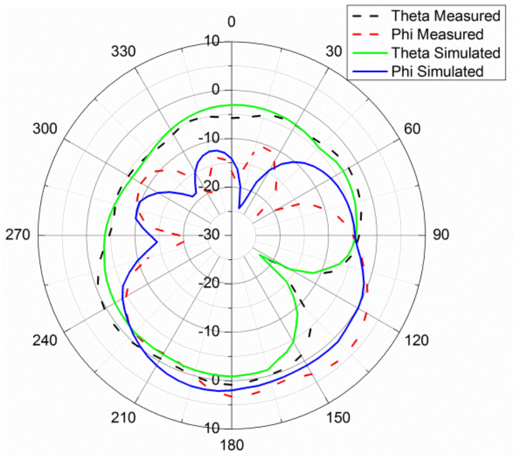


**Figure 14** Measured and simulated *XZ*-plane patterns at 1860 MHz.

## 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 omni-directional radiation characteristics, high efficiency and gain across the whole operation frequency range. The antenna is low cost and low profile.


## 6. Acknowledgements

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