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Performance Analysis of Dual-Arm Printed Monopole Antenna for LTE1800/2600

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Abstract—**Dual-arm printed monopole antenna covering 1.8GHz and 2.6GHz bands for LTE applications is presented. The antenna consists of two parallel monopoles fed by a microstrip line. The ground plane is of length 40 mm and width 50 mm. The 50Ω microstrip feed line and the dual-arm monopole are printed on a dielectric substrate at the opposite side of the ground plane. The dielectric substrate is made of FR4 material which has dielectric constant of ε_r = 4.5 and thickness of 0.8mm. The proposed antenna provides a good return loss, omni-directional radiation patterns, and good directivity. The proposed antenna is simulated using the 3-D electromagnetic solver of CST®.**

Index Terms: **multiband printed monopole antenna, LTE 1800MHz, LTE 2600MHz, wireless communications.**

I. INTRODUCTION

Nowadays multiband and wideband antennas are more popular than multiple antennas having different resonant frequencies due to huge demand and rapid advances in wireless communication systems in the last decade [1]. On the other hand, the rapid evolution has also come forward as an advancement in hand held mobile devices [2]. LTE technology is much used at the present time that it is covers 3.5G and 4G Generations. LTE is quickly becoming the de facto standard for the next generation of mobile data services. With fast data rates, low latency, and good coverage, all data exchange occurs with very less power consumption[3 - 4].

Good antenna design is critical for successful LTE operation, In high-performance applications where performance, size, and weight are constraints, the printed monopole has many advantages such as small size, lightweight, ease of fabrication, low cost, conformable to planar and non-planar surfaces, mechanically robust, broad bandwidth, multi frequency mode, and easy integration with other systems[5 - 6]. Hence, it is the most suitable antenna used in wireless communication systems [7 - 9].

Printed monopole antennas are very attractive and suitable for dual-band or multi-band applications owing to their simple structures, compact size, good impedance matching, and omni-directional radiation patterns [10 - 11]. Multi-band monopole antennas can be realized by employing parasitic structures, slots, or slits in the antenna configuration or using various radiating elements with different shapes. Configuration of the presented design consists of a modified F-shaped radiation patch, a rectangular microstrip feed-line, and a ground plane [10]. However, the size reduction will decrease the radiation efficiency of the antenna especially when its size is very small compared to the free space wavelength at its lowest resonant frequency. Conventional high permittivity substrates can be employed to reduce the size of the monopole antenna [11][12].

The proposed two-arm printed monopole antenna designed to operate in the LTE 1.8GHz and 2.6GHz bands. The configuration of the presented design consists of two parallel conducting strips, a microstrip feed-line, and a ground plane. It is printed on a low-cost FR-4 dielectric substrate. The FR4 dielectric combines good electrical features, price, and availability. Compared with other materials, FR4 material is sufficiently cheap and available in the market and has been widely used in antenna designing for frequencies less than 6 GHz, Other materials from Rogers or Taconic can be also used. Such materials are expected to provide higher efficiency and more compact size since they have lower dielectric losses and higher dielectric constants. [10][14][15]. The frequency response of the antenna can be controlled by adjusting the lengths and widths of the arms of the monopole [14]. The proposed antenna is designed using the transmission line model and simulated using the 3-D solver of CST®. The proposed two-arm printed monopole has a good radiation efficiency, omni-directional radiation patterns, and good return loss.

II. ANTENNA DESIGN

The proposed two-arm printed monopole antenna is shown in Figure 1. It consists of two parallel monopoles whose lengths are λ/4 at 1.8 and 2.6 GHz. Thus, the parallel arms act as parallel monopole antennas. The width of the printed monopole is W_m =2 mm and it is chosen to provide a good impedance matching. The feeding microstrip has a characteristic impedance of 50Ω and therefore its width is W_f =1.5 mm. The ground plane

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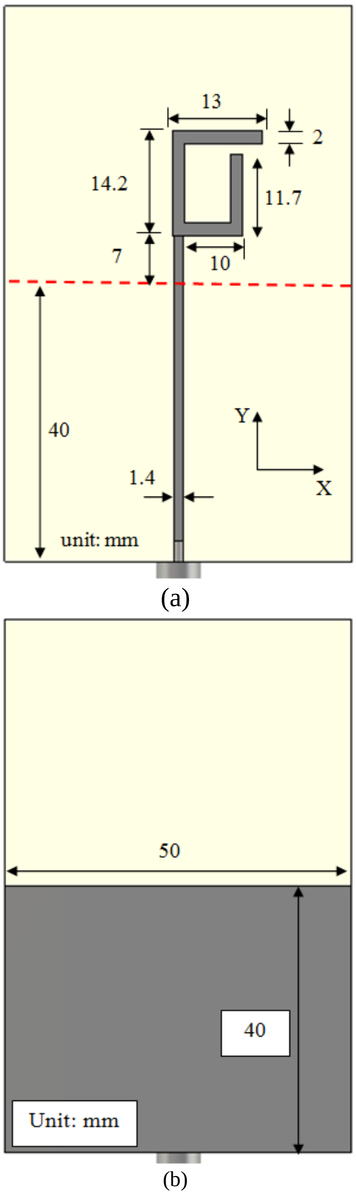
is of length 40 mm and width 50 mm. The 50Ω microstrip feed line and the dual-arm monopole are printed on a dielectric substrate at the opposite side of the ground plane. The dielectric substrate is made of FR4 material which has dielectric constant of ε_r = 4.5. The size of the dielectric substrate is 80x50 mm, and thickness is 0.8 mm. The design specifications of the dual-arm printed monopole are summarized in Table 1

Table 1:.The specifications of the dual-arm monopole

Operating frequency	1.8 GHz, 2.6 GHz
Dielectric substrate	FR4 substrate: ε_r = 4.5, h = 0.8 mm
Feeding technique	Microstrip line
Matching technique	Changing the monopoles dimensions
Return loss	< -10 dB
Radiation Pattern	Omni-directional
Bandwidth	>5%



(a)

(b)

Figure 4.1. The proposed dual-arm monopole antenna: (a) top view; (b) bottom view.

It consists of a rectangular patch fed by a microstrip line. The patch is printed on FR4 dielectric substrate with thickness (*h)* of 1.6mm and dielectric constant ε_r =4.5. The length of the patch (*L*) is approximately quarter wavelength at the operating frequency of 1.8 GHz as given by:

$$L = \frac{\lambda}{4} = \frac{C}{2f_0\sqrt{\varepsilon_r}} \qquad (1)$$

Where *C*=3X10^8 is the speed of light, f_0 =1.8 GHz is the resonant frequency, and λ is the guided wavelength. The length *L* is calculated using (1) and found to be *L* = 39.28mm.

Given the dimensions of the microstrip line, the characteristic impedance can be calculated from (2)

$$Z_0 = \begin{cases} \frac{60}{Z_0} ln\left(\frac{8d}{W} + \frac{W}{4d}\right) & for\ \frac{W}{d} \le 1 \\ \frac{120\pi}{\sqrt{\varepsilon_e}\left(\frac{W}{d} + 1.393 + 0.667\ln\left(\frac{W}{d} + 1.444\right)\right)} & for\ \frac{W}{d} > 1 \end{cases} \qquad (2)$$

Where W is the width of the microstrip line and d is the height of the dielectric substrate. ε_e is the effective dielectric constant of the dielectric substrate and it is given by:

$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\frac{1}{\sqrt{1 + 12d/W}} \qquad (3)$$

ε_r is the dielectric constant (permittivity) of the substrate and it is equal to 4.5 for the FR4 material.

III. SIMULATION RESULTS AND DISCUSSION

The simulated reflection coefficient of the proposed antenna is shown in Figure 2. Two resonances are observed at 1.8GHz and 2.6 GHz covering the LTE bands as desirable. The magnitude of the return loss is well below -10 dB within these frequency bands. Thus, the antenna provides a good impedance matching and very little power is lost due to reflections. The bandwidth is 6% and 8% in the 1.8GHz and 2.6GHz bands respectively.

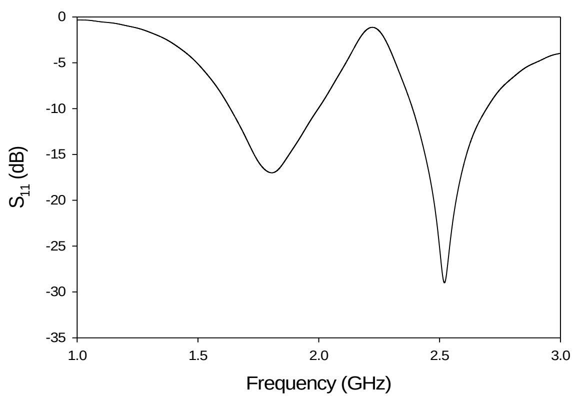
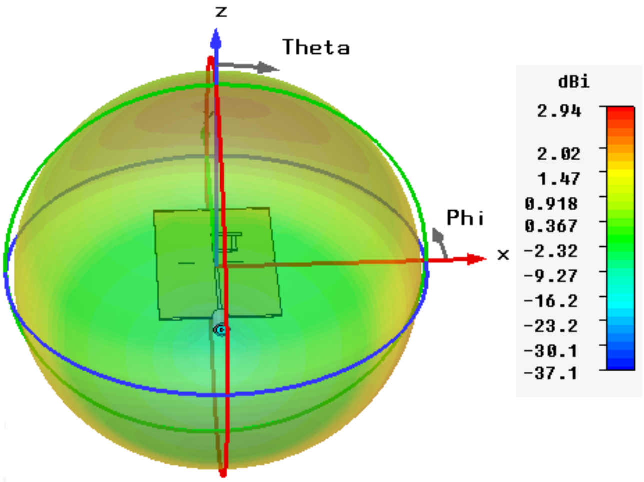


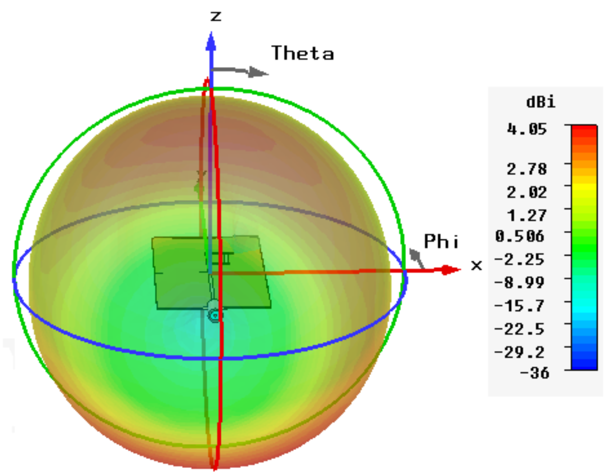
Figure 2: The simulated return loss of the dual-arm monopole

The 3-D simulated radiation pattern of the dual-arm monopole shown in Figure 3. The 3-D pattern at 1.8 and 2.6 GHz are shown in Figures 3a and 3b respectively.

The radiation patterns are Omni-directional with uniform coverage in the XZ plane. The directivity is 3.2 dB and 3.1 dB at 1.8 and 2.6GHz respectively. The total efficiency is about 90%.



(a)

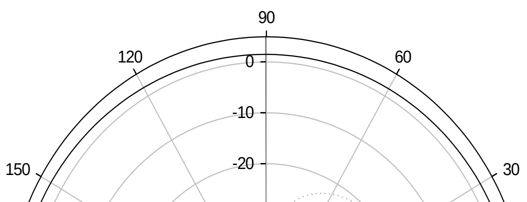


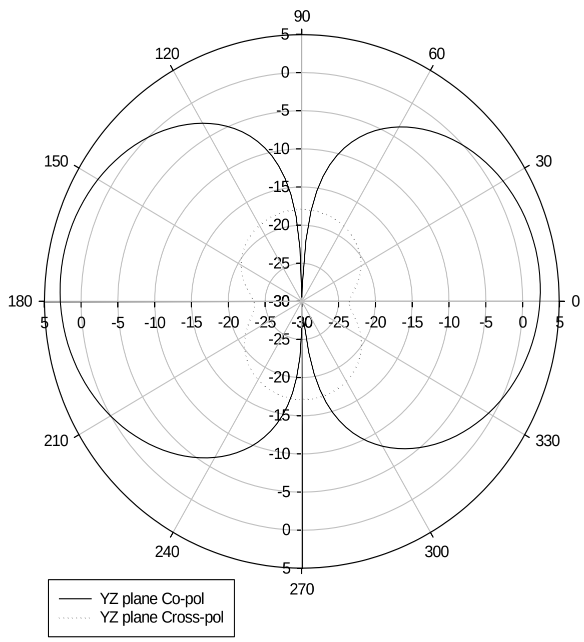
(b)

Figure 3: 3-D radiation pattern of the dual-arm monopole (a) 1.8GHz (b) 2.6GHz

The polar plot of the radiation pattern at 1.8GHz is shown in Figures 4. Figure 4a and 4b show the radiation pattern in the XZ and YZ planes respectively. The radiation pattern is uniform (constant) in the XZ plane. There is a null along the Y axis. The cross polarization levels are below -20 dB.

From the simulated results it is shown that the two-arm monopole provides a satisfactory performance within LTE 1800 and 2600 bands. The return loss is below -10 dB and the operating bandwidth are wide enough. Furthermore, the antenna provides a well-shaped and stable radiation pattern. The pattern is omni-directional with uniform coverage in one plane as desirable.





(b)

Figure 4: The polar plot of the radiation pattern of the dual-arm monopole at 1.8GHz (a) XZ plane; (b) YZ plane.

IV. CONCLUSION

A design of dual-band antenna covering 1.8/2.6 GHz has been presented for LTE bands. The proposed provide good impedance matching, good radiation patterns and good directivity. The return loss is below -10 dB and the operating bandwidth are wide enough. The directivity is 3 dB and 4 dB at 1.8 and 2.6 GHz respectively. The total efficiency is about 90%. The radiation patterns are Omni-directional with uniform coverage in the XZ plane.

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