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Design a Compact Monopole Printed Antenna for UMTS,LTE and WLAN Applications

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Abstract- In this paper, a new compact design of the printed monopole antenna has been presented. The single layered antenna has been designed to resonate in wideband frequency for UMTS, LTE and WLAN with enhanced bandwidth of more than 1.25GHz.The antenna has a simple structure consisting of a T- shaped and parasitic element in the ground plane. The proposed antenna has a low profile and can easily be fed by using a 50 Ω microstrip line.It is believed that the size of the antenna is about the smallest among the existing internal mobile antennas for UMTS, LTE and WLAN operation. Compact size, low cost, ease of printed and good radiation parameters respect to the previous designs are the most important advantages of the proposed antenna. The antenna has an overall dimension is 67*50*1.6 mm^3, when printed on a FR-4 substrate of dielectric constant 4.3.The proposed antenna was designed based on the simulations from Computer Simulation Technology (CST), through which the return loss and other antenna parameters were generated such as gain, VSWR and radiation pattern.

Keywords: Monopole Antenna, Wideband Antenna, UMTS, LTE, WLAN.

Introduction

Microstrip antenna structure contains of a dielectric substrate having ground plane on one side and patch geometry on the other [1].Recently, wireless communication has been developed, and many digital communication products have been taken into our life, and many wireless communication services are integrated into a communication product. A desired antenna for modern wireless communications is needed to cover many bands, such as UMTS band (1920 -2170MHz), and WLAN band (2400 - 2484MHz).Many techniques such as fractal-shapes [2, 3], reactive loads [4], stacked elements [5, 6], shorting pins [7], slots on the ground plane [8] are being used to design multiband , wideband monopole antenna. Monopole antennas have been used in numerous civilian and government applications despite of their advantages and disadvantages.Monopole antennas include Wireless Personal Area Network (WPAN) and good performance in antenna technology and low cost[9]. Recently, many modern techniques are used to bandwidth enhancement such as parasitic element, multilayer substrate, …etc.Planar antennas have been developed very fast, because of its advantages such as Omni-directional radiation patterns, low cost, light weight, easy to printed and small size.

The LTE (Long Term Evolution) project was initiated in 2004. The incentive for LTE included the desire for a reduction in the cost per bit, the addition of lower cost services with better user experience, the flexible use of new and existing frequency bands, a simplified and lower cost network with open interfaces, and a reduction in terminal complexity with an allowance for reasonable power consumption[10]. These high level goals led to further expectations for LTE, including reduced latency for packets, and spectral efficiency improvements above release 6 high speed packet access (HSPA) of three to four times in the downlink and two to three times in the uplink[10].

In this paper, a T- shaped antenna with wideband characteristic from 1.425 GHz to 2.704 GHz is proposed with over all dimensions 67* 50 mm^2 and height of 1.6 mm. A parametric study on the structure is made in-order to obtain the best possible size, and bandwidth. Simulation results based on a commercially available Finite Integration package, CST, on the return loss, and E, H plane radiation pattern are provided and discussed.The antenna geometry has been optimized to cover requisite bandwidth for UMTS (1920 -2170MHz), LTE (2300-2400 MHz) and WLAN (2400-2484 MHz). Moreover, discussions on the impedance bandwidth, and realized gain have also been given in the literature.

ANTENNA DESIGN AND STRUCTURE

Figure 1 shows the design of proposed antenna.The antenna has a slot structure, printed on the FR-4 substrate with a thickness of 1.6 mm, dielectric constant of 4.3. The proposed antenna is designed and simulated using CST. The dimensions of the substrate are 67 × 50 × 1.6 mm^3. The optimized dimensions of the proposed antenna are as follows: (q=67, m= 50, k= 4, i=40, j=4, g=45, a= 52, b= 5, c= 10, f= 5, e=5,d=10), (all dimensions are in mm) .As we known, the side length of the patch affects the center frequency of the antenna, using empirical formula on the transmission line model approximation in which microstrip radiating element is watched as a transmission line resonator with no transverse field variations. The calculation states that the length and width of the patch antenna can be modeled agreeing to the specified central frequency by using the following equations[11].

$$w = \frac{v_o}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \quad \ldots(1)$$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1+12\frac{h}{w}\right)^{-\frac{1}{2}} \quad \ldots(2)$$

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{w}{h}+0.8)} \quad \ldots(3)$$

$$L = \frac{1}{2f_r\sqrt{\varepsilon_{reff}}\sqrt{\mu_o\epsilon_o}} - 2\Delta L \quad \ldots(3)$$

Where W is the width of the patch, f_r is target center frequency, v_o is the speed of light in a vacuum,$\varepsilon_r$is the dielectric constant of the substrate,ε_{reff} is theeffective dielectric constant,h is the thickness of the substrate, ΔLis the extension in the patch length due to fringing field, and L is the length of the patch.

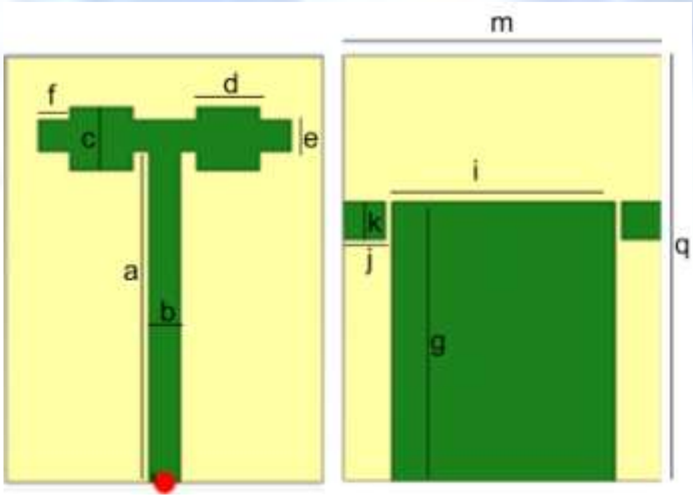

Figure 1: The structure of the proposed antenna.

RESULTS AND DISCUSSION

Analysis has been performed on the basis of results generated by CST (Computer Simulation Technology) and plotted using MATLAB R2008A. Parametric study for different parameters of the antenna has been performed to find the most optimum values. The simulated return loss of the antenna is shown in Figure 2. It is observed that, the calculated return loss curve for antenna is less than –10 dB. The impedance bandwidth of the simulated return loss is 1.25 GHz (1.4527GHz - 2.704GHz).

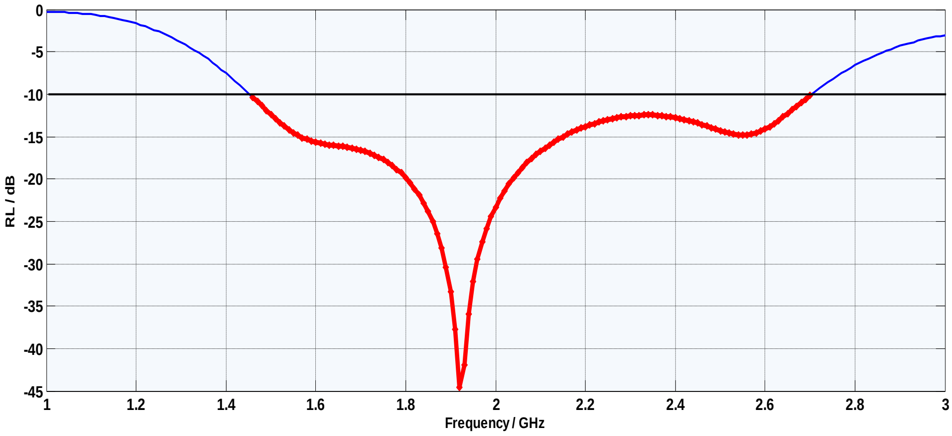

Figure2: Return Loss of the proposed antenna.

The normally desired value of VSWR to identify a good impedance match is 2.0 or less. Figure 3 indicates the VSWR of the proposed antenna. The VSWR varies from (1.01 – 2).

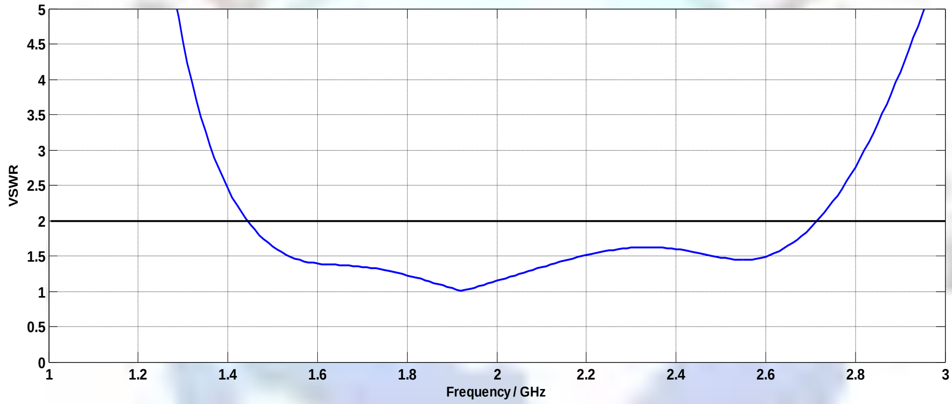

Figure 3: Plot of the VSWR for the proposed antenna.

The proposed prototype has been designed to provide uniform radiation patterns on the broadside of the radiating surface. Figure4 shows the 2D plots of the radiation pattern for both E and H plane.

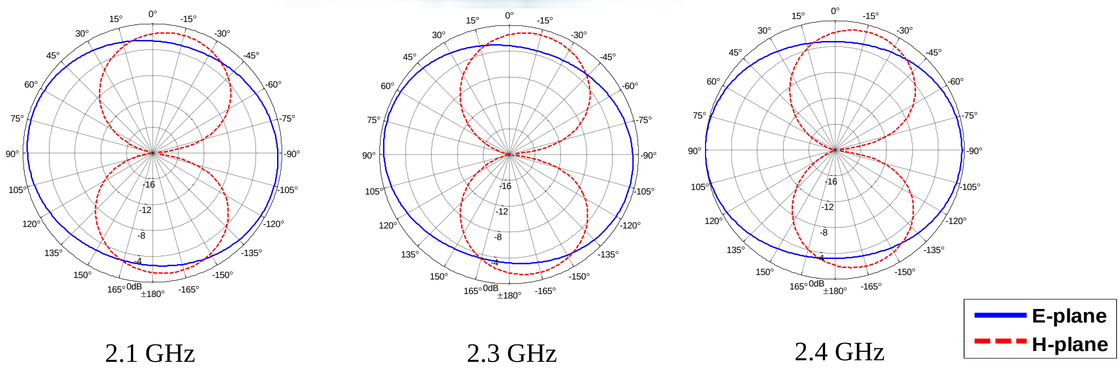

Figure 4: Radiation Pattern for proposed antenna.

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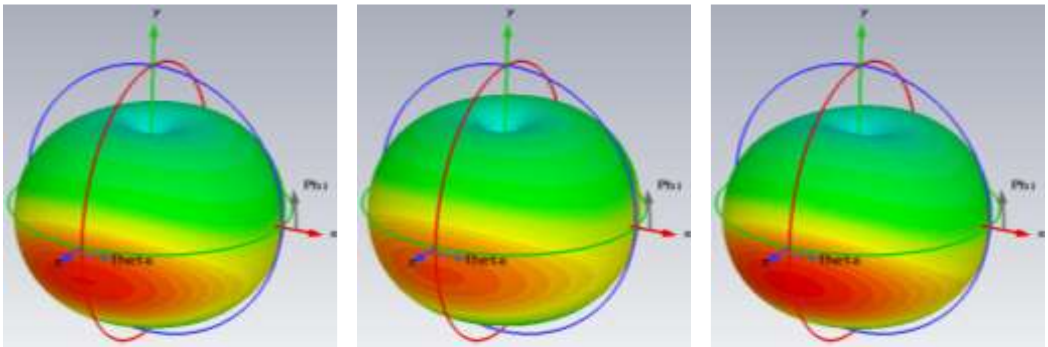
For further evaluation of the volumetric radiation patterns, the three dimensional variations of the radiated fields for the proposed antennas were calculated and are shown in Figure5.



2.1 GHz 2.3 GHZ 2.4 GHz

Figure 5: Scheme of the simulated 3-D radiated fields for the proposed antenna

The gain of the proposed antenna was calculated from the far field patterns using the CST package, and the obtained gains versus frequency are shown in Figure 6.A peak gain of 2.654 dBi at UMTS band, 2.442 at LTE band, 2.663 at WLAN band.

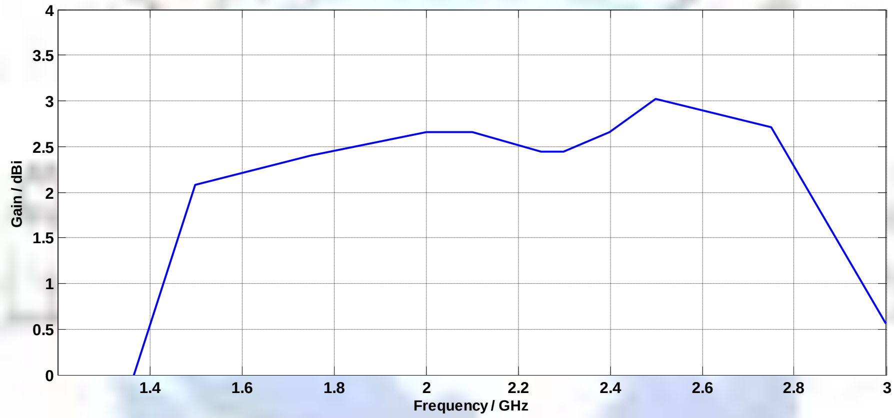
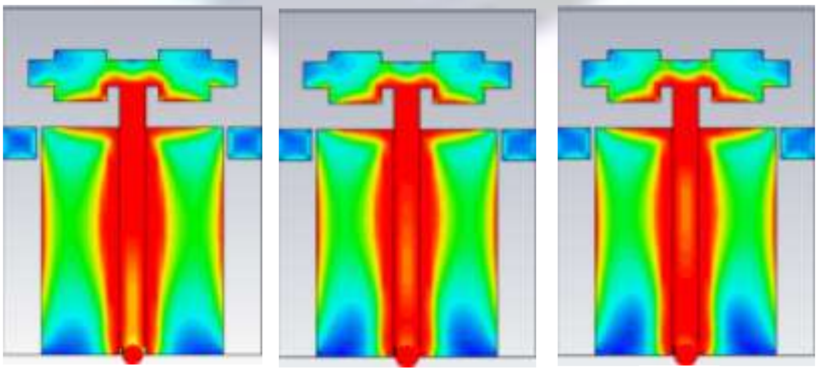


Figure 6: Plot of the gain versus frequency of the proposed antenna.

The simulated current distributions of the printed rectangular monopole of the proposed antenna at 2.1 and 2.4 GHz are given in Figure7. The relatively strong current distributions are observed on the strip fed line, rectangular patch with slots, slotted ground structure.



(a) (b) (c)

Figure 7. Scheme of the simulated current distribution for the proposed antenna
(a) current distribution for 2.1 GHz.
(b) current distribution for 2.3 GHz.
(c) current distribution for 2.4 GHz.

CONCLUSION

A novel monopole antenna with T- shaped have been demonstrated. That is suitable for UMTS, LTE and WLAN operations in the (1920 -2170MHz), (2300-2400 MHz), (2400-2484 MHz)bands respectively. It is believed that the size of the antenna is about the smallest among the existing internal mobile antennas. The operating bands based a minimum value of S11 is -16.7 dB at frequency 2.1 GHz while, the minimum value of S11 is -12.56 at frequency 2.3 GHz, and S11 is -12.77 dB at frequency 2.4 GHz band.The simulated impedance bandwidths (-10dB return loss) are 1.25 GHz from1.4257GHz to 2.704 GHz. This bandwidth exceed the requirements of any wireless applications.The dimensions of 67 * 50 * 1.6 mm3 can be easily applied in the back mobile phone. Due to good coverage and stable gain variation, the suggested internal antenna will be a favorable solution for UMTS, LTE and WLANmobile handset operations.The nearly omnidirectional radiation patterns are achieved over the interested operating frequency bands. From the results, it is seen that the suggested antenna achieves good wideband performance and the antenna has omnidirectional radiation characteristics with a good gain, this makes the suggested antenna design suitable for use in the UMTS, LTE and WLAN mobile applications.

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