Gsm 1900/Umts Printed Monopole Antenna For Mobile Base Station

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Abstract: In this paper, printed rectangular monopole antenna, which is basically printed microstrip patch antenna with partial ground plane, is designed for mobile base station. The substrate FR4 with a relative permittivity of 4.4 and thickness 1.8 is used in design. In addition, the printed monopole antenna is of low profile in appearance and suitable for most application. The proposed antenna can cover GSM1900 (1850-1990 MHz) and UMTS (1920-2170 MHz) bands. Design and simulation processes are carried out with the aid of FEKO software, which is used for the analysis of electromagnetic problems. Simulation results of the return loss, gain, and radiation patterns are presented.

Keywords: Printed, Monopole, GSM, UMTS, Radiation Patterns, Return Loss.

1. INTRODUCTION

Wireless communication has become an integral part for modern world. The most popular standard for mobile application in today's world is GSM. GSM networks operate in different frequency ranges in different countries around the world. The proposed antenna can cover the operating band of GSM 1900 and UMTS mobile applications. Microstrip patch antennas have a limitation of narrow bandwidth. Printed monopole antenna is designedto achieve required bandwidths for the applications. The antenna is easy to design, low-cost and can be easily integrated within the printedcircuit boards of notebook computers and other wireless networking equipment. In this design of printed monopole antenna for mobile base station, the antenna is to be used for GSM 1900/UMTS bands with resonant frequency 2.045 GHz. In thispaper, printed rectangular monopole antenna has been designed for mobile base applications. The propose antenna is simulated in FR 4 dielectric material with dielectric constant 4.4 and a thickness of 1.8 mm. A substrate with a high dielectric constant is chosen since it reduces the dimension of the antenna.

2. ANTENNA DESIGN

Fig.1 shows the structure of the printed rectangular monopole antenna. The antenna is printed on the FR 4 substrate material. The dimension of the substrate material is chosen at length (L_s) and width(W_s)equal to56 mm. The patch radiator is connected to a 50Ω microstrip feed line for voltage excitation. The feed width (W_m) of the propose antenna is 4.8 mm and feed length (L_f) is 19 mm on one side of substrate. The antenna has a size of length (L_p) 35 mm and a width of(W_p) 40 mm according to the equations. A ground plane size is chosen at length (L_g) 16 mm and width (W_g) 56 mm since the antenna is to resonate at required bandwidth. The parameters of the antenna can be calculated from the following equations.The width of the antenna can be determined by

$$W = \frac{c_o}{2f_o}\sqrt{\frac{2}{(1+\varepsilon_r)}}$$

The effective constant can be obtained from

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-1/2}$$

The dimensions of the patch along its length have now been extended on each end by a distance ΔL:

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)}$$

The actual length L of the patch is given as:

$$L = \frac{c_o}{2f_o\sqrt{\varepsilon_{reff}}} - 2\Delta L$$

For microstrip feeding lines, the width of the microstrip lines (W_m) for 50Ω characteristic impedance can be calculated from

$$\frac{W_m}{h} = \begin{cases} \dfrac{8e^A}{e^{2A}-2}; \dfrac{W_m}{h} < 2 \\ \dfrac{2}{\pi}\left[\begin{array}{l} B-1-ln(2B-1) \\ +\frac{\varepsilon_r-1}{2\varepsilon_r}\left\{\begin{array}{l} ln(B-1)+ \\ 0.39-\frac{0.61}{\varepsilon_r}\end{array}\right\}\end{array}\right]; \dfrac{W_m}{h} > 2 \end{cases}$$

$$A = \frac{Z_0}{60}\sqrt{\frac{\varepsilon_r+1}{2}} + \frac{\varepsilon_r-1}{\varepsilon_r+1}\left(0.23+\frac{0.11}{\varepsilon_r}\right)$$

$$B = \frac{377\pi}{2Z_0\sqrt{\varepsilon_r}}$$

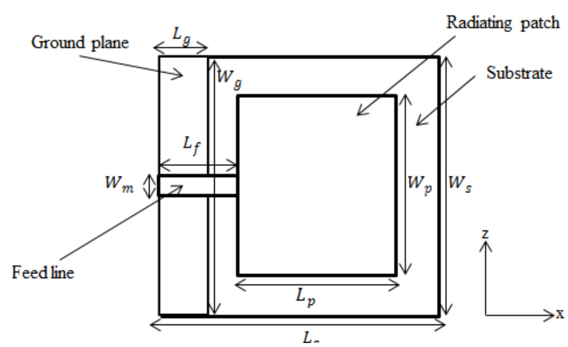

Fig. 1(a)

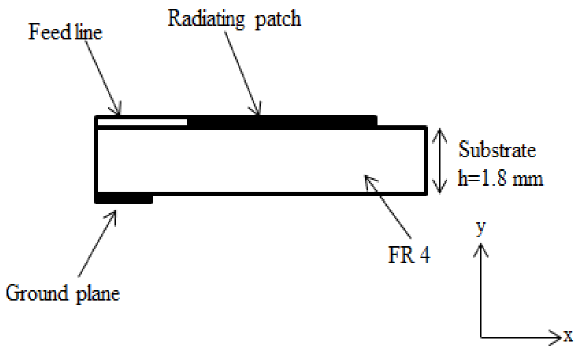

Fig. 1 (b)

Fig. 1*(a) Top View and (b) Side View of the propose antenna*

3. SIMULATION RESULTS

Fig.2 shows the return loss graph of the antenna at ground length 16 mm. Return loss is the difference between transmitted and reflected power in a system. An antenna with a more negative return loss is better.Fig.3 shows return loss graph for different ground plane lengths.At ground length of 16mm, impedance match is closed to 50Ω.So, the antenna is designedat ground length 16mm.Fig.4 shows impedance variation of the antenna. From figure, the average value of the resistance is approximately 50Ω. From return loss vs frequency plot in figure, the reflection coefficient is below -10 dB for GSM 1900 and universal mobile telecommunication system. The antenna bandwidth is 800 MHz (1.75 to 2.55 GHz) with fractional bandwidth 39.11% and return loss of -14.9 dB at resonant frequency 2.045 GHz.

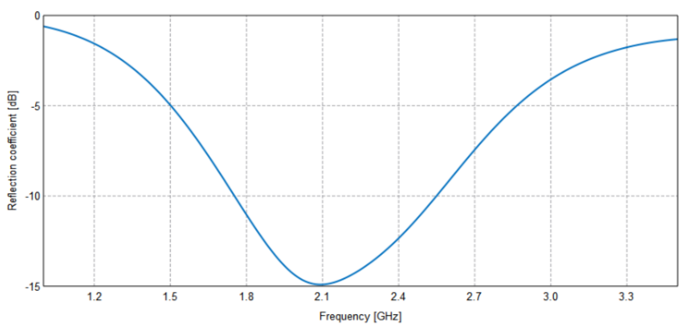

Fig. 2 *Return loss function against frequency*

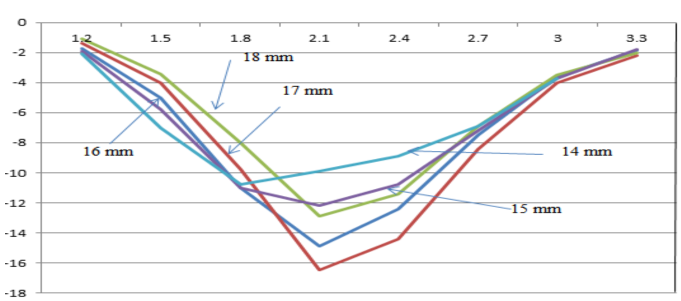

Fig.3 *Return loss function with different ground plane lengths*

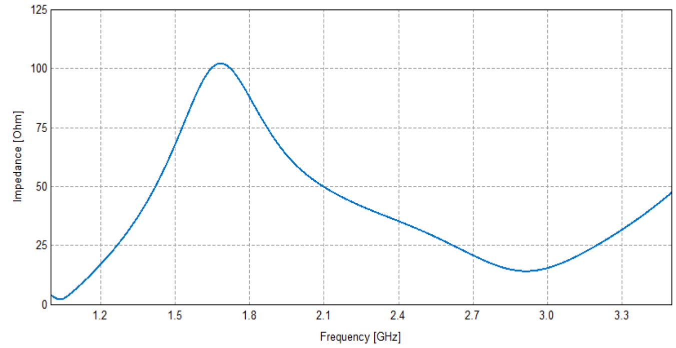

Fig.4 *Impedance versus frequency*

Figure.5 shows Voltage Standing Wave Ratio for the antenna. Voltage Standing Wave Ratio is defined as the ratio of voltage maximum to voltage minimum on standing wave along the line caused by mismatch. It shows how the antenna is well match. (1≤VSWR≤2) is acceptable for the antenna.

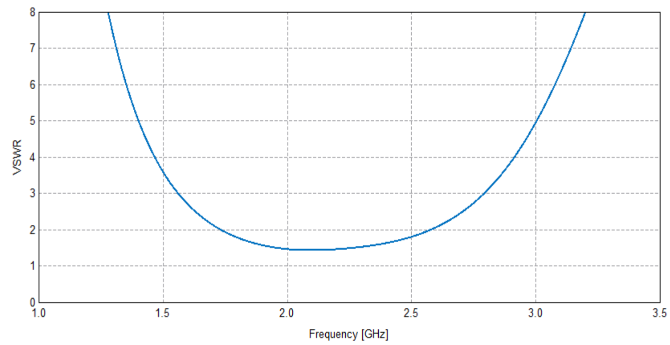

Fig.5 *VSWR versus frequency*

Fig. 6shows gain of the propose antenna. Antenna gain indicates how much of input power is concentrated in antenna a particular direction. It is defined as the radiation intensity in a specific direction to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically. The antenna gain is 2.49 dBi at resonant frequency 2.045 GHz.

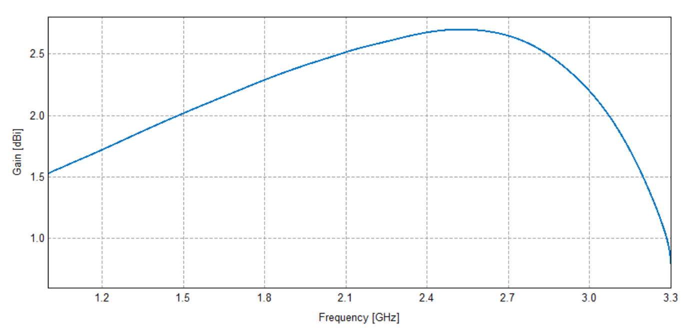

Fig. 6 *Gain function versus frequency*

Fig.7 and Fig.8 show E-plane and H-plane radiation pattern of the propose antenna at 2.1 GHz and 1.83 GHz respectively.The radiation pattern is defined as "a mathematical function or a geographical representation of the radiation properties of the antenna as a function of space coordinates". The radiation patterns of the proposed antenna can be seen in figures. The E-plane radiation is in the form of 8 and the H-plane radiation pattern in the shape of O.

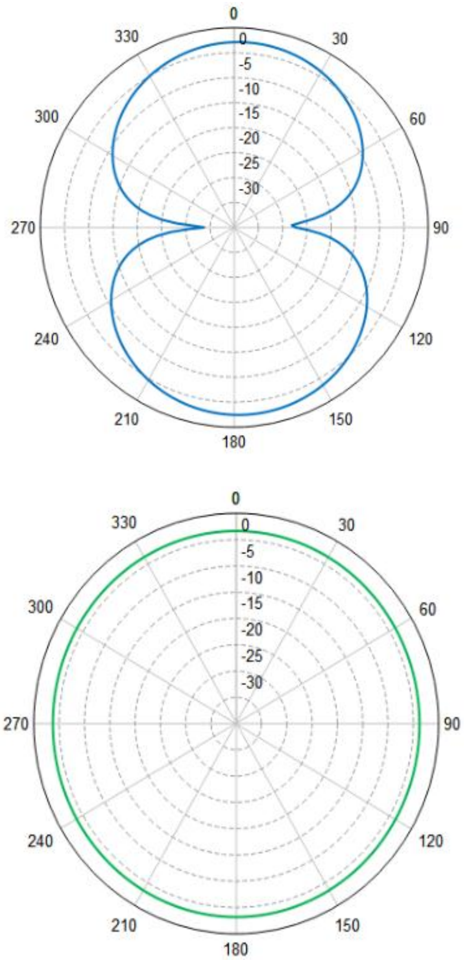

Fig.7 *(a) E-plane and (b) H-plane radiation pattern at 2.1 GHz*

4. Conclusion

In this paper, printed monopole antenna which is basically a printed microstrip antenna with partial ground plane for mobile applications has been simulated. Printed monopole antennas are less fragile, planar and can be integrated with the integrated circuits unlike monopole antennas which have non-planar structures above the ground plane. The proposed antenna design produces a bandwidth of 800 MHz (1.75 to 2.55 GHz) covering both GSM 1900 and UMTS frequency ranges. From the results, the antenna design can be used for mobile applications and in different portable devices.

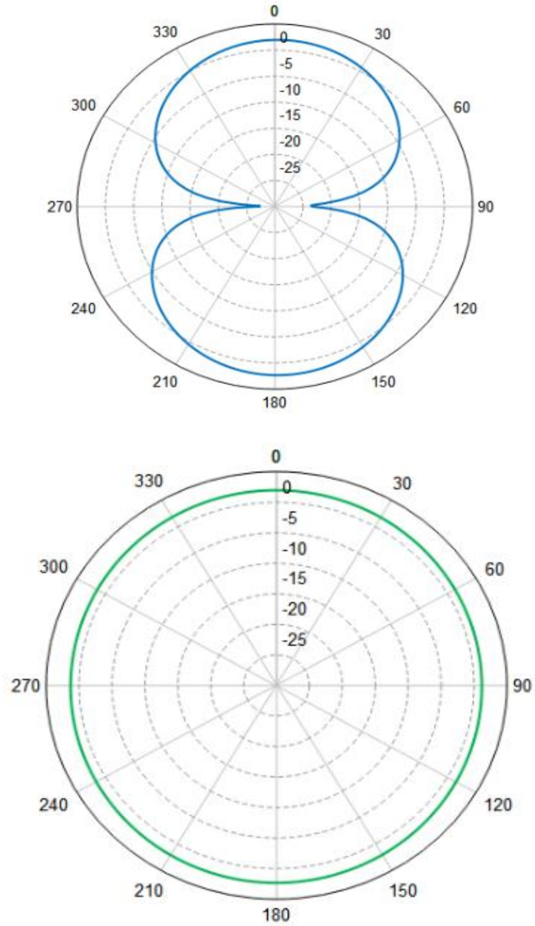

Fig.8 *(a) E-plane and (b) H-plane radiation pattern at 1.83 GHz*

5. References

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