Advance in Electronic and Electric Engineering.
ISSN 2231-1297, Volume 3, Number 3 (2013), pp. 347-354

http://www.ripublication.com/aeee.htm

Design Simulation and Fabrication of Microstrip Patch Antenna

Mayuri. M. Dekate

Electronics and Telecommunication Engineering, University of Mumbai, India.
E-mail: dekatemayuri@gmail.com

Abstract

Long-term evolution (LTE) is one of the 4th generation (4G) mobile communication technologies developed at different frequencies ranging from 400 MHz to 4 GHz with bandwidths up to 20 MHz.. The proposed antenna is designed in LTE band II for 4G MIMO communication. The antenna is operating in LTE band II having frequencies of 1860 MHz-1910 MHz which is uplink frequency and 1930 MHz-1990 MHz which is downlink frequency. So the antenna is dual band antenna. The center frequency for first band is 1880 MHz and desired bandwidth is of 60 MHz. The center frequency for second band is 1960 MHz and desired bandwidth is 60 MHz. Center frequency of 1920 MHz is considered for the designing of antenna which is mean of 1880 MHz and 1960 MHz. A circularly polarized Microstrip Antennas can be realized by exciting two orthogonal modes with equal magnitudes, which are in phase quadrature. The sign of the relative phase determines the sense of polarization (LHCP or RHCP).

Keyword: Microstrip patch antenna 4G Technology Resonant Frequency LTE band Bandwidth.

1. Introduction

Thanks to the success of smartphones and mobile-ready portables, such as laptops or tablets mobile data traffic has recently experienced an exponential growth. The demand for mobile data services has increased by an average of 160% in the year 2009 alone and some mobile carriers have experienced even more aggressive growth numbers. According to a recent forecast, the global mobile data traffic is expected to continue to double every year through 2014, leading to a global compound annual growth rate of 108%. These large capacity demands can be met only by highly efficient and optimized mobile network infrastructures.

Wireless mobile-communications systems[7] were introduced in the early 1980s, first-generation (1G) systems were marked by analog-frequency modulation and used primarily for voice communications. Second-generation (2G) wireless-communications systems, which made their appearance in the late 1980s, were also used mainly for voice transmission and reception. The wireless system in widespread use today goes by the name of 2.6Gan in-between service that serves as a stepping stone to 3G. Whereby 2G communications is generally associated with Global System for Mobile (GSM) service, 2.6G is usually identified as being fueled by General

Packet Radio Services (GPRS) along with GSM. In 3G systems, making their appearance in late 2002 and in 2003, are designed for voice and paging services, as well as interactive-media use such as teleconferencing, Internet access, and other services. The problem with 3G wireless systems is bandwidth these systems provide only WAN coverage ranging from 144 kbps (for vehicle mobility applications) to 2 Mbps (for indoor static applications). Segue to 4G, the next dimension of wireless communication. The 4G wireless uses Orthogonal Frequency Division Multiplexing (OFDM), Ultra Wide Radio Band (UWB), and millimetre wireless and smart antenna. Data rate of 20mbps is employed. Mobile speed will be up to 200km/hr. Frequency band is 2-8 GHz. it gives the ability for world-wide roaming to access cell anywhere.

2. Research Method

The preferred models for the analysis of microstrip patch antennas[3] are the transmission line model, cavity model, and full wave model (which include primarily integral equations/Moment Method). The transmission line model is the simplest of all and it gives good physical insight.

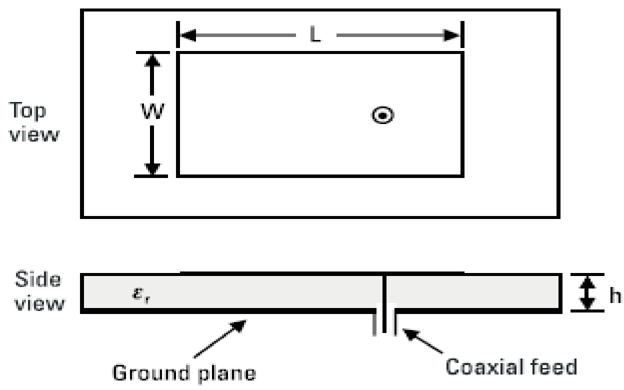


Figure 1: MSA ConFigureuration.

The proposed antenna is designed in LTE band II for 4G MIMO communication. The design specifications for the antenna are given as below. The antenna is operating in LTE band II having frequencies of 1850 MHz-1910 MHz which is uplink frequency and 1930 MHz-1990 MHz which is downlink frequency. So the antenna is dual band antenna. The center frequency for first band is 1880 MHz and desired bandwidth is of 60 MHz. The center frequency for second band is 1960 MHz and desired bandwidth is 60 MHz. Center frequency of 1920 MHz is considered for the designing of antenna which is mean of 1880 MHz and 1960 MHz. Computation of patch dimension[3] is given by formulae Below are the list of important formulae required for determining the Length L,Width W,Effective dielectric ε_{eff} ,Effective length due to fringing effects ΔL of the patch:

1. Computation of width of patch

$$w = \frac{1}{2Fr\sqrt{\mu_0 \varepsilon_0}} \sqrt{\frac{2}{\varepsilon_r + 1}}$$

2. Effective dielectric constant

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \frac{1}{\sqrt{1 + 12\frac{h}{w}}}$$

3. Effective length due to fringing effects

$$\Delta L = 0.412h \frac{(\varepsilon_r + 0.3)(\frac{w}{h} + 0.264)}{(\varepsilon_{eff} - 0.268)(\frac{w}{h} + 0.8)}$$

4. Computation of length of the patch

$$L = \frac{1}{2F_r\sqrt{\varepsilon_{eff}\mu_0 \varepsilon_0}} - 2\Delta L$$

Where,
w = Width of the antenna
Fr = Resonant frequency
μ_0 = Permeability of free space
ε_0 = Permittivity of free space
ε_r = Dielectric constant of substrate material
h = Height of substrate material
L = Length of the patch

Design Patch Specifications:

Before designing the desired antenna,the first step is to consider the specifications of the microstrip patch antenna based on its application.After performing some research,the various parameters are listed in the table()

Center-frequency	1.92GHz
Substrate	Air (=1)
Loss tangent	0
Substrate height	5.5 mm
Length of Patch	54.3mm
Width of Patch	59mm
Center to center spacing between patches	0.64lambda=100mm
Feedpoint Location	(18.4,20)
Ground Plane Length	20mm
Ground Plane Width	10mm

For the proposed antenna the optimized parameters selected are as given below.

The primary objective of the antennas used in MIMO systems is to improve the bandwidth[5] of the patch antenna. The bandwidth of microstrip antenna can be increased by using air as the substrate. So while designing this antenna air is selected as a substrate.

Circular polarization

In the case of a dual-feed Circularly Polarized[6] Microstrip Antennas, an external power divider with quadrature phase difference is required to generate the two orthogonal modes. Alternatively, an offset feed line or a 3-dB branch line coupler can be used, but it increases the overall size of the antenna. Instead of dual feed, various single feed Microstrip Antenna conFigureurations can be used to generate Circular Polarization. In proposed antenna the feed is provided along the diagonal.

The dimensions of the Microstrip Antenna are modified such that the resonance frequencies *f* 1 and *f* 2 of the two orthogonal modes are close to each other. The antenna is excited at a frequency *f* 0 in between the resonance frequencies of these two modes, such that the magnitude of the two excited modes are equal. Also, the feed-point location is selected in such a way that it excites the two orthogonal modes with phase difference of +45° and -45° with respect to the feed point, which results in phase quadrature between the two modes. These two conditions are sufficient to yield CP.A circularly polarized microstrip antennas can be realized by exciting two orthogonal modes with equal magnitudes which are in equal phase quadrature.The sign of relative phase determines the sense of polarization (LHCP or RHCP). There are different techniques to provide feed for obtaining circular polarization.

For nearly square patch antenna the ratio of the two orthogonal dimensions L1 /L2 should be generally in the range of 1.01–1.10 depending upon the substrate parameters as described above. When the patch is fed along the diagonal, then the two resonance modes corresponding to lengths L1 and L2 are spatially orthogonal. The Circular Polarization is obtained at a frequency, which lies between the resonance frequencies of these two modes, where the two orthogonal modes have equal magnitude and are in phase quadrature.

For the proposed antenna the feed point location for the first patch is (18.4mm, 20mm) because of which

RHCP is obtained and for second patch is (135.9mm, 20mm) which gives LHCP. Thus as there are two different polarizations for two patches mutual coupling is avoided which increases the efficiency of antenna.

By trial and error method the distance between two patches which is center to center distance is taken as 0.64λ. Here λ=0.15625 and therefore the distance is 100mm.

3. Simulation Results

3.1 Discussion of Results

4G MIMO antenna[1] is designed and implemented on its ground plane by using Agilent's ADS Software. Different dimensions were considered for the optimization of the antenna, impedance matching and parametric characterization in terms of return loss. Final dimensions are considered for the two patches as length L=54.3mm and width W=59mm. These dimensions provided good results in terms of parametric characterization. Size optimization for the final patches was done around 25-35%. For practical implementation air is used as dielectric and tested using vector network analyzer. Following are the simulation results. In Figure 1 feed point is given along diagonal. Figure 2 shows the radiation pattern of the proposed antenna. Figure 3 shows resonant frequencies and center frequency and impedance matching smaller the kink achieved at center more the impedance matching is achieved. Figure 4 shows which polarization is dominant. In Figure 4 RHCP is dominant Figure5 represents s11 graph and Figure6 shows the impedance matching achieved swr(standing wave reflection for mobile should be around 1 which is achieved as seen in Figure 7.

3.2 Simulation Results

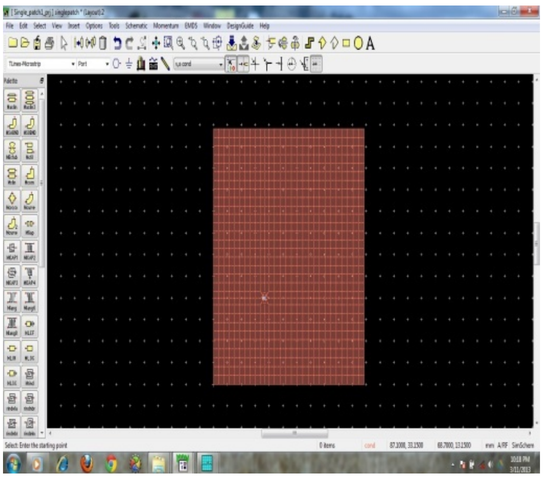


Figure 1: Single patch

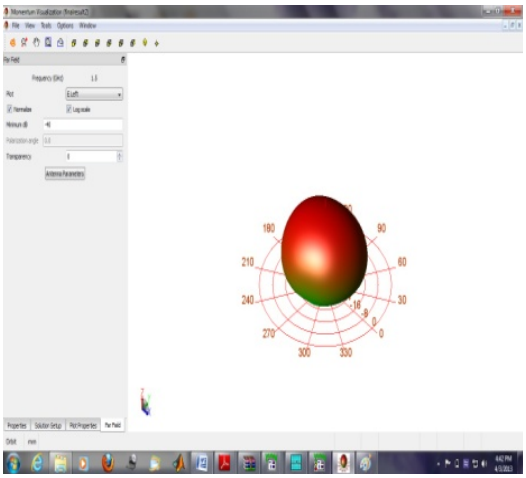


Figure 2: Radiation pattern

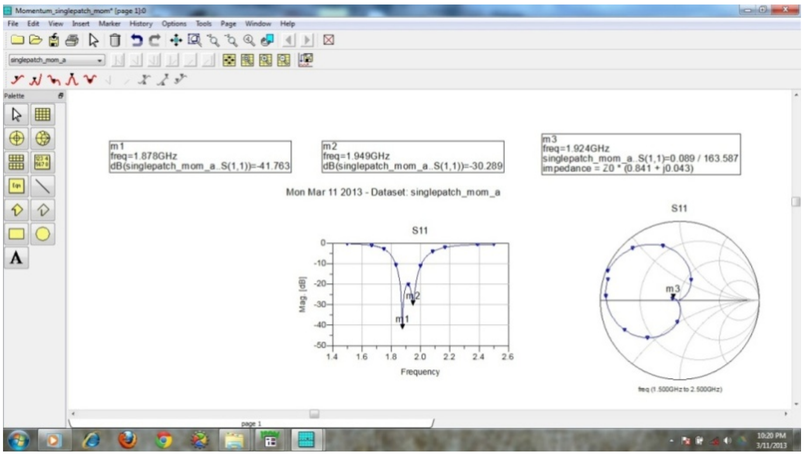


Figure 3: Momentum results for Single Patch1
(Resonant frequency and impedance Matching)

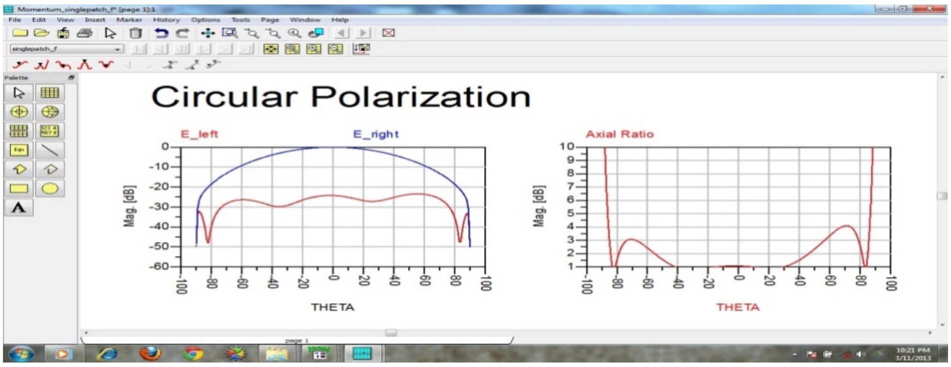
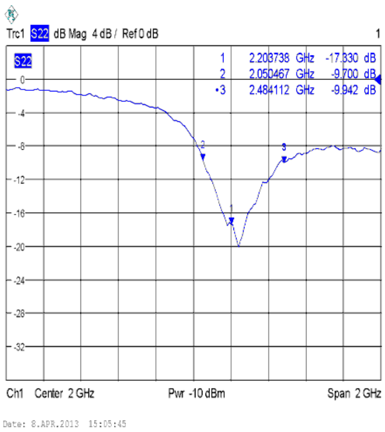


Figure 4: Circular Polarization Graph of Single Patch1.



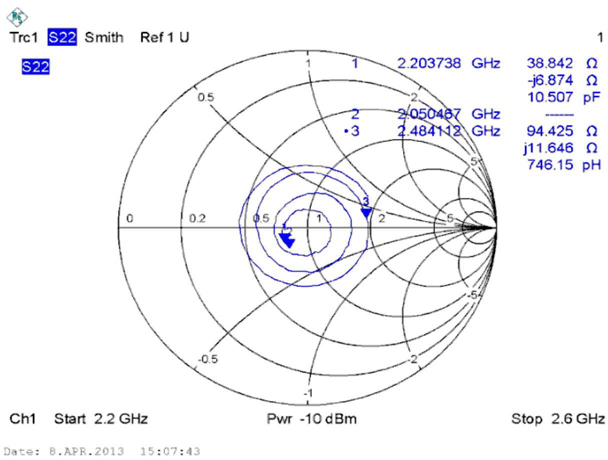


Figure 5: 11 graph

Figure 6: impedance matching

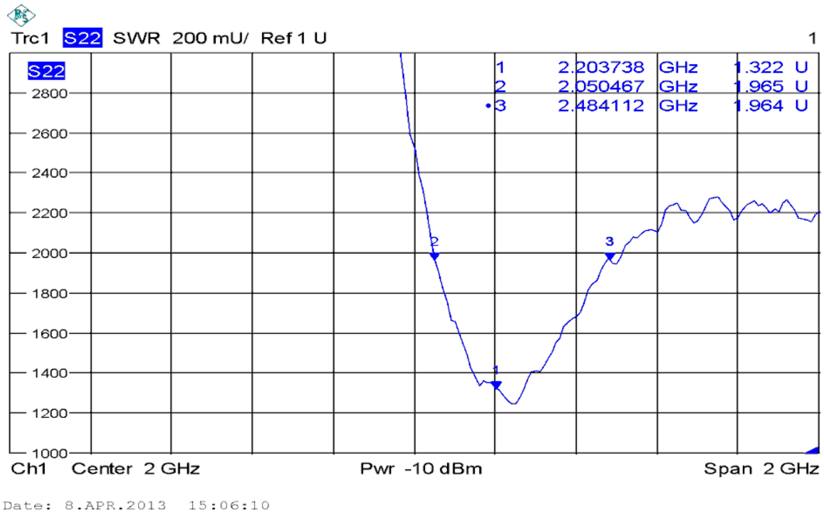


Figure7: SWR(standing wave reflection.

4. Conclusion

In our propose antenna Mutual coupling is reduced. Also Bandwidth is improved as it can be seen from the practical results Orthogonal diversity has been achieved. Low transmit output power..Impedance matching is achieved. Various issues like antenna array conFigureuration and their impact on channel capacity, selective antenna concepts, the scope of research involved in reconFigureurable antennas, types of patch antennas and their usability and the main sources for mutual coupling and the ways to reduce it are discussed.4G MIMO Antenna design presents a brief review of recent research findings concerning the antennas and their design for MIMO systems In designed antenna, left handed patch gives RHCP and right handed patch gives LHCP and because of this mutual coupling is avoided. Scope of further improvement is that Increased size of antenna can be reduced by using MMIC technology Proposed antenna provides dual band.It can work on more than two bands .Gain of the antenna can be increased further by using other substrate optimization over thickness can be achieved. Finally, it is concluded that a lot of research is required to be done in antenna design for the better performance of MIMO systems, which form a main part for the future 4G communications.

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