Develop Model for an Antenna with Dual Band Microstrip Patches

Ahmed Shamil Mustafa  
Department of Computer Engineering Techniques  
Al-Maarif University College  
Iraq  
ahmedshamil90@gmail.com

Mohamed Muthanna Al-Heeti  
University Of Anbar  
Iraq  
Mohamed.muthanna@uoanbar.edu.iq

Ahmed Muhi Shantaf  
Department of Computer Engineering Techniques  
Al-Maarif University College  
Iraq  
ahmedmuhi89@gmail.com

Abstract: 
The wavelength, low scale, medium-frequency, and high-frequency typically defined as antenna. This article implemented a dual-band patch antenna for band 7 and 3 for suitable with LTE. Physically, the scale of the patch antennas may be minimized. The FR4 substrates 4.3, 1.6 mm represent εr and h respectively is used for developing the new model of an antenna with the dual band microstrip. Antenna of width (108.7 mm), length (77.8 mm) and height (1.6 mm) are built for the ground plane. The other parameters calculate to achievement the frequencies 1.8 GHz and 2.6 GHz purposed of design. The result shows the return loss of S-Parameter achieved -20 at 1.8 GHz and -20.5dB at 2.6 GHz. The bandwidth at 1.8 GHz is 55 MHz while at 2.6 GHz is 89 MHz depending on the S-Parameter. The Fairfield of the maximum directivity is 7.200 dBi with total efficiency -2.899 dB at a frequency 1.8 GHz while 2.6 GHz obtain 6.868 dBi and -3.718 dB for a maximum directivity and total efficiency, respectively. The simulation and design were done by CST microwave studio.
1. Introduction

The transducer is designed for electromagnetic waves to be broadcast or obtained. The antenna is graded in total by the wave level, low frequency, medium frequency and high frequency [1]. First of all, a German scientist H Hertz proposed the low-frequency antenna. A dipole antenna, then this antenna was built 20 years ago [2]. The need for lightweight antennas and low cost, which can operate with the adequacy of bandwidth at different frequencies [3], has been increased in recent developments in wireless communication.

Microstrip antenna delivers many advantages over traditional microwave antennas and is mostly used for a variety of realistic applications. Since easy and directly print onto a circuit board, microstrips or patch design antenna are even more useful [4]. In the cell phone industry, microstrip antennas are becoming quite popular. The reduced price and low profile are leading to simplify the production of a Microstrip Antenna. Figure 1. It comprises two sides, the first one appears a dielectric substratum $\varepsilon_r (\leq 10)$ of radiation layer, the second one appears a ground-level [5].

![Figure 1: Microstrip rectangular patch antenna](image)

In the figure 1 there are two rectangles, the lower rectangle is the ground plane which has the area $L_g \times W_g$. Whereas the upper rectangle is the patch that has the area $L \times W$. The substrate is at height $h$ from the ground.

This research focuses on the construction of an LTE dual band 3 and 7 patch antenna. The fact that the patch antennas have been found to be broad-based in wireless communication systems has a small scale, lightweight, minimum requirement to
profile, Small assembly price ease of mounting on board, and alignment a printed platform (PCB) [7]. It does have many drawbacks, such as a weak exposure, low benefit and a restricted bandwidth of impedance [8]. Various innovations are used in the area of antenna architecture to offset the drawbacks. The choosing of the correct substrate material is one of the major problems in antenna architecture. The substrate's permit ability and tangent failure have a clear relation to the size and function of the antenna. The purpose of the research is to identify the right microstrip patch antennas parameter. The parameter was used to build and model a dual- patch antenna with a CST microwave lab, for LTE band 7 and band 3. It operates in (1.8 and 2.6) GHz dual - frequencies, for this antenna architecture. These are widely used by LTE to allow more consumer devices and data frequencies than in the previous century. This paper includes also descriptions of this antenna architecture and efficiency simulation.

2. Antenna Parameters

Several antenna parameters are useful for explaining microstrip patch antenna efficiency. Various parameters including VSWR, return loss, Antenna Gain, Control and Performance of a ntenna are evaluated. Some of which are the following:

a) The Gain of Antenna

The antenna gain is determined by the sensitivity relationship of a given path to the radiation level since the antenna power is radiated isotropically. Representation in formula (1) [9].

\[ G = 4\pi \frac{U(\theta, \Phi)}{Pin} \]  

For \( U(\theta, \Phi) \), a pin is an input intensity in a given direction

b) Radiation pattern

The configuration is named the mathematical function or a graphical depiction according to the space coordinates of the antenna radiation characteristics [9].

c) Efficiency of Antenna

The overall antenna output to an antenna input capacity ratio [9].

d) VSWR

VSWR= Vmax / Vmin is known as the standing wave voltage ratio. It will range from 1 to 2. [9].

e) Return loss

Return loss reflects signal strength as a system is embedded in a transmission cable. That is why the RL is an antenna parameter like the VSWR that indicates how closely the antenna suits the transmitter. The RL is as follows: [9].

\[ RL = -20 \log_{10}(r) \text{ dB} \]  

(2)
If $\Gamma = 0$, $RL = \infty$ that implies that there is no mirrored of power, or a $\Gamma = 1$, $RL = 0 \text{ dB}$, this will lead to ensure that the power of the incident is mirrored. A VSWR of 2 is suitable for realistic applications.

3. Design Model

For configuring LTE dual band microstrip patch antenna. Figure 2 demonstrates the Microstrip's antennal architecture.

![Microstrip Patch Antennas](image)

Figure 2 Microstrip Patch Antennas

The following seven phases determine the feature parameters [6, 10-12]:

**Step1:** The first step is to measure the patch diameter. For estimation of the patch width $w$ of an antenna, the following formula (3) used.

$$W = \frac{c}{2 \cdot f_0 \cdot \sqrt{\varepsilon_r + 1}}$$

For $f_0$ is a resonant frequency or a dielectric layer constant and $c$ is light speed.

**Step2:** The $\varepsilon_{\text{reff}}$ is measured in the second stage. The formula (4) is used to calculate an efficient dielectric constant in the $\varepsilon_{\text{reff}}$.

$$\varepsilon_{\text{reff}} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \left[1 + 12 \left(\frac{h}{w}\right)\right]^{-0.5}$$

$\varepsilon_r$ represents a constant of dielectric substratum, while $h$ is an above ground substratum height and $w$ is a patch distance. For this scenario, the size parameter $h$ is 1.6 mm.
Step3: At this phase, $\Delta L$ is calculated. Formula (5) for Length extension $\Delta L$ is

$$\Delta L = 0.1412h \left( \varepsilon_{\text{reff}} + 0.3 \right) \left( \frac{w}{h} + 0.264 \right) \left( \varepsilon_{\text{reff}} - 0.258 \right) \left( \frac{w}{h} + 0.8 \right)$$

(5)

If $\varepsilon_{\text{reff}}$ dielectric constants are accurate, the above ground and width of patch representation the height of the substrate and $w$ respectively.

Step4: The next step is to find the utility of $L$. Effective Formula (6)

$$L_{\text{eff}} = \frac{c}{2f_0 \sqrt{\varepsilon_{\text{eff}}}}$$

(6)

The estimation is done using $c$, $f_0$ & $\varepsilon_{\text{reff}}$.

Step5: The following formula (7) determines the patch duration after step 4.

$$L = L_{\text{eff}} - 2\Delta L$$

(7)

Step 6: The duration of the feed line in the feed can be calculated using the formula (8)

$$f_i = 10^4 \left( 0.001699 \times \varepsilon_r^7 + 0.13761 \times \varepsilon_r^6 - 6.1783 \times \varepsilon_r^5 + 93.187 \times \varepsilon_r^4 - 682.69 \times \varepsilon_r^3 + 2561.9 \times \varepsilon_r^2 - 4043 \times \varepsilon_r + 6697 \right) \times \frac{L}{2}$$

(8)

Step 7: For inset feed by definition measure the width of the feed formula (9)

$$Z_c = \frac{120\pi}{\sqrt{\varepsilon_{\text{eff}} \left[ \frac{W_f}{h} + 1.393 + 0.667 \times \ln \left( \frac{W_f}{h} + 1.444 \right) \right]}}$$

(9)

4. Result and Simulation

The specifications are for the 1.8 GHz and 2.6 GHz microstrip patch antennas, the physical requirement, more specifically, to decrease patch antennas size. However, the type of FR4 substrate form has to be chosen: A 4.3 value for $\varepsilon_r$ and 1.6 millimeters for $h$. The model design of the antenna is planned accordingly. First of all, the microstrip patch antenna substratum was planned at width = 108.7 mm and length = 77.8 mm and height 1.6 mm and then the real substrate face which became the ground point. This was then built. The parchment of the antenna, which is half-width (54.35 mm), with lengths of 38.90 mm and height = 0.035 mm has been developed more. Further on, it was constructed. Eventually, we have produced a microstrip line of 50 Ω that is 3.137 mm width ($W_f$). All the above prototypes are accompanied by measures that are the same: by pressing the Program Brick icon and clicking the key to exit from the keyboard, then the symbol is shown by a computer with the configuration directions
are applied to that symbol. Next, use the content library to pick the correct design choice. Finally, all parameters which are calculated in (mm) of the microstrip patch antenna display in table 1 and Figure 3 indicate the parameters for this configuration as follows.

![Diagram](image)

Figure 3: details of parameters on location

Table 1: Summary of parameters calculated by seven steps

| Parameter | Value (mm) |
|-----------|------------|
| W         | 54.35      |
| L         | 38.90      |
| Lg        | 77.8       |
| Wg        | 108.7      |
| Fi        | 8.8        |
| Wf        | 3.137      |
| ht        | 0.035      |
| hs        | 1.6        |
| Gpf       | 2.5        |
| F1        | 1.8 GHz    |
| F2        | 2.6 GHz    |

The result of this simulation is shown in the figures below after coming out from simulation tools. The structure of the visualization is shown in Figures 4 while figure 5 presents the specification of the patch antenna is proposed. Return less of the antenna suggested (S-Parameter) was seen in Figure 6 and the antenna's time signal in Figure 7. Figures 8 and 9 illustrate the energy balance and field energy, respectively. In the end figure, 10 and 11 showed Far Field of both frequencies 1.8 and 2.6 GHz for the new design of antenna which is suggested.
Figure 4 The Configuration of the proposed model design.
In figure 6, We had been built and test the Patch antenna for dual band successfully based on parameters proposed in table 1 mention above. The result of the Patch antenna achieved -20 dB return loss of S-Parameter at 1.8 GHz and -20.5dB at 2.6 GHz. The design is improving the return losses in both frequencies 1.8 GHz and 2.6 GHz. The bandwidth at 1.8 GHz was 55 MHz while at 2.6 GHz is 89 MHz, A Port of the signal in the proposed antenna is presented in figure 7. Also, the figure shows the time signal of proposed antenna record in (ns).
In figure 8, an energy balance of the suggestion model is presented. Side of energy achieved 0.1 over frequency. Both frequencies 1.8 GHz and 2.6 GHz record a 0.1 energy balanced as mentioned in figure 8. While figure 9 presents the field energy in dB over time. The field energy in figure 8 shows stability records over time.
A Fairfield directivity in the new models suggested of both resonant frequencies is presented in Figures 10, 11. In Figure 10, the Fairfield of design achievement that the maximum record of directivity is 7.200 dBi then the -2.899 dB is recorded for a total efficiency of the proposed design of the antenna. on the other hand, Figure 11 presents the result of the maximum directivity of the frequency of 2.6 GHz which record 6.868 dBi at 2.6 GHz in simulation. Finally, the last value at 2.6 GHz it is a total efficiency achieved -3.718 dB in the design.
CONCLUSION

The rising market for wireless devices has expanded the area of double band antenna science. The antenna suggested is a basic configuration that can be mounted on wireless devices for applications with LTE. Two frequencies are focused on this design 1.8 and 2.6 measured in GHz, which represents the two bands 3 and 7. We build and test the LTE dual band antenna in this article. The simulation program of CST microwave studio for the patch antenna was included. In this work, we had successfully managed to design an antenna that works in the two frequencies (1.8 and 2.6) GHz on the FR4-epoxy substrate of the thickness (1.6) millimeters with Ɛr (4.3), three parameters had been used for the optimization, which was W, L, and Wf. From the optimization result, it shows that different values of the dimension of the design proposed would cause the antenna to resonate at a different frequency and affect the bandwidth of the antenna. The design achievement a good value of return loss in both frequencies and record a suitable value of energy for dual band patch antenna.

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