

Design of Dual -Band Coax Patch Antenna for GSM and Bluetooth Applications

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Abstract: *This paper proposes the design of dual-band coax patch antenna for GSM and Bluetooth applications. The proposed antenna is suggested to be used in a mobile phone handset that covers dual frequency bands which include GSM1900(1850-1990MHz) and Bluetooth(2400-2483.5MHz). The simulation of the antenna is performed using a High Frequency Structure Simulator(HFSS) software. Analysis for return loss, VSWR, gain and radiation pattern were carried out. The proposed antenna shows return loss of -29dB at 1.9GHz and -30dB at 2.4GHz which implies good results. The impedance matching is good at the desired frequencies with VSWR < 2 respectively. The overall simulation results shows that the antenna worked well at the desired dual frequencies and hence making the antenna suitable for use in both GSM and Bluetooth applications. This antenna is implemented on FR4 Epoxy dielectric substrate with relative permittivity $\epsilon_r=4.4$, thickness of the substrate $h = 1.6\text{mm}$.*

Keywords: Frequency, Dual band, V SWR, Return loss, GSM, Bluetooth, Coax patch.

1. Introduction

Antennas played a significant role in the field of wireless communication. It can be regarded as the driving force behind the modern advances in the area of wireless communication technology. In this paper, the design of dual band coax patch antenna for Bluetooth and GSM is proposed. The Bluetooth technology provides short range of wireless connections between electronics devices like computers, mobile phones, and many others thereby exchanging voice, data and videos(3). Micro strip Patch antennas are widely utilized due to their advantages over other radiating systems which includes: light weightiness, reduced size, low cost, conformability and the ease of integration with active device(5). The patch is generally made of conducting material such as copper or gold. The radiating patch and the feed lines are usually photo etched on the dielectric substrate(1). Micro strip patch antennas radiate primarily because of the fringing field and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a micro strip line or probe feed. The antenna can be design to have many geometrical shapes and dimensions but rectangular and circular micro strip resonant patches have been used extensively in many applications(4). In this paper, a rectangular shaped patch antenna is chosen and is expected to operate at dual frequency of 1.9GHz and 2.4GHz respectively. The dimensions of the rectangular

shaped Patched antenna were carefully selected by using a validated equation(1) for dual band operation. The performance characteristics such as VSWR, return loss, radiation pattern are obtained from the simulation result. However, the major problem of patch antenna is their narrow bandwidth(1) due to surface wave losses and large size of patch for better performance. The proposed antenna is designed with FR4-Epoxy dielectric substrate with dielectric constant of $\epsilon_r=4.4$ and dimensions are base on resonant frequencies. Various adjustment were made on these dimensions to improve the parameter such as resonant frequencies, return loss, and the voltage standing wave ratio (VSWR) respectively.

2. Design Methodology

The rectangular coax patch antenna has dimensions 37.1mm×30mm as shown in figure1. The FR4-epoxy substrate [ϵ_r] used is 4.4 with dielectric loss tangent of 0.002, having thickness [h] of 1.6mm. The ϵ_r is chosen such that it gives better efficiency. Under normal condition the substrate material should be low in insertion loss with a loss tangent of less than 0.005 [6]. So, for this design in particular dielectric loss tangent of 0.002 is used. Generally, substrate materials have many categories in accordance with their dielectric constant. Some are in the range of 1.0 to 2.0, 2.0 to 4.0 but for the purpose of this design, 4.4 is used, much higher value can

significantly reduced the antenna's radiation efficiency also reduced bandwidth [6]. There are different methods that can be used in the design of dual band micro strip antenna. In this paper the coaxial feed method is used simply because the feed can be placed at the desired position or location inside the patch to match its impedance as shown in the figure1. Shown in figure 1, is the architecture of the proposed antenna design using high frequency structure simulator software (HFSS) which starts with a conventional micro strip patch. This consists of an active radiating patch on one side of a dielectric substrate and also, the other side consists of ground plane.

Table1: Design Parameters of the Antenna.

Parameters	Values[mm]
h	1.60
Length	30.00
L_0	29.00
W_0	37.10
L_1	6.60
L_2	7.20
A	Port/coaxial connector

3. Design Equations

The parameters of the antenna can be calculated using validated equations of transmission line method (1) as shown below:

Width of the Patch

The width of the antenna can be determined by (1)

$$W = \frac{c}{2F\sqrt{\frac{\epsilon_r+1}{2}}}$$

where c is the speed of light, F is the resonant frequency and ϵ_r is dielectric substrate. By substituting all the values in the table to this equation, the width of the patch antenna is calculated to be:

$$W = 37.10\text{MM}$$

Effective dielectric constant

The effective dielectric constant is given by(1)

$$\epsilon_e = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2} \sqrt{\frac{1}{1+12\frac{h}{w}}}$$

Hence, ϵ_e is the effective dielectric constant, W is the width of the patch respectively. By substituting the values of FR4-epoxy dielectric substrate, width and the h. Therefore, $\epsilon_e = 4.08$

Effective Length

The effective length is given by (1) L_{eff}

$$L_{eff} = \frac{c}{2F\sqrt{\epsilon_e}} \tag{1}$$

Hence, C is equal to 3×10^8 m/s and desire resonant frequency is 2.4Ghz, the effective length is calculated to be, $L_{eff} = 30.30\text{mm}$.

Length of Patch

The length of the Patch $L_0 = L_{eff} - 2\Delta L$, (1)

$$\text{when, } \Delta L = 0.412h \left[\frac{\epsilon_{eff} + 0.3}{\epsilon_{eff} - 0.258} \right] \left[\frac{\frac{w}{h} + 0.264}{\frac{w}{h} + 0.813} \right]$$

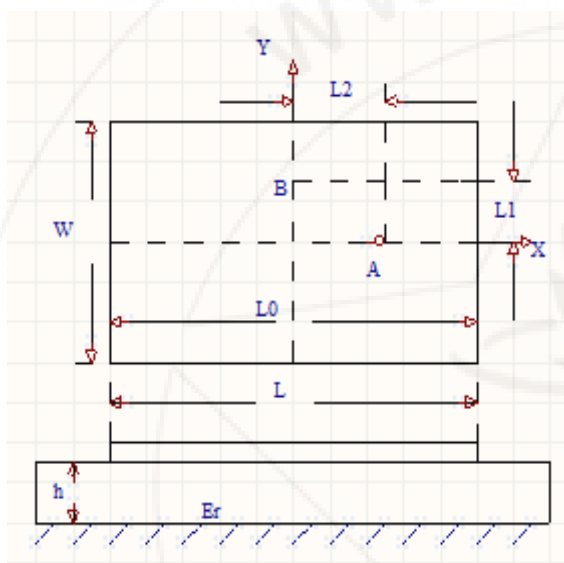


Figure1: Proposed Antenna

$\Delta L = 6.56\text{mm}$, and
Hence, $L_0 = 29.00\text{mm}$.

Insert Feed location

The insert feed location is given as (1)

$$L_2 = \frac{L_0}{2\sqrt{\epsilon_e}}$$

The calculated value of feed location

$$L_2 = 7.20\text{mm}$$

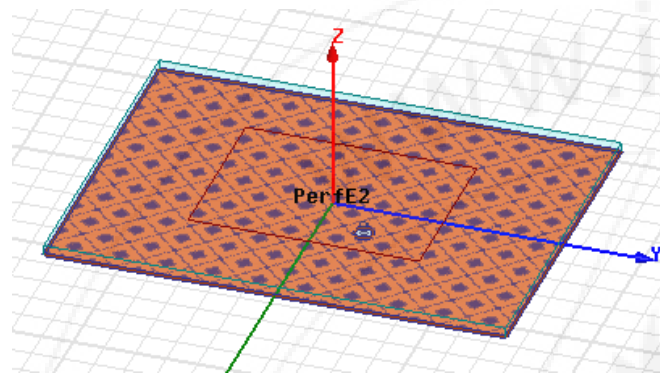


Figure 2: Perfect E2- Plane using HFSS Software

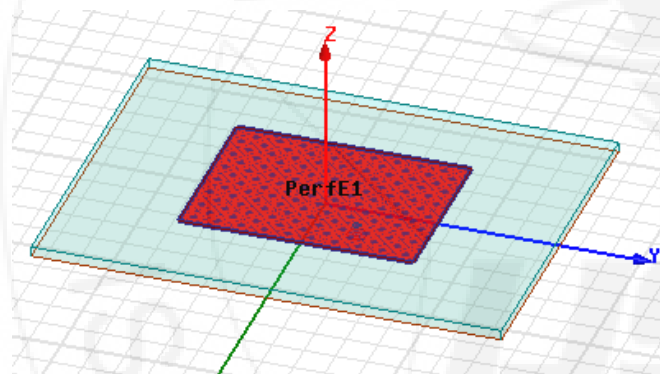


Figure 3: Proposed Antenna Showing perfect E1- Plane

4. Simulation Results

The proposed dual band coax patch antenna in figure1 was simulated using HFSS Software. The details of the resonant frequencies are shown in the table 2.

Table 2

Frequency [GHz]	Return Loss [dB]	VSWR [dB]
1.90	-29dB	1.4
2.40	-30dB	1.5

The designed antenna resonates at 1.9GHz and 2.4GHz. The values of return loss at centre frequencies of 1.9GHz and 2.4GHz are -29dB and -30dB as shown in figure4 respectively. However, for 1.9GHz, it indicates that 6.6% of power is

reflected and 93.4% of power is transmitted. Similarly, return loss obtained at center frequency of 2.4GHz indicates that 8% of power is reflected and 92% of power is transmitted respectively. The VSWR was measured as shown in the figure5. The VSWR is a measured of how well matched antenna is to the cable impedance (6)(1). A perfectly matched antenna would have a VSWR of 1:1 which indicates how much power is reflected back or transferred into the cable(6)(1). The voltage standing wave ratios obtained from the simulations are 1.4dB at 1.9GHz and 1.5dB at 2.4GHz. Under normal condition the voltage standing wave ratio should be < 2. The result obtained is considered to be good a value as the level of mismatched is not very high. A high value of VSWR implies that the port is not properly matched (1).

5. Radiation Pattern

The radiation pattern for E and H-plane of the antenna at center frequencies of 1.9GHz and 2.4GHz are shown in figure 6, using HFSS Software. It can be observed from this radiation pattern the design antenna has good radiation pattern throughout the operating frequency bands. In addition, the S11 Parameter for this design at the centre frequencies were shown on the smith chart.

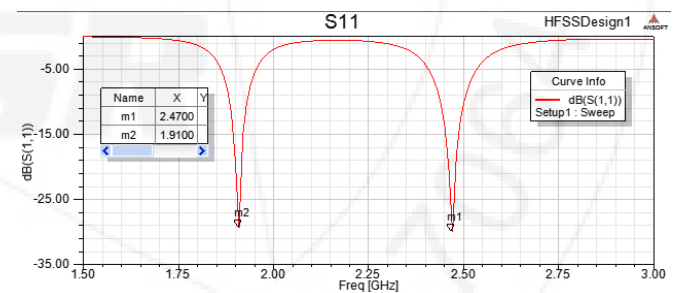


Figure 4: The return Loss

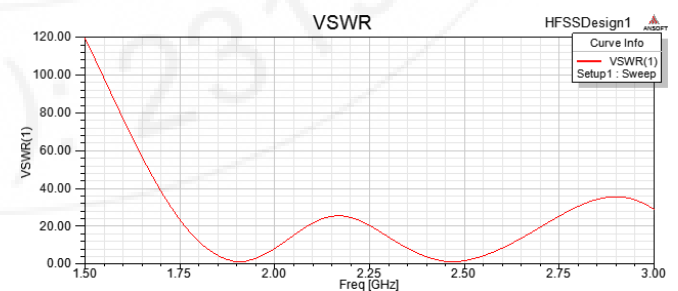


Figure 5: The VSWR of studied antenna

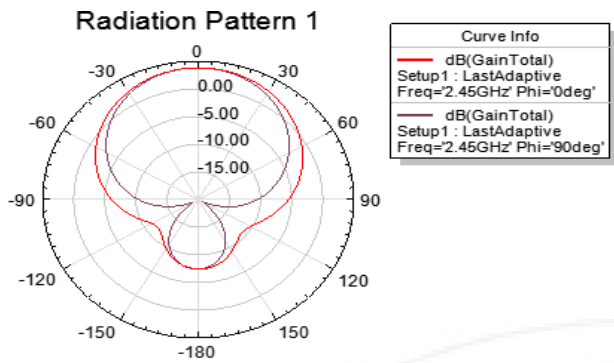


Figure 6: Radiation Pattern at 2.4GHz

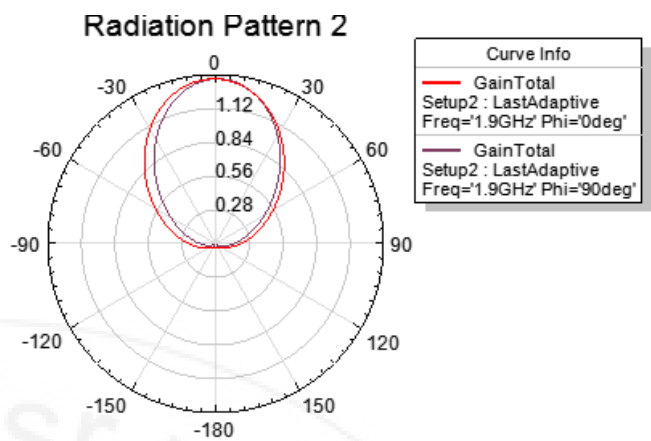


Figure 9: Radiation pattern for 1.9GHz

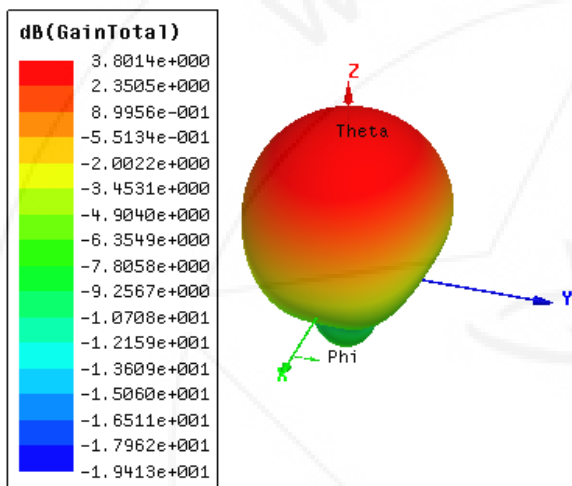


Figure 7: 3D-Gain Total at 2.4GHz

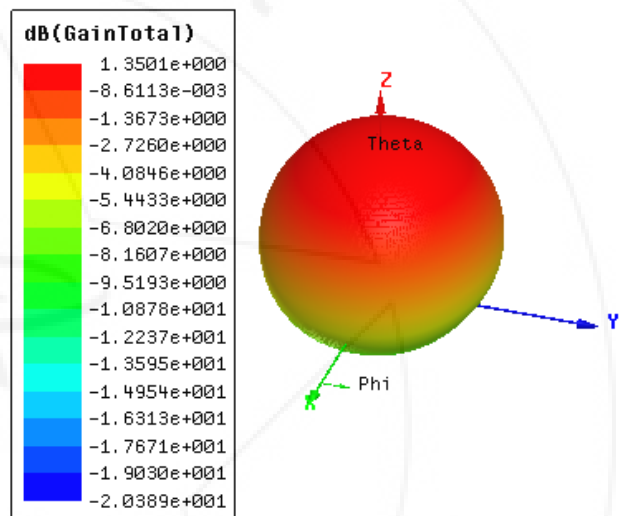


Figure 10: 3D-Gain total at 1.9GHz

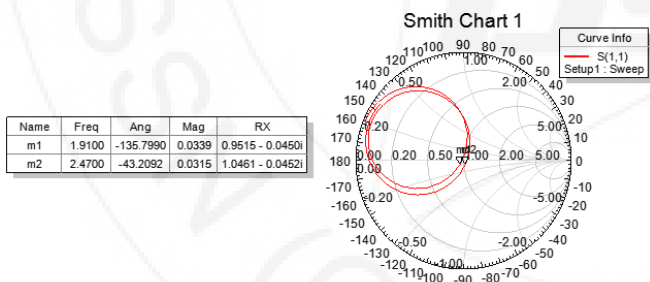


Figure 8: Smith chart

6. Conclusion

The Design of dual band coax patch antenna for GSM and Bluetooth applications has been proposed. It is shown that the proposed dual band antenna can effectively operates in two frequency bands in the range of GSM(1900MHz) and Bluetooth(2400-2500MHz) respectively. The location of the port is optimized in such a way that the antenna can operate in two frequency bands. The return loss , radiation Pattern, VSWR, results obtained are considered to be good and acceptable values. The VSWR level of mismatched is not very high, it is properly matched. It is expected that the proposed antenna is very useful and suitable for GSM with services such as Bluetooth and Wi-Fi respectively.

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