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# MINIATURE COMPONENT DESIGN FOR COMMUNICATIONS WIRELESS APPLICATIONS

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**AUTHOR'S' CONTRIBUTION**

The sole author designed, analysed, interpreted and prepared the manuscript.

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## ABSTRACT

The performance and advantages of microstrip patch antennas such as low weight, low profile, and low cost made them the perfect choice for communication systems engineers, and the integration of more services into personal devices, Personal digital assistants( PDAs) must operate in multiband frequencies. In this paper, a dual band Microstrip antenna is proposed. The proposed antenna is proposed to be used in a mobile phone covering two frequency bands including, GSM, bluetooth, Wifi. A comprehensive analysis of the return loss, radiation pattern and gain of the designed antenna is presented. The effects of packing on antenna parameters have been studied, and the proposed antenna shows a return loss (RL) of (-34,423) dB at (2.401) GHz; (-23.533) dBreturn loss (RL) at a frequency of (1.852) GHz; These are encouraging results. The proposed antenna design and simulation were based on thecomputer system technology (CST) software package.

**Keywords:** Couple band; one layer; microstrip.

## 1. INTRODUCTION

Microstrip radiators were first proposed as early as 1953 while the first actual microstrip antenna appeared in 1974 [1]. Microstrip patch antennas (MPAs) consist basically of three layers: metallic layer with antenna radiating patch, dielectric substrate and another metallic layer as the ground plane [2]. The light weight, low cost, low profile, planner configuration and easy in fabrication are the main advantages of MPA which enable it to be used with microwave integrated circuits. In spite of these advantages, MPAs suffer from low gain and relatively large size [3,4]. Due to the development in the field of wireless network and mobile communication, many researches started to develop multi-band MPAs to cover the bands of GSM 900, GSM 1800, GSM 1900, UMTS, Bluetooth, WLAN... etc. Singh et al. [4] designed a conventional rectangular MPA with Ψ-shaped structure suitable to work in two different frequency bands. Hussein A. Abdulnabi, et al. [5], design and investigates of graphene based plasmonic microstrip antenna for terahertz high speed communication and application systems 0.1-20 THz, the antenna structure composed of grapheme based rectangular patch and transmission line mounted on a grounded silicone dioxide substrate. Shahanawaz Kamal, et al. [6], designed a circular-shaped copper (Cu)-based antenna for 28 GHz mmWave applications, employs air as a substrate to substantially reduce the manufacturing cost. The coaxial probe feed technique was utilized to excite the system. Veereshappa and Mulgi [7], designed a slotted rectangular MPA for quad-band operation and ominidiretional radiation characteristics. Jayasinghe et al. [8], designed a small multi-band MPA for GSM 900, GSM 1800, GSM 1900, UMTS, LTE 2300, and Bluetooth applications using a genetic algorithm. Puri

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and Tiary [9], designed a simple single layer, single feed triangular slot patch antenna with air dielectric substrate for quad-band frequency operation in different wireless applications. Mendha and Kosta [10], designed and simulated a stacked 3-layer rectangular Ultra Wide Band antenna. AL Noman et al. [11], designed a single layer single feed miniaturized MPA for multi services using multi layers separated by dielectric substrates. Kharade and Patil [12], enhanced the gain of the MPA using multi-layer and multi-dielectric layers separated from patch by air as another dielectric. Sayidmarie et al. [13], designed a compact dual-band; dual ring printed monopole antenna for WLAN applications. Wang et al. [14], designed two broad bands MPA using planer line feed to enhance band width by 25%. AL Mously [15,16], designed a triple-band; multi-layer patch antenna for 0.9, 1.8 and 2.4 GHz frequency bands

## 2. DESIGN OF ANTENNA

Different methods can be used in the design of multi-band Microstrip antennas. such as single feed dual-band using higher order modes of the circular microstrip antenna (CMSA) and triangular microstrip antenna (TMSA) are out of our scope.

In this paper, a dual band Microstrip antenna was designed ,and This antenna is designed using CST software and this type of antenna (MPA) has a single feed(coaxial feed)**,**This type of antenna consists of three main layers**.**

1-metal layer ( radiation patch)
2- insulating layer ( Substrat)
3- metal layer (Ground)

Technology has been selected (coaxial feed)Because this technique can be installed in the right place inside the radioactive patch layer To match the impedance**.**

The design of the radiation patch antenna**.**

The coaxial feed consists of three layers:

1-Inner conductor
2-Insulator
3-Outer conductor

As shown in Fig. (1) and Fig. (2)**.**

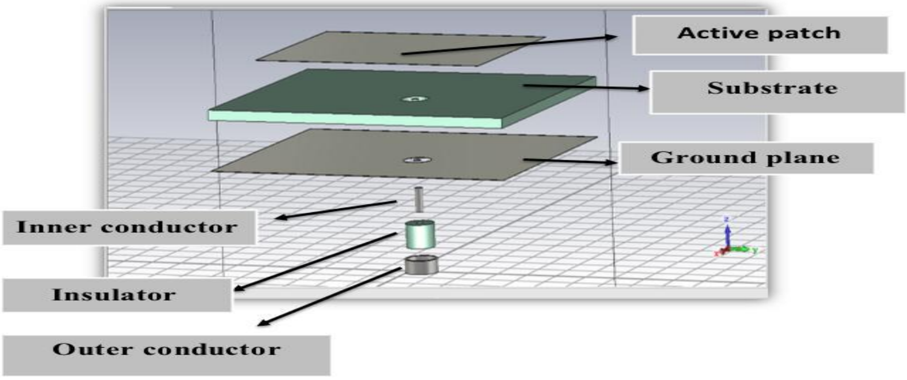



**Fig. 1. Dual band antenna layers and parts of the coaxial feed**

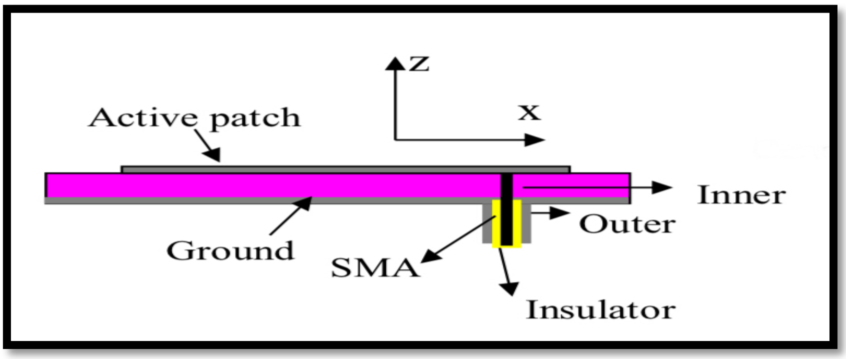



**Fig. 2. Conventional MPA1 side view**

The advantage of this type of antenna is that it is light in weight, cheap in price, and has favorable surface features for mobile devices, and is easy to manufacture and assemble with the rest of the electroniccircuits. Despite its many advantages, it has some disadvantages, such as small gain, relatively large size and narrow bandwidth.

This dual band antenna operates on two frequencies:

• 1st-band centered at fr1 = 2.401 GHz.
• 2nd-band centered at fr2 =1.852 GHz.

This typeof antenna works to cover working communication systems (GSM, WiFi, Bluetooth).

Where the frequency of the first band (2.401) works to cover communication systems (Bluetooth, Wi-Fi).

The second band frequency (1.852) covers communications systems (GSM).

The following are the steps for designing a dual-band radiation patch antenna :

Initially, these equations were used in the design of the dual band antenna. shown in the Table 1.

**Table 1. Used design equations**

| Parameter | Symbol | Equation used |
|---|---|---|
| Resonance frequency [2] | $f_r$ | $f_r = \frac{c}{2W\sqrt{(\varepsilon_{r1}+1)/2}}$ …..(1) |
| Effective dielectric constant [2] | $\varepsilon_e$ | $\varepsilon_e = \frac{\varepsilon_{r1}+1}{2} + \frac{\varepsilon_{r1}-1}{2}\left[1+12\frac{h_1}{W}\right]^{-1/2}$ …..(2) |
| Effective Length [2] | $L_{eff}$ *(mm)* | $L_{eff} = \frac{c}{2 f_r \sqrt{\varepsilon_e}}$ …..(3) |
| Length of patch [2] | *L (mm)* | $L = L_{eff} - 2h$ ..(4) $* 0.412\left[\frac{(\varepsilon_e+0.3)}{(\varepsilon_e-0.258)}\frac{\left(\frac{W}{h_1}+0.26h_1\right)}{\left(\frac{W}{h_1}+0.8\right)}\right]$ |
| Length of ground plane [2] | $L_g$ *(mm)* | $L_g = 6h + L$ …..(5) |
| Width of ground plane [2] | $W_g$ *(mm)* | $W_g = 6h + W$ …..(6) |
| Inset feed location [17] | $x_f$ *(mm)* | $x_f = \frac{L}{2\sqrt{\varepsilon_e}}$ …..(7) |
| | $y_f$ *(mm)* | $y_f = \frac{W}{2}$ …..(8) |

*$\varepsilon_r$ = Relative dielectric constant…..$\varepsilon_r$ = 4.3*
*C = Speed of the light.*
*L = Length of active patch.*
*W = Width of active patch.*
*$x_f$ , $y_f$ = They represent the coordinates of the feeding site.*
*h = Height of the substrate.*

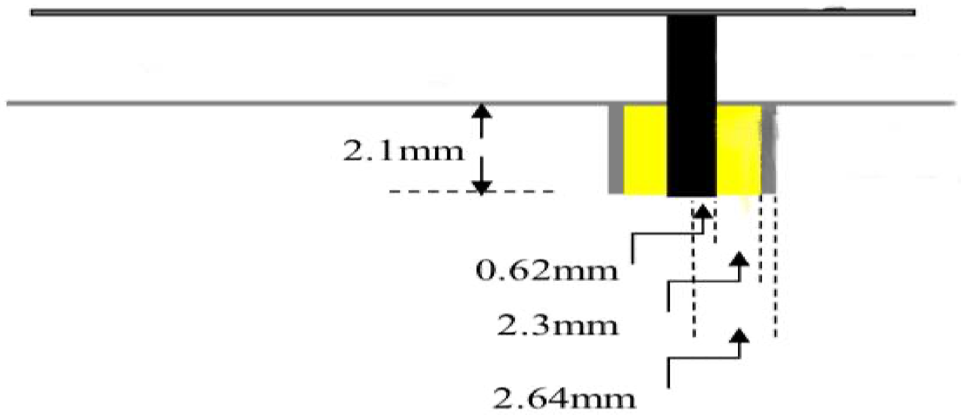



**Fig. 3. Parts of coaxial feed**

**Table 2. Equations result**

| **Parameter** | **L** | **W** | **Lg** | **Wg** | **hc** | **hs** | **X** | **Y** |
|---|---|---|---|---|---|---|---|---|
| Value | 29 | 38 | 40 | 50 | 0.035 | 1.6 | 7.7 | 9.7 |

*As (x, y) represent the coordinates of the coaxial feed*

The antenna was fed with a coaxial cable modeled as a standard link (SMA) with the following specifications shown in Fig. (3). To get impedance( Z = 50 Ω).

- Radius of inner conductor = 0.62 mm.
- Radius of insulator = 2.3 mm.
- Radius of outer conductor = 2.64 mm.
- εr of insulator (Teflon-lossy) = 2.1.
- Length underground plane = 2.1 mm.

After applying the equations shown in table I,the following results were obtained, which are shown in Table 2.

## 3. SIMULATED RESULTS OF ANTENNA

The designed antenna was simulated using (CST) software based on the values and characteristics given in Table 2. Two frequencies were obtained: first resonance frequency *fr*12.38 GHZ, the second resonance frequency *fr2* 1.86 GHZ, the frequency response (dB return loss) of *fr1*(-7.8949), and *fr2* (-4.6007) as shown in Fig. (4). The response (dB return loss) was low in this case, as the lower (dB return loss) should be *(*-10*)*, and the higher its negative values, the better.

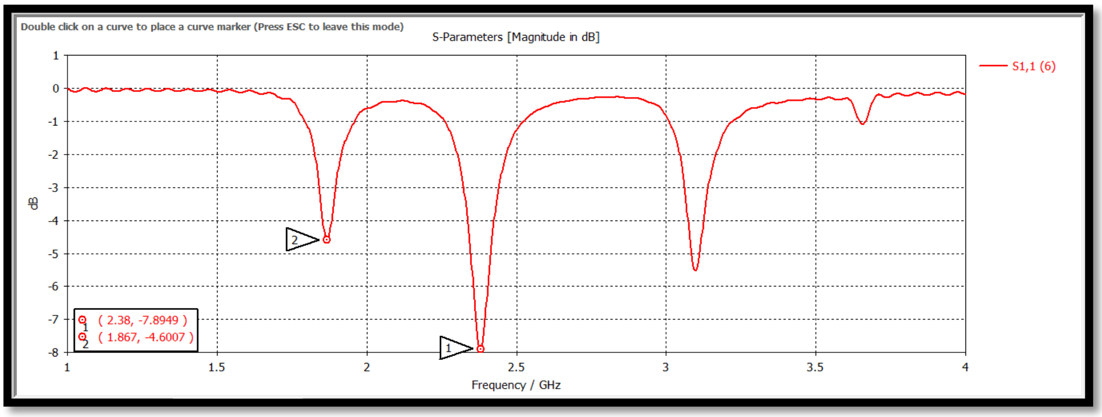
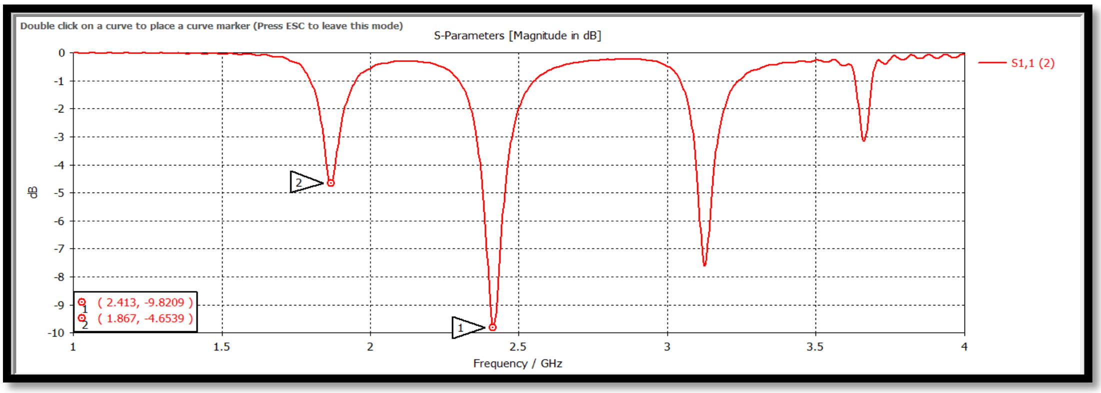
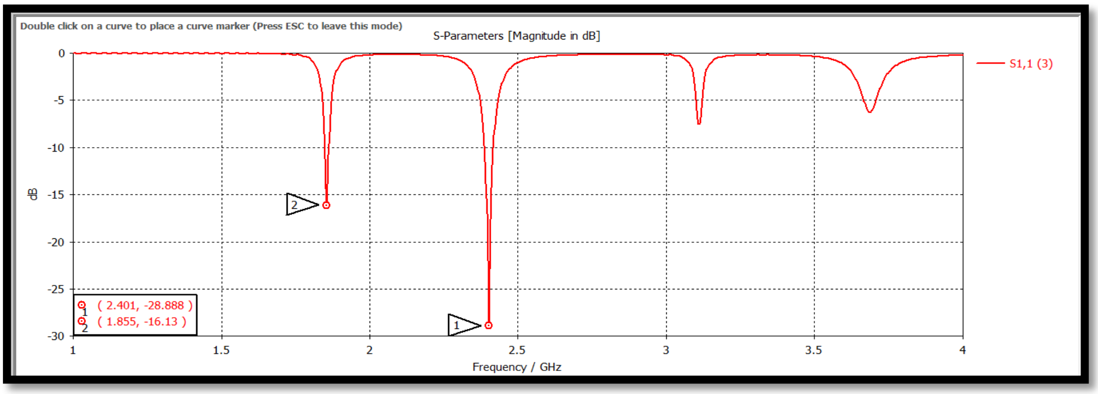



**Fig. 4. first resonance frequency *fr1* equal to 2.38 GHz and second resonance frequency *fr2* of value 1.86GHz**

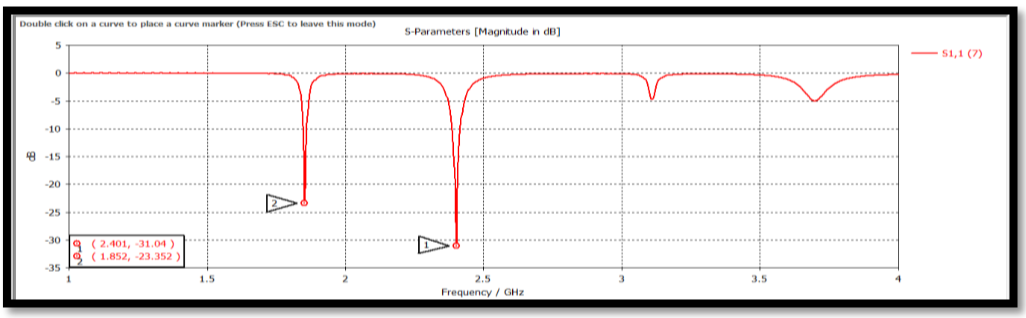
Now we will make adjustments to the values of the coaxial feed (x,y) and the length of the radiating patch (L) to get better values for frequencies and better values for the response, where the values of x = 7, y = 9, L = 28.5. *fr1*was 2.413GHZ, the *fr2* was 1.867GHZ, and the response (dB return loss) for the first frequency was -9.8209, and the second frequency was -4.6539, as shown in Fig. (5-a)**.**We make another adjustment to the same values as follows: x=5, y=5, L=28.6. The *fr1*= 2.401GHZ and the *fr2* =1.855 GHZ were obtained and better response values (dB return loss) for the firstfrequency -28.888 and the second frequency - 16.13 as shown in Fig. (5-b)**.**We continue to make adjustments to the values as follows: x = 4.9, y = 4.1, L = 28.6. The best frequencies were obtained: the *fr1*= 2.401GHZ, the *fr2*=1.852 GHZ, and the response (dB return loss) is a better frequency for the first frequency -31.04 and the second frequency - 23.352 as shown in Fig. (5-c).




(a)




(b)




(c)

**Fig. 5-a,b,c. Simulated return loss of the MPA**

Now we make the last adjustment to the values x = 4.93, y = 4.11, L = 28.6. In this step, the best possible frequencies were obtained, which is for the *fr1*= 2.401GHZ , for the *fr2*=1.852GHZ, and the highest possible response (dB return loss) was also obtained for the frequencies. It is for the first frequency (-34.423) and the second frequency (-23.533). These values are good and give an effective response to the signal sent and received from the radiation patch layer, as shown in Fig. (6).

Now we will perform the remaining calculations (gain, directivity, bandwidth) on the best values obtained for the frequencies : (bandwidth) is calculated according to the following relationship:

$$Bw = \frac{f_h - f_l}{f_c} \times 100\% \quad .....(9)$$

$f_h$ highest frequency$f_l$ lowest frequencyFor frequency bands at -10dB return loss, *fc* the center frequency is the center of the working beam.

We calculate the bandwidth of the first frequency ($fc_1$=2.401GHz) , ($f_{h1}$= *2.4161GHZ* ) , ($f_{l1}$ = *2.3868 GHZ*) as show in Fig. (7-a), then calculate the bandwidth of the second frequency ($fc_2$=1.852GHz) , ($f_{h2}$= *1.8602GHZ* ) , ($f_{l2}$ = 1.8464 *GHZ*) as show in Fig. (7-b)**.**

The results of the calculations for the bandwidth of the first frequency and the second frequency are as shown in the Table 3**.**

Calculate the (directivity, gain) values for the first frequency and the second frequency, since the directivity value for the first frequency is (5.8018) as shown in the Table 4**.**

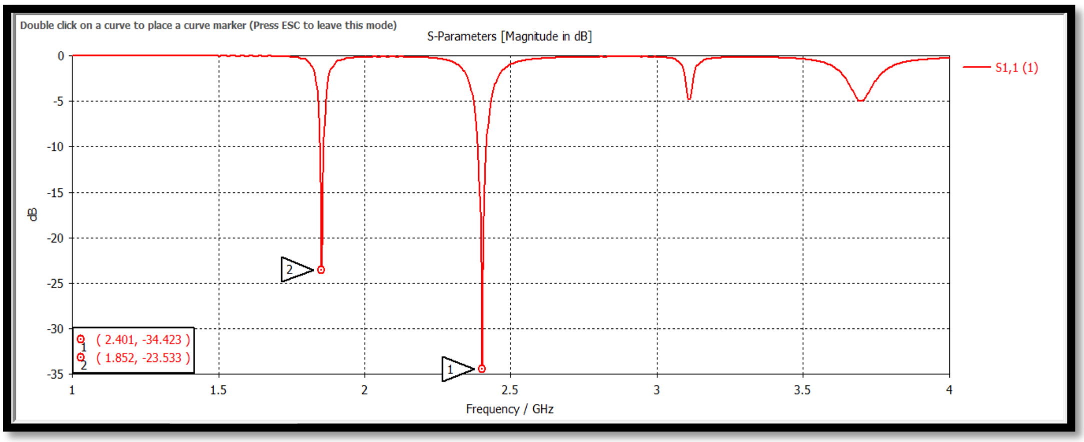
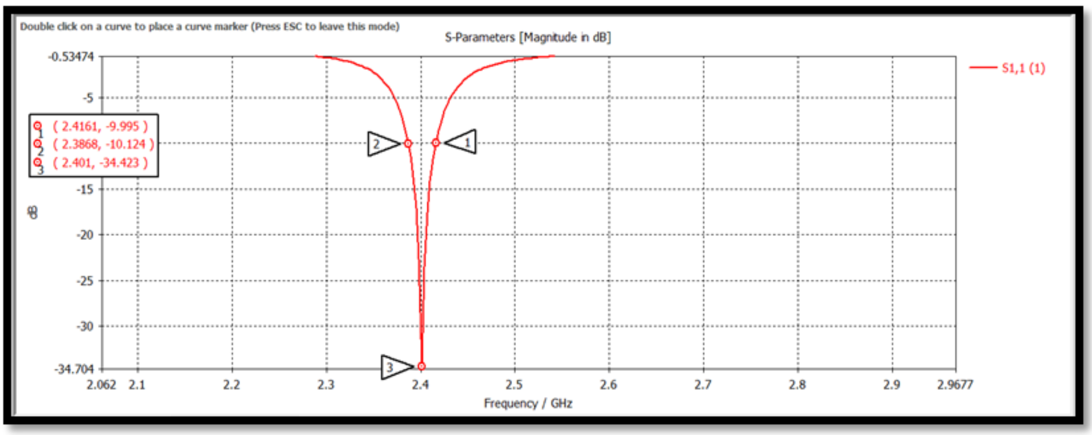
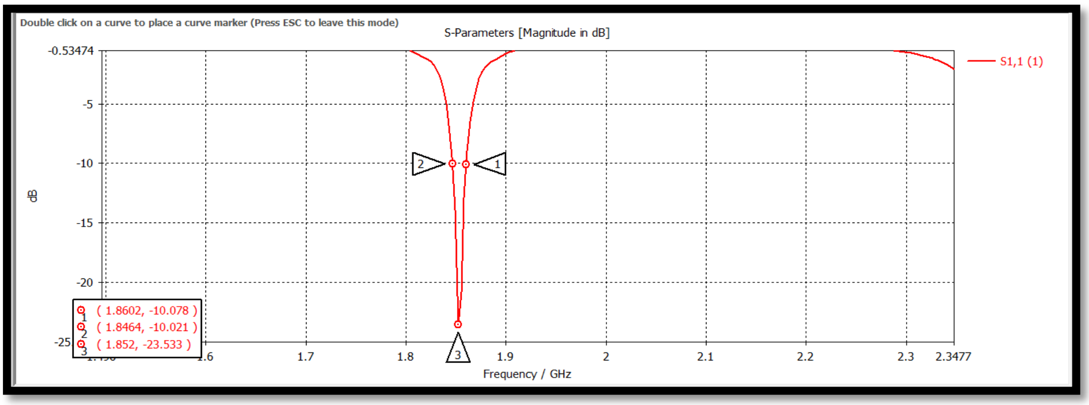



**Fig. 6. Final simulated return loss of the MPA**




(a)




(b)

**Fig. 7. a- Bandwidth for the first frequency**
**b-Bandwidth for the second frequency**

**Table 3. Bandwidth values for the first and second frequencies**

| Beam center frequency | Resonance frequency (GHz) | Backwave Loss Ratio RL (dB) | Bandwidth |
|---|---|---|---|
| *fr1* | 2.401 | -34.423 | 1.22 |
| *fr2* | 1.852 | -23.533 | 0.74 |

**Table 4. Directivity, Gain values for the first and second frequencies**

| Beam center frequency | Resonance frequency (GHz) | Gain | Directivity |
|---|---|---|---|
| *fr1* | 2.401 | 5.8108 | 5.8018 |
| *fr2* | 1.852 | 4.8124 | 4.9808 |

Now make the last adjustment to the values X = 4.93, Y = 4.11, L = 28.6. In this step, the best possible frequencies were obtained, which is for the first frequency (2.401GHZ) for the second frequency (1.852GHZ), and the highest possible response (dB return loss) was also obtained for the frequencies. It is for the first frequency (-34.423) and the second frequency (-23.533). These values are good and give an effective response to the signal sent and received from the radiation patch layer.

## 4. CONCLUSION

A dual-band single-feed microstrip antenna. It turns out that the antenna can work effectively in two frequency bands (Bluetooth, WiFi, GSM). Two central frequencies operating at: (2.401, 1.852) MHz. The bandwidth of each frequency was (1.22) MHz and (0.74) MHz, respectively. The maximum antenna gain is found to be around (5.8108) dB at (2.401) GHz and (4.8124) dB at (1.852) dB. The dimensions of the designed antenna were 40 x 50 x 3.77 mm.And the proposed antenna characteristics, such as reverse diffraction rate, radiation pattern and working bandwidth, are acceptable. The proposed MPA is expected to be very useful for future mobile systems and suitable for mobile phones that have multiple services such as Bluetooth, WIFI and of course GSM or 3G services together.

## COMPETING INTERESTS

Author has declared that no competing interests exist.

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