# Dual-Resonance Microstrip Patch Antenna

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**Abstract:** In this work, a dual resonance microstrip patch antenna is designed and simulated in the 2.5 – 3.5 Ghz band. Simulated results show 2 resonance frequencies at 2.98 and 3.065 GHz. A return loss of -47 dB is achieved. Theta polarized radiation pattern gains have 6 dB value. Desinged antenna is simulated by Sonnet Suites [1], a planar 3D electromagnetic simulator. Details of the simulation results are presented and discussed.

**Keywords:** Microstrip, Patch, Antenna, Compact, Dual-resonance

## 1. Introduction

Microstrip antennas have attracted a lot of antention due to rapid growth in wireless communications area. In this design study, the main purpose was to design a microstrip patch antenna for the various communication systems used in the frequency range of 2.5 to 3.5 GHz. Dual resonances are maintained at 2.98 GHz and 3.065 GHz. The real and (imaginary) parts of the input impedances are 49.57 (-0.05) Ω and 74.99 (5.97) Ω, respectively. Design consists of step by step changes on the geometry which improves the values required in specifications. Some articles and applications are examined about microstrip antennas [2-4]. Previous works deal with the parametric studies made on the geometry in order to meet the specifications. In this work some of those techniques are used.

## 2. Design Procedure

Figure 1 has the top view and Figure 2 has the 3-D view of the antenna. Design started with the main patch shown with the letter A in Fig. 1.The return loss was still less than -10 dB. When the extension B is added, two resonance frequencies are determined. As a dielectiric, FR4 ($\varepsilon_r = 4$) is used. Dimensions of the box are as follows: the length of the X-axis = 300.0 mm, the length of the Y-axis = 300.0mm. Dimensions of the microstrip patch antenna are: the length of the X-axis = 23.00 mm, the length of the Y-axis = 46.00 mm. Probe feed is applied as seen in Figures 1 and 2.

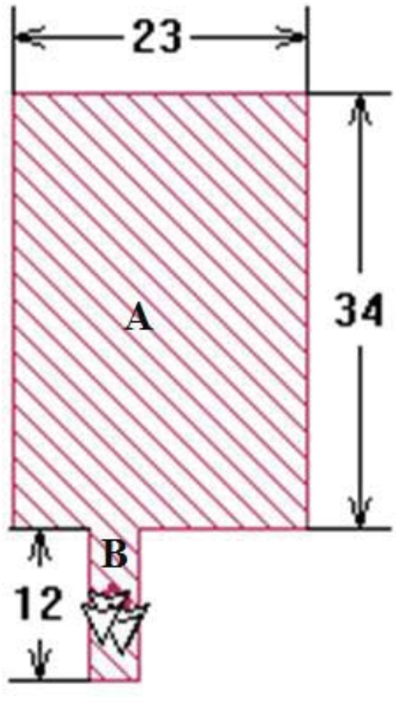


Fig. 1. Top view of the antenna.

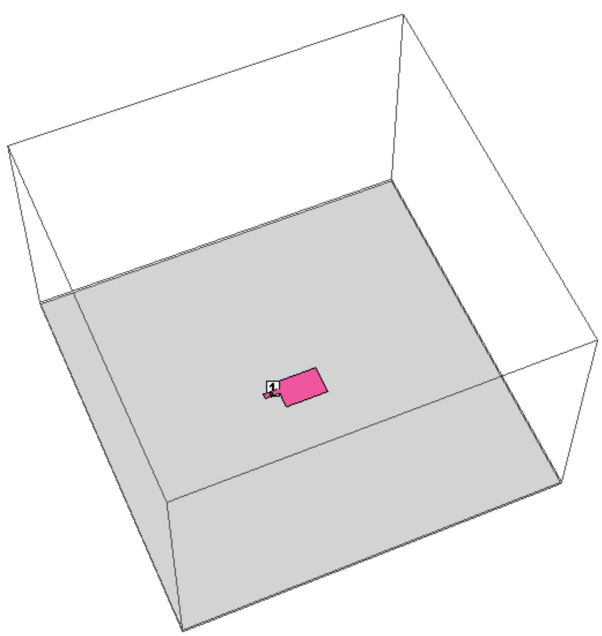


Fig. 2. 3D view of the antenna.

The design started with the rectangle shape but there was no resonance between 2.5-3.5 GHz

Table 1:Values of the parameters with design step 1

| PARAMETERS | $f_c$(GHz) | $S_{11}$(dB) | $Gain_{max}$ (dB) | θ=40° Gain(dB) |
|---|---|---|---|---|
| Step 1 | 2.5 - 3.5 | - 2.1 | θ=25° ⇒ -18.2 | -25 |

The next step was to add the extension B, which is an extension to the main patch near the feed point. This helped to reduce the S11 and increase the gain, and also caused the two resonances.

Table 2:Values of the parameters with design step 2

| PARAMETERS | $f_c$(GHz) | $S_{11}$(dB) | $Gain_{max}$ (dB) | θ=40° Gain(dB) |
|---|---|---|---|---|
| Step 2 | 2.91 | - 23.15 | θ=0° ⇒ 7.36 | 5.97 |
| | 3.035 | - 13.75 | θ=0° ⇒ 6.64 | 5.26 |

Finally, when the extension B is shifted to the left 0.5 mm, an offset feding is maintained. This helped to improve the gain. Table 3 summarizes those changes.

Table 3:Values of the parameters with design step 3

| PARAMETERS | $f_c$(GHz) | $S_{11}$(dB) | $Gain_{max}$ (dB) | θ=40° Gain(dB) |
|---|---|---|---|---|
| Step 3 | 2.98 | - 47.2 | θ=0° ⇒ 7.76 | 6.40 |
| | 3.065 | - 13.75 | θ=0° ⇒ 7.1 | 5.73 |

## 3.Simulation Results

Figure 3 has the input match of the antenna and Figure 4 has the input impedances real part.

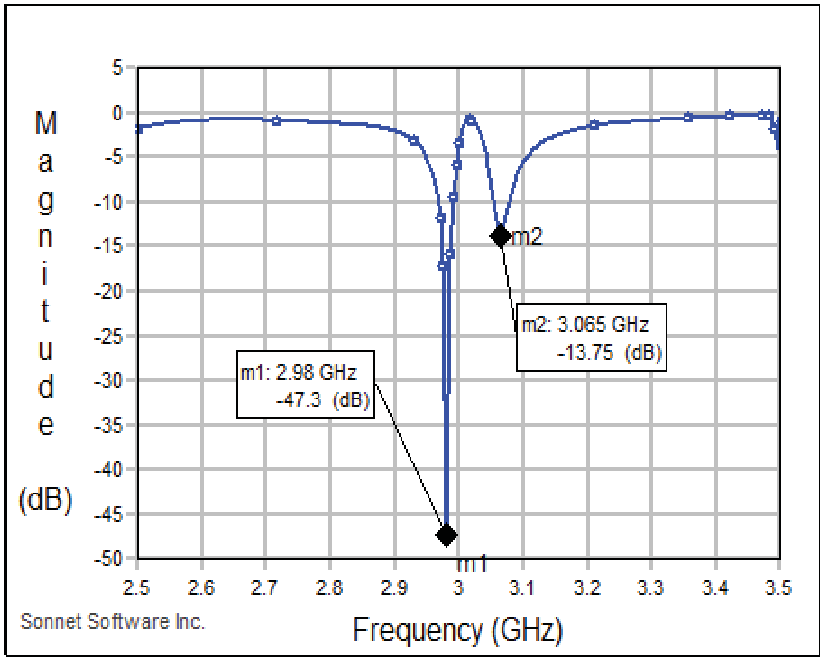


Fig. 3. Input ref. coefficents with dual-resonance.

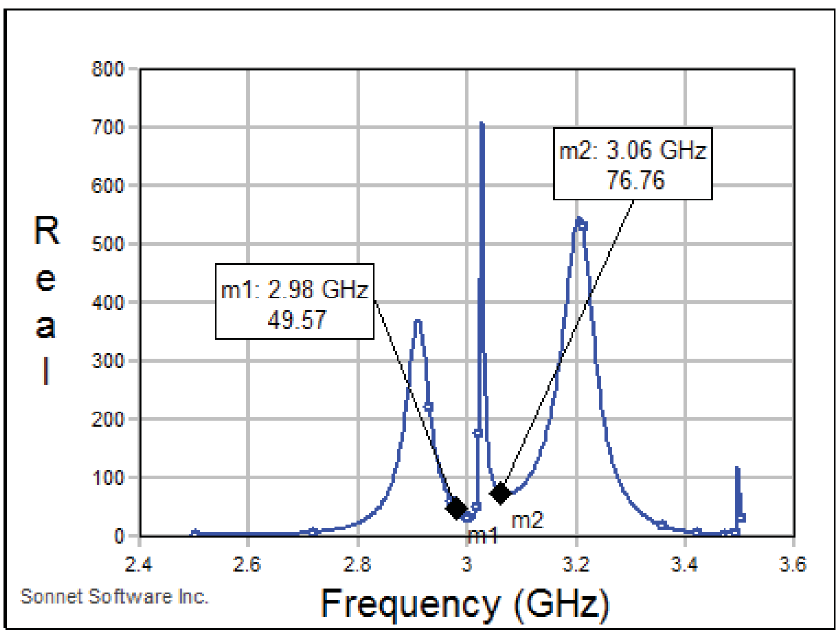


Fig. 4. Real part of the input impedances.

Theta polarized electric field radiation patterns are in Figures 5 and 6 respectively, for two resonance frequencies. Note that, cross polarization levels are near -20 dB.

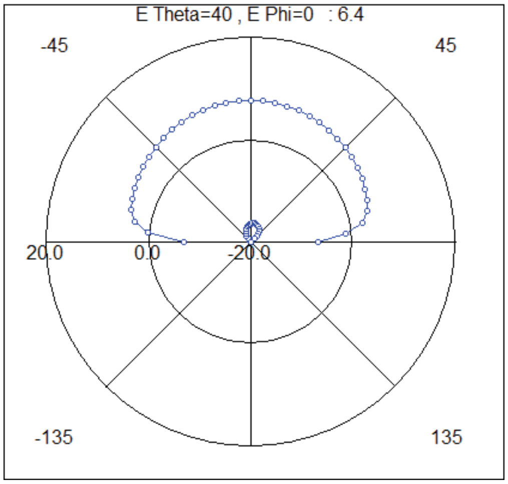


Fig. 5. Radiation pattern at 2.98 GHz.

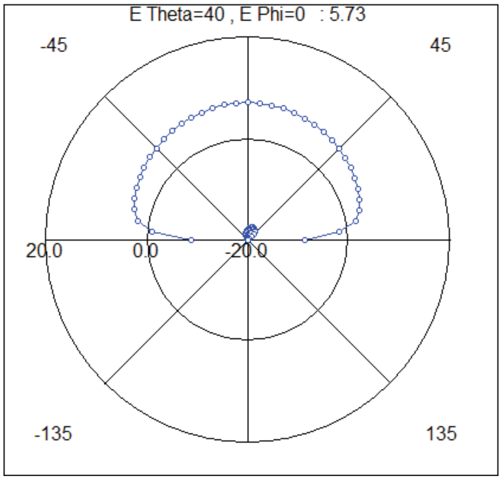


Fig.6. Radiation pattern at 3.065 GHz.

Next design step was to change the cell size in order to use the simulation program effectively. Parameter changes are seen in Table 4.

Table 4: Comparison of the cell size

| Cell cize (mm) | Magnitude (S11:dB) | Resonance Freq. (GHz) | Gain (dB) |
|---|---|---|---|
| **0.25** | **-39.1** | **2.98** | **7.76** |
| | **-12.7** | **3.065** | **7.11** |
| 0.5 | -22.4 | 2.985 | 7.72 |
| | -13.2 | 3.07 | 7.09 |
| 1.0 | -38.6 | 2.98 | 7.78 |
| | -13.1 | 3.06 | 7.1 |

A tolerance analysis is conducted on dielectric thickness. Results are shown in Table 5.

Table 5:Comparison of the dielectric thickness

| Dielectric thickness (mm) | Magnitude (S11:dB) | Resonance Freq. (GHz) | Gain (dB) |
|---|---|---|---|
| 2.65 | -22.4 | 2.985 | 7.72 |
| | -13.2 | 3.07 | 7.09 |
| 2.7 | -24 | 2.98 | 7.78 |
| | -12.79 | 3.065 | 7.71 |
| **2.75** | **-47.3** | **2.98** | **7.7** |
| | **-13.7** | **3.065** | **7.1** |

Figure 7 shows the current on the patch for two resonance frequencies. Currents are crowded at the center of the patch.

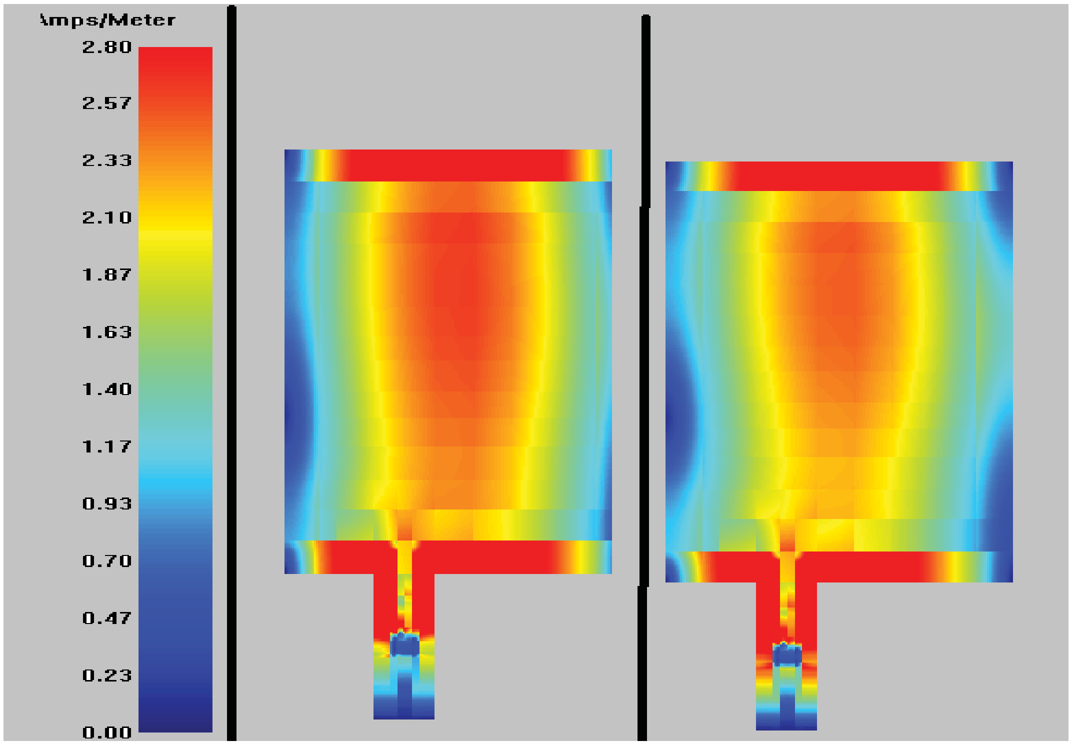


Fig. 7. Current distribution (2.98 GHz and 3.065 GHz) on the antenna.

## 4 Conclusions

A microstrip patch antenna for dual band operation was designed and specifications are met according to simulation results. Dual band operation were successfully incorporated into a single patch. Modifications on the patch geometry helped to maintain and improve the specified design parameters such as; return loss, input impedance, and gain.

## References

1 Sonnet Software, version: 12.56, www.sonnetsoftware.com, 2009.
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