Design of a Planar Antenna for WiFi Applications

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Abstract- **In this report, we design a planar patch antenna for WiFi applications. Our goal The operation frequency can be at 2.4 GHz with 10dB fractional bandwidth of** 1%**. In this report, we choose stacked rectangular antennas for main structure. Finally,the simulation results and the radiation characteristics of patch antenna are demonstrated in this report.**

1 Introduction

Microstrip or patch antennas are becoming increasingly useful because they can be printed directly onto a circuit board. Microstrip antennas are becoming very widespread within the mobile phone market. Patch antennas are low cost, have a low profile and are easily fabricated.

Consider the microstrip antenna shown in Figure 1, fed by a microstrip transmission line. The patch antenna, microstrip transmission line and ground plane are made of high conductivity metal (copper(pure)). The patch is of length L=29.24mm, width W=38mm, and sitting on top of a substrate (FR-4) of thickness h=1.6mm with permittivity $\varepsilon_r = 4.3$.

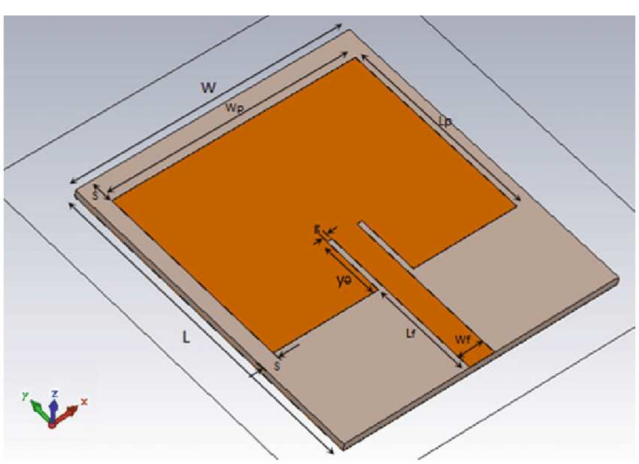

Fig. 1. Architecture of patch antenna

2 DESIGN PROCEDURE

2.1 *Half-Wavelength Microstrip*

The following equations can calculate wavelength. The half-wavelength of microstrip $\frac{\lambda}{2}$ can be determined by (1). Because we select W >h, (2) is used to determine ε_{eff}.

$$\frac{\lambda}{2} = \frac{150}{f\sqrt{\varepsilon_{eff}}} \tag{1}$$

where f is operation frequency.

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + [\frac{\varepsilon_R - 1}{2\sqrt{1+12(\frac{h}{W})}}] \tag{2}$$

where $\frac{W}{h} > 1$.

2.2 *Patch Size*

For the microtstrip patch antenna, the patch width P and length L can be determined by (3) and (6) respectively.

$$P = \frac{v_0}{2f}\sqrt{\frac{2}{\varepsilon_r + 1}} \tag{3}$$

where $v_0 = 3 \cdot 10^8$.
The effective permittivity for patch ε_{patch} is calculated as

$$\varepsilon_{patch} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}[1 + 12\frac{h}{P}]^{\frac{1}{2}} \tag{4}$$

Due to the fringing fields, the electrical length of the patch is longer than its physical length. To compensate, ΔL is calculated.

$$\Delta L = 0.412 \cdot h\frac{(\varepsilon_{patch} + 0.3)(\frac{P}{h} + 0.264)}{(\varepsilon_{patch} - 0.258)(\frac{P}{h} + 0.8)} \tag{5}$$

Finally the length can be calculated, accounting for the fringing fields, as

$$L = \frac{v}{2f\sqrt{\varepsilon_{patch}}} - 2\Delta L \tag{6}$$

2.3 *Operation Frequency Adjustment*

Since the operation frequency is not as same as the value calculated in the above equations, we need some adjustment on size of patch. The constant A is calculated by $\frac{f_0}{f}$ where f_0 is the result in CST,and new length of patch $L' = A \cdot L$

2.4 *Waveguide Port Feed*

Waveguide ports are used to feed the calculation domain with power and to absorb the returning power. In modeling, we select proper port extension coefficient k to set port size, where k can be determined by toolbox in CST.

3 SIMULATION RESULTS AND DISCUSSION

Figure 2 shows the reflection coefficients(S_{11}) as a function of frequency. The microstrip patch antenna has impedance match over frequency range from 2.36 GHz to 2.43GHz. That fractional bandwidth with 10dB is about 3% which reaches our goal.

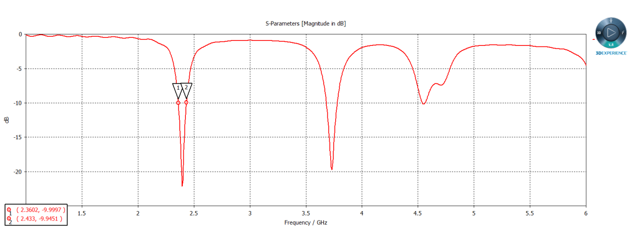

Fig. 2. S11parameter as a function of frequency

Figure 3 to 5 shows the radiation pattern in 3D and polar plots. Figure 6 and 7 are directivity. Figure 8 and 9 are gain. Figure 10 and 11 are radiation efficiency and polarization versus frequency.

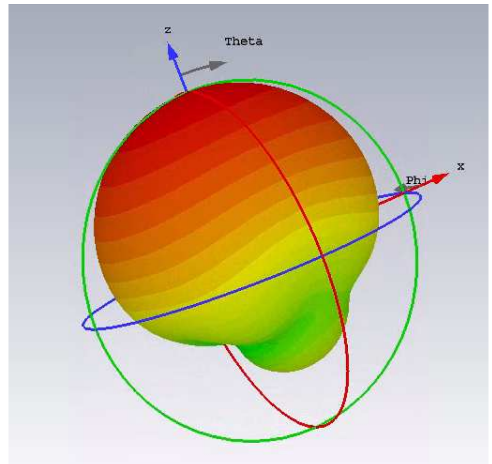

Fig. 3. 3D radiation pattern

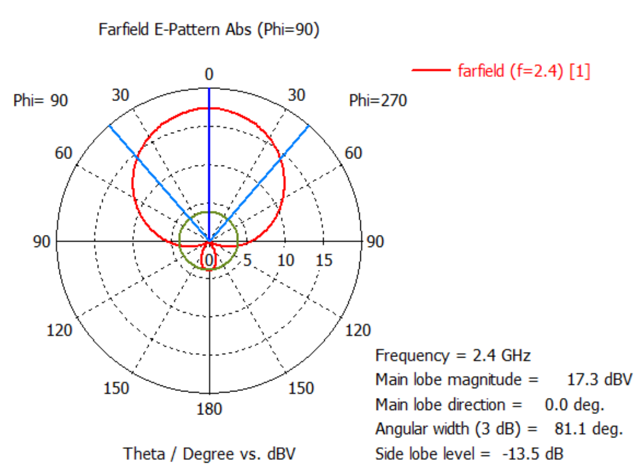

Fig. 4. Radiation pattern in YZ plane

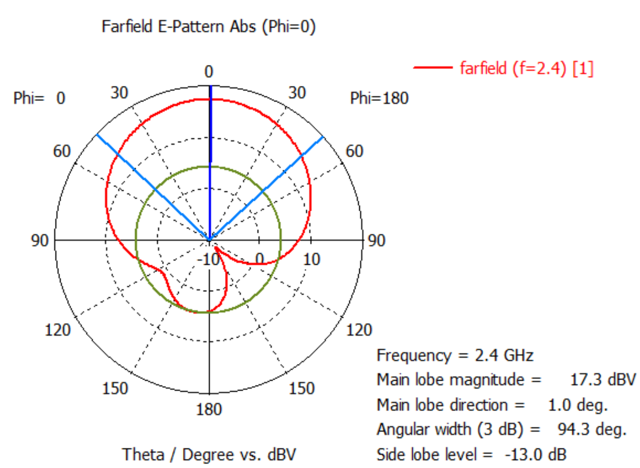

Fig. 5. Radiation pattern in XZ plane

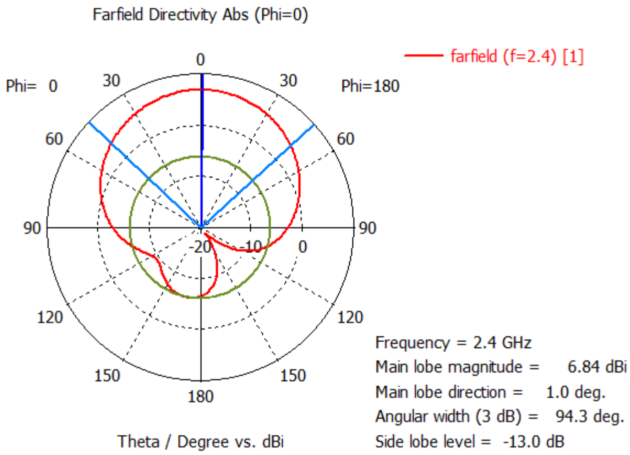

Fig. 6. Directivity in XZ plane

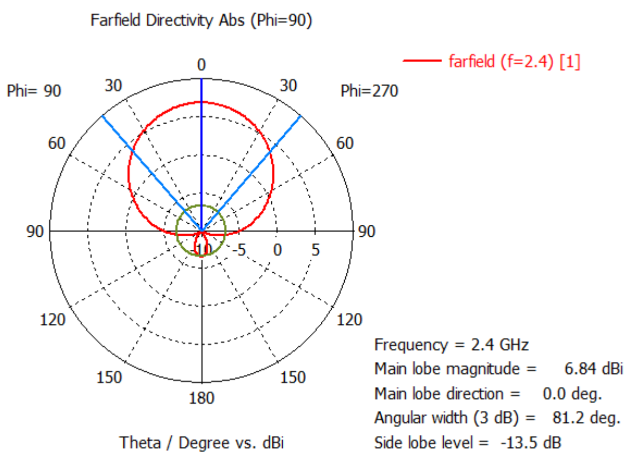

Fig. 7. Directivity in YZ plane

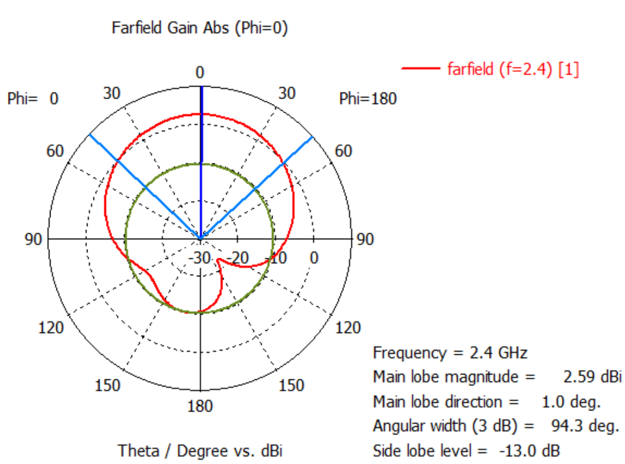

Fig. 8. Gain in XZ plane

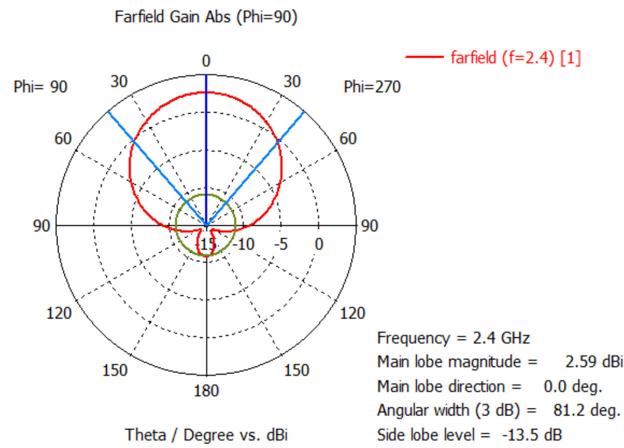

Fig. 9. Gain in YZ plane

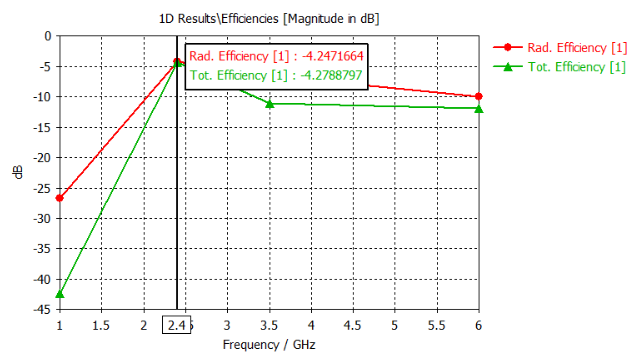

Fig. 10. Radiation efficiency

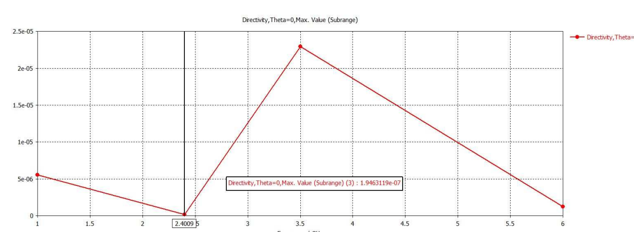

Fig. 11. Polarization

The directivity has angular width(3dB) about 90° and main lobe magnitude 6.84dBi, but gain are less than 3dB as well as low radiation efficiency. Polarization is below -3dB, which means the antenna is hard to receive circular wave.

4 CONCLUSION

In this report, we design a patch antenna, and meet our goal. This antenna radiates towards the desired zenith direction with a maximum gain of 2.94dBi.However, radiation doesn't have good performance. That is, there is 38% power radiated by antenna. Hence, there is still much to be desired in impedance matching.