DOUBLE BI-QUAD ANTENNA

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I. Introduction

THE objective of this project was to design an antenna for energy harvesting at vertically polarized 5.8 GHz. This group chose a double bi-quad directional antenna on a printed circuit board with 50 ohm SMA connector. The bi-quad antenna was chosen for its high gain, directivity and simplicity to fabricate. Our design consists of four equally sized squares radiating element and one reflector. It resulted in a high directivity and peak gain(14 dBi).

II. Design and Simulation

The double bi-quad antenna was first created and simulated in NEC software before fabricating the antenna. The antenna was constructed so that the four squares each had a side length equal to one quarter wavelength of 5.8 GHz, or 13 mm. The ground plane was designed to be 3.4 mm away from the radiating elements. The physical design of the simulated antenna can be seen in Figure 1 and Figure 3.

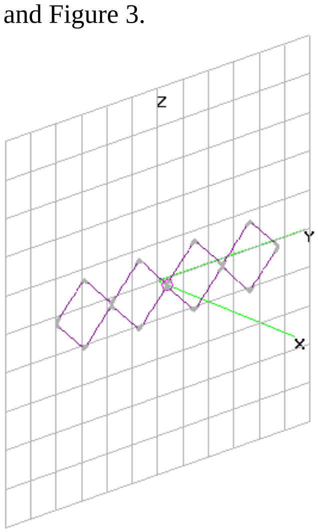
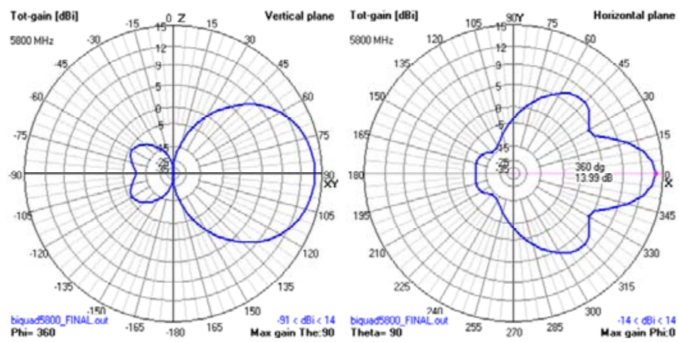


Figure 1. Double bi-quad antenna constructed in NEC.

Simulation of the antenna at 5.8GHz showed a peak gain of 14 dBi in the vertical plane and very good directivity. The impedance of the antenna was reported at 4.6 + j8.6 ohms, which is very close to the desired 50 ohms. Making an appropriate matching network is quite simple.



(a) vertical plane (b) horizontal plane

Figure 2. Simulation of double bi-quad antenna pattern.

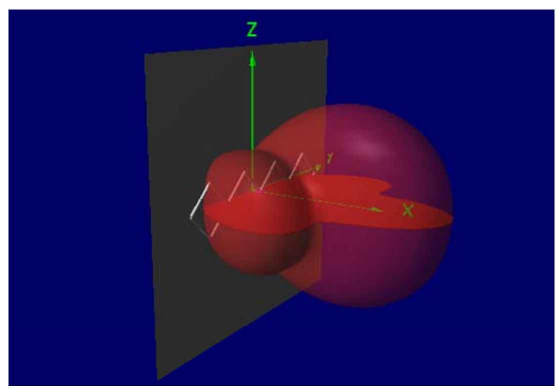


Figure 3. 3D model of double bi-quad antenna with overlayed 3D radiation pattern in NEC.

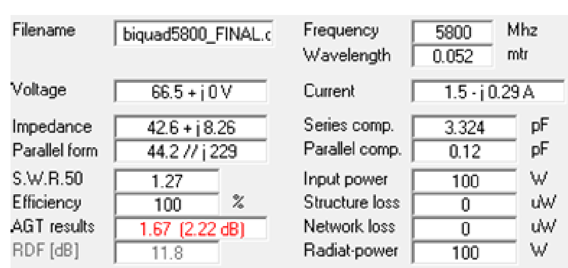
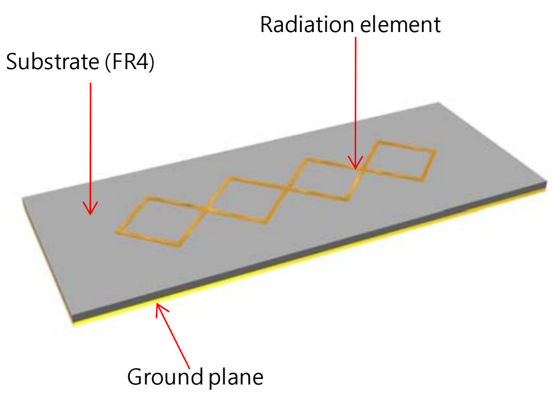


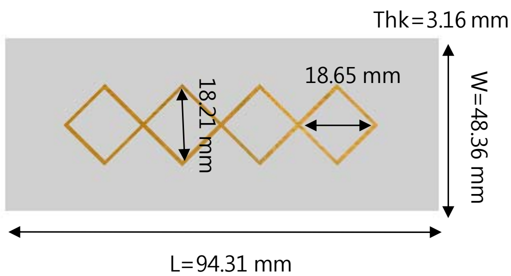
Figure 4. Antenna and simulation characteristics from NEC.

III. FABRICATION

The double b-quad antenna was milled on to a printed circuit board which is composed of a substrate layer of FR4 and a 1.4 mil layer of copper on one side of the FR4. The radiating elements were milled out of the copper layer, and a single hole was drilled in the middle to attach the SMA connector. The ground plane was cut in the same shape and placed directly below the PCB with the radiating element. Simulation showed that a normal two-sided copper PCB would have the ground plane too close to the radiating elements, so we elected to glue the two one-sided layer PCBs together. The final PCB size is 94.31 mm x 48.36 mm x 3.16 mm.



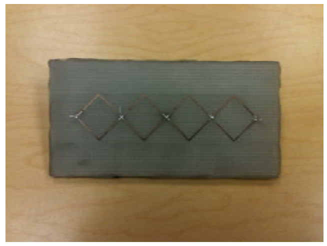
(a) 3D view



(b) Top view

Figure 6. Dimensions of the fabricated double bi-quad antenna.

The radiating elements (double bi-quad shape) were etched out of a copper layer on FR4, bent at 90 degrees. The width of traces is 0.254mm (10 mils). Figure 1 shows the dimensions and layout of the antenna and Figure 2 shows the final, fabricated double bi-quad antenna design.



(a) Front side

(b) Back side

Figure 7. Final double bi-quad antenna produced with milling machine.

IV. EXPERIMENT & RESULTS

Once the antenna was printed on to a circuit board, it was tested using a network analyzer. The return loss (S11 parameter) shown in Figure 8 has two peaks at 6.30GHz and 7.82GHz. The result was quite different from our simulation.

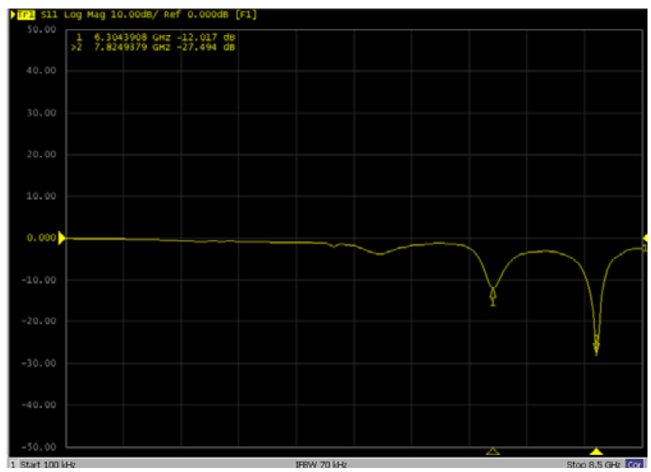


Figure 8. Return loss (S11 parameter) of the antenna measured with network analyzer.

V. CONCLUSION

The produced antenna would indeed work at the desired 5.8 GHz, but turned out to be a far more effective antenna at 7.82 GHz.

REFERENCES

[1] Macro Zennaro, Carlo Fonda, "Radio Labortory Hand book " Volume 1, 2004.02

[2] MicroWave Antenna Book Online, *"http://www.qsl.net/n1bwt/contents.htm"*

[3] RF Cafe Antenna Patterns and Gains *"http://www.rfcafe.com/references/electrical/antenna_patterns.htm"*

[4] Trevor Marshall BiQuad Antenna *"http://www.trevormarshall.com/biquad.htm"*

Appendix

INPUT NEC FILE FOR DOUBLE BI-QUAD ANTENNA DESIGN

```
SY L=.0517
SY A = .1814 * L  'Element dimensions
SY B = A * 2
SY R = 0.000254  'Wire radius
SY G = R + .001*L    'Gap for soldering to feed
SY H = 0.0017018*2 'Element height over reflector
SY RX = 1 *L  'Reflector vertical length / 2
SY RY = 1 *L  'Reflector horizontal length / 2
SY RH = .230  *L 'Height of reflector sides
GW   11 10 H  0   G  H  A  A  R
GW   21 10 H  A  A  H  2*A   G  R
GW   9   1   H  0   -G H  0   G  R
GW   12 10 H  0   -G H  A  -A R
GW   22 10 H  A  -A H  2*A   -G R
GW   8   1   H  2*A   G  H  2*A   -G R
GW   31 10 H  2*A   G  H  3*A   A  R
GW   41 10 H  3*A   A  H  4*A   G  R
GW   32 10 H  2*A   -G H  3*A   -A R
GW   42 10 H  3*A   -A H  4*A   -G R
GW   7   1   H  4*A   G  H  4*A   -G R
GW   51 10 H  0   G  H  -A A  R
GW   61 10 H  -A A  H  -2*A  G  R
GW   52 10 H  0   -G H  -A -A R
GW   62 10 H  -A -A H  -2*A  -G R
GW   6   1   H  -2*A  G  H  -2*A  -G R
GW   71 10 H  -2*A  G  H  -3*A  A  R
GW   81 10 H  -3*A  A  H  -4*A  G  R
GW   72 10 H  -2*A  -G H  -3*A  -A R
GW   82 10 H  -3*A  -A H  -4*A  -G R
GW   5   1   H  -4*A  G  H  -4*A  -G R
SM   12 10 0   -RY   -RX   0   RY    -RX
SC0  0   0   RY    RX
GE   0
GN   -1
EK
EX   0   9   1   0   1.  0   0
FR0  0   0   0   5800  0
RP0  73 73 1001  -90.   90.    5.  5.  10000.
EN
```