Performance of Vertically-Polarized, Half-Rhombic Antennas Fabricated with Direct Write Technology

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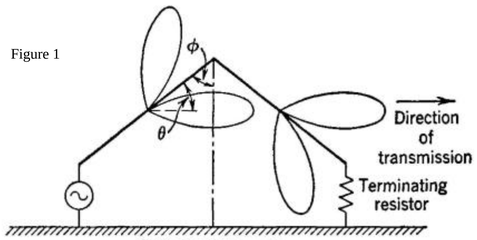
1. Objectives

This study investigated the use of direct-write technology to construct vertically-polarized, half-rhombic antennas (Figure 1). By the Method of Images principle, these antennas perform like full-rhombic antennas. Antennas were fabricated with a material deposition printing system and from wire. The feed end of the antennas was connected to an SMA connecter. A chip resistor was connected to the other end to terminate the antenna. In further work, the antennas will be compared to models generated with Numerical Electromagnetic Code (NEC-4) computer software.

Figure 1



Source: http://www.vias.org/albert_ecomm/aec12_radio_wave_propagation_027

2. Procedure

Stage 1 - Building:

- Equipment
  - nScrypt 600-3Dn-HP machine (Figure 2)
  - Omegalux LMF-3550 oven (not pictured)
- Conductive ink
  - ECM LLC (CI-2002)
- Flexible substrate
  - Kapton (HPP-ST)
- Rhombic Specifications (Figure 3)
  - Included angles of 30˚, 35˚, 40˚, 45˚ (θ)
  - Leg length of 125 mm (L)
  - Printed trace width of 1 mm

Figure 2

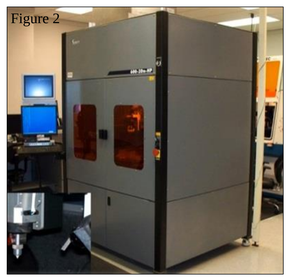
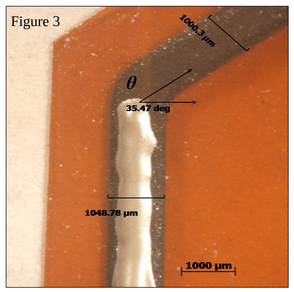
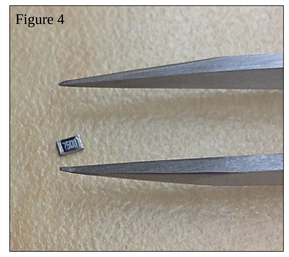


Figure 3



- Termination
  - Surface mount chip resistors (Figure 4)
  - Varied resistance values to achieve the best impedance match
  - Soldered to terminating end

Figure 4



Stage 2 - Testing:

- Ground plane
  - 91 cm x 91 cm (36” x 36”)
  - SMA connector centered on ground plane
- Used Vector Network Analyzer (VNA) to measure S_{11}/Reflection Coefficient
- Input impedance (Z_{in}) calculated from S_{11}:

$$Z_{in} = Z_o \frac{(1+S_{11})}{(1-S_{11})}$$

Figure 5

Figure 6

Stage 3 - Simulation:

- NEC-4 Software used to model:
  - Input Impedance
  - Gain
  - Radiation Pattern

3. Results

CI-2002 Ink Antenna:

(θ = 35˚ - Figures 5 and 6)

- Resistance of trace was an unexpectedly large value of 3.87 kOhm
- Terminating resistor was not necessary
- Behavior more consistent with that of a Vee antenna
- Measured input impedance (Figure 7) and Smith Chart (Figure 8)

Figure 7

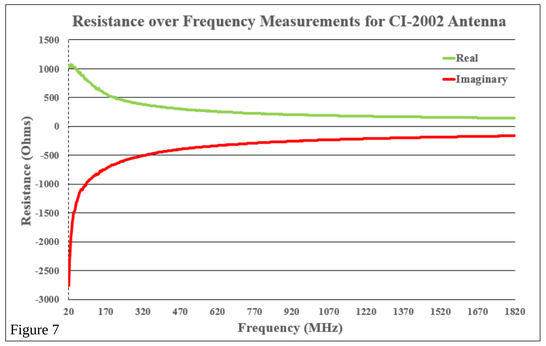
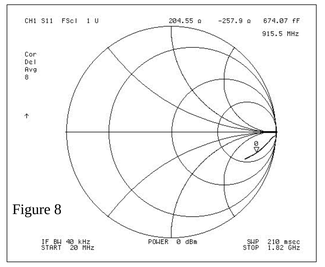


Figure 8



Smith Chart for the CI-2002 Antenna

Copper Wire Antenna:

(θ = 35˚ - Figure 9)

- Wire resistance of 0.37 Ohm
- Built to mimic dimensions of ink trace antenna
  - 18 AWG cylindrical wire
  - 1 mm diameter
- 372.63 Ohm terminating resistor attached
- Measured input impedance (Figure 10) and Smith Chart (Figure 11)

Figure 9

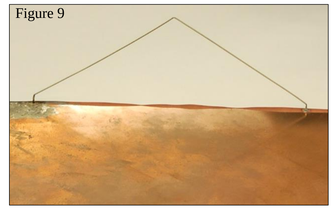


Figure 11

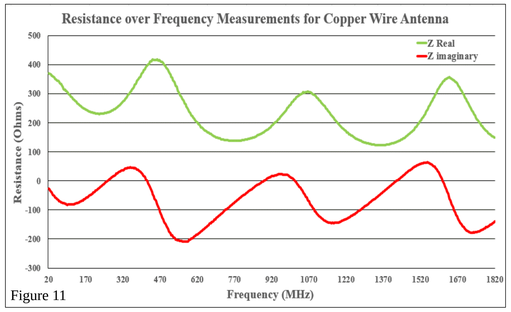
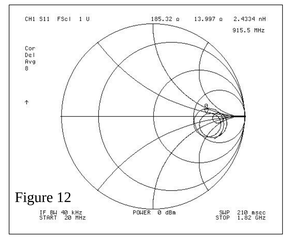


Figure 12



Smith chart for the Copper Wire Antenna

4. Conclusion

The CI-2002 ink used did not have the conductive properties that were necessary to construct the desired vertically-polarized, half-rhombic antenna.

Further Work:

Future research with a different conductive ink will offer a direct-write technology fabrication method for vertically-polarized, half-rhombic antennas with significant advantages over wire antennas:

- Inexpensive manufacturability
- Easy design adaptability
- High bandwidth and directivity

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