

High Directivity Patch Array Antenna with Fractal Structure for Wireless Power Transmission

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I. INTRODUCTION

Wireless power transmission (WPT) enables energy transfer without physical connections. High-directivity antennas are mandatory in these systems to efficiently direct energy toward the receiver. Unlike usual array architecture, a fractal architecture allows better control over the feeding and transmission losses, while allowing all antenna to be on the same phase.

II. ANTENNA STRUCTURE

For wireless power transmission, having a large bandwidth is less important than achieving high gain. Therefore, a patch array antenna was chosen for this purpose. All subsequent calculations are based on reference [1].

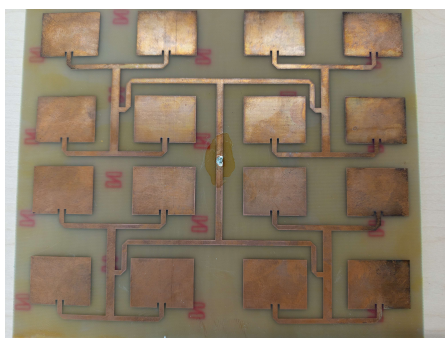


Figure 1. Produced Antenna

To maximize the transmitted power, all patches must operate in phase. A fractal architecture (Figure 1) was implemented with this goal in mind. Although FR4 was selected as the substrate due to its low cost and availability, its high loss tangent limits efficiency and thus reduces the power that can be transmitted. The input port is on the center of the antenna.

The feed network uses varying microstrip widths to maintain 50 Ohms at the inputs of the patch elements. More precisely, an augmentation of the width (4 mm for input port line, 5 mm for the other dividing line) when a single 50 Ohms line (2.9 mm) divide into two lines.

III. ANALYSIS AND EXPERIMENT

The antenna was analyzed using the Method of Moments (ADS Momentum), assuming an ideal ground plane and a perfect 50-Ohm input port with no losses.

Theoretical gain and directivity were estimated for far-field operation (with a target distance of over 1 meter). The antenna was fabricated on 1.6 mm thick FR4. Simulations yielded a directivity of 16.2 dBi, a gain of 13.2 dBi, and a maximal aperture gain of about 15.4 dBi.

Practical measurements showed a gain of approximately 12 dBi. The S11 is about -22 dB at the antenna frequency (2.5 GHz)

$$\eta = \frac{G}{D} = \frac{10^{(G_{dBi}/10)}}{10^{(D_{dBi}/10)}} \quad (1)$$

$$P_r = P_t + G_t + G_r - 20 \cdot \log \frac{(4 \pi R)}{\lambda} \quad (2)$$

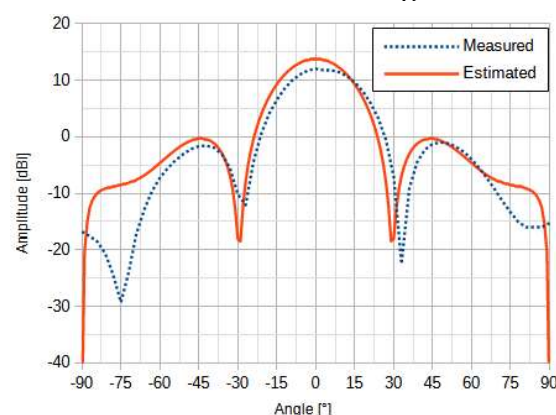


Figure 2. Radiation Pattern of the antenna (scaled with gain)

The fabricated antenna have a simulated efficiency of 50.1% and a measured efficiency of 38%. Given this gain, approximately 15 mW of power can be received from a 1 W input (Fig 2). The antenna can performs in the near field, reaching 100 mW (for an input of 1W) at a distance of 0.38 m.

IV. CONCLUSION

The antenna achieved a measured gain of 12 dBi. To enhance performance, future designs should consider using low-loss substrates such as Rogers RO4350 and more efficient feed networks. The current design is suitable for both far-field and near-field WPT due to its directivity and gain. Future implementations could employ arrays of these antennas at the transmitting end for improved far-field performance.

REFERENCES

[1] C. A. Balanis, *Antenna Theory: Analysis and Design*, 4th ed. Hoboken, NJ, USA: Wiley, 2016.

ACKNOWLEDGEMENT

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