Reconfigurable Low Profile Antenna

James Soon
Advisor: Dr. Prasad Shastry
Topics

- Introduction
- Project Design Objectives
- Antenna Polarization
- Methods/Diagrams
- Results
- Conclusions
Diversity

- Multiple copies of information
- Reduces effects of signal fading
- Time
- Space
- Frequency
- Polarization
Polarization

- orientation of electric field vector
- described by geometric figure traced by sum of e field vector
- linear – horizontal/vertical
- circular – right hand/left hand
The sum of the E field vectors determines the sense of polarization
Wave is travelling toward viewer - Out of the paper

Vertical polarization

Counter Clockwise

Clockwise

RHCP

LHCP

Horizontal polarization

Phase angle between E Field Vectors

-180° -135° -90° -45° 0° +45° +90° +135° +180°
- Dual port polarization diverse device
Project objectives

- Design
- Simulate
- Manufacture
- Analyze
Design Characteristics

- Antenna construction
  - Microstrip
- Antenna feed structure
  - Microstrip line
- Diode biasing
  - Independent
Circular Polarization

Truncated

Nearly Square

Hybrid fed patch

Reactive splitter fed patch
- Antenna with switchable polarization
Design Specifications

- Gain > 5dBi
- Frequency Range: 2.4 GHz range
- Return Loss < -15 dB
- Polarization: Linear; RHCP or LHCP
- Bandwidth: approx. 2%
- VSWR 2.0:1
Methods

- **CAD tools**
  - PCAAD
    (Personal Computer Aided Antenna Design)
  - ADS – Momentum
    (Advanced Design System)
- **Microwave Integrated Circuit Fab Lab**
- **Network Analyzer, Anechoic Chamber**
Preliminary Design

- Basic patch design equations from “Antenna Theory” by Balanis
\[ W = \frac{V_0}{2f_r} \sqrt{\frac{2}{\varepsilon_r + 1}} \quad \Delta L = 0.412h \frac{(\varepsilon_{eff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{eff} - 0.258)(\frac{W}{h} + 0.8)} \]

\[ \varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \left[ 1 + 12 \frac{h}{W} \right] \]

\[ L = \frac{1}{2f_r \sqrt{\varepsilon_{eff}} \sqrt{\mu_0 \varepsilon_0}} - 2\Delta L \]
Preliminary Design

- Basic design equations from Balanis text
- Iterative calculations to optimize L & W
- PCAAD for further optimization and analysis
Preliminary Design

- Basic design equations from Balanis text
- Iterative calculations to optimize L & W
- PCAAD for further optimization and analysis
- Momentum analysis
Eqn \[ VSWR = \frac{1 + \text{mag}(S(1, 1))}{1 - \text{mag}(S(1, 1))} \]
Preliminary Design

- Basic design equations from Balanis text
- Iterative calculations to optimize L & W
- PCAAD for further optimization and analysis
- Momentum analysis
- Quarter wave impedance matching
Preliminary Design

- Momentum analysis with quarter wave matching
3D Top View
Results

- Design Specifications vs
- Simulation Results vs
- Measured Results
# Design vs Measured Results

<table>
<thead>
<tr>
<th>Design</th>
<th>Actual</th>
<th>Ant 1</th>
<th>Ant 2</th>
<th>Ant 3</th>
<th>Ant 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain: &gt; 5dBi</td>
<td></td>
<td>5.57</td>
<td>?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freq: 2.4 GHz</td>
<td></td>
<td>2.42</td>
<td>2.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RL: &lt; -15 dB</td>
<td></td>
<td>-25</td>
<td>-14.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polar: Linear/Circ.</td>
<td></td>
<td>Linear</td>
<td>Linear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BW: 2%</td>
<td></td>
<td>2.7%</td>
<td>1.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VSWR 2.0:1</td>
<td></td>
<td>1.11:1</td>
<td>1.48:1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Simulated vs Measured Results

<table>
<thead>
<tr>
<th></th>
<th>fr</th>
<th>R.L.</th>
<th>VSWR</th>
<th>Zin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ant 1 Simulation</td>
<td>2.40 GHz</td>
<td>-13.2 dB</td>
<td>1.55</td>
<td>38.5 Ohms</td>
</tr>
<tr>
<td>Ant 1 Measured</td>
<td>2.42 GHz</td>
<td>-25 dB</td>
<td>1.11</td>
<td>44.9 Ohms</td>
</tr>
<tr>
<td>Ant 2 Simulation</td>
<td>2.41 GHz</td>
<td>-14.3 dB</td>
<td>1.48</td>
<td>42.8 Ohms</td>
</tr>
<tr>
<td>Ant 2 Measured</td>
<td>2.42 GHz</td>
<td>-14.3 dB</td>
<td>1.48</td>
<td>33.8 Ohms</td>
</tr>
</tbody>
</table>
Conclusions - Part 1

- Antenna design/manufacture/analysis:
  - is iterative
  - requires persistence
  - quarter wave matching limitations
  - Momentum simulations fairly accurate
  - takes much more time than I expected
Conclusions - Part 2

EE from Glenayre, Inc.

“What you learn in Electrical Engineering ...

... can be directly applied to 75% of your life.

The other 25% ...

...concerns women.”
Acknowledgments

Dr. Prasad Shastry
Mr. Balamurugan Sundaram
Mr. Krishna Katragadda
Questions?