Master Thesis

Control and Prediction of Scan Blindness Effects in Printed Planar Antenna Systems

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Presentation Outline

Blindness Problem

Prediction Methods

Control Mechanism

Printed Dipole

Microstrip Patch

Electrical Shielding

Waveguide Simulator

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Blindness Concept

Surface Wave on an Array

Scanning Array

- Null in Pattern
- Scan Coverage
- Big Mismatch in Input Impedance
- No Feeding Possible

\[ \beta^2 = k_x^2 + k_y^2 \]

\[ k_x = \left( \frac{2\pi m}{a} + k_0 u \right) \]

\[ k_y = \left( \frac{2\pi n}{b} + k_0 v \right) \]

\[ u = \sin \theta \cos \Phi \]
**Surface Wave Circle Diagram**

Scanning Part

\[ \beta_{sw}^2 = \left( \frac{m}{d_x/\lambda} + u \right)^2 + \left( \frac{n}{d_y/\lambda} + v \right)^2 \]

- TM (TE) mode excitation
- \( X \rightarrow 0.55\lambda \)
- \( y \rightarrow 0.5 \lambda \) and \( \beta = 1.3 \)

**Grid Spacing**
- Blindness in Visible Space

**Polarization Match**
- Blind Spot

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Scan Impedance Method and SEP

Perpendicular Lumped Port

Arrow entered in top view

Layer Arrow

Angle
- Easy to Calculate
- Size Dependent

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Effective Propagation Constant

Surface Wave Excitation

TM

TE

Dielectric

Sender Probe

Receiving Probe

Ground Plane

P1
**TM Mode $\beta$ Calculation**

1. The first mode is excited on the waveguide port.
2. Two simulations are needed to calculate $\beta$.
3. Blind spot is predicted with new effective $\beta$ using classical method.

*Transmitting Waveguide* $TE_{10}$

*Dipole*
### TE Mode β Calculation

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Mode</th>
<th>Ideal β</th>
<th>Calculated</th>
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</thead>
<tbody>
<tr>
<td>Substrate1</td>
<td>TM</td>
<td>1.1349</td>
<td>1.145</td>
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<tr>
<td>Substrate2</td>
<td>TM</td>
<td>1.6168</td>
<td>1.597</td>
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<td>Substrate2</td>
<td>TE</td>
<td>1.1316</td>
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</table>
Printed Dipole

Graph showing E Field magnitude in dB versus angle in degrees.
# Method Comparison for Dipole

<table>
<thead>
<tr>
<th>Spacing</th>
<th>Substrate</th>
<th>Surface Wave</th>
<th>SEP</th>
<th>Scan Impedance</th>
<th>β Effective</th>
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</thead>
<tbody>
<tr>
<td>0.49λ , E</td>
<td>Substrate1</td>
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<tr>
<td>0.6λ , H</td>
<td>Substrate2</td>
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<td>29</td>
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</tbody>
</table>
Arrays of Microstrip Patches

$\varepsilon = 3.48$

$h = 0.121\lambda$

$\beta = 1.2383$

Scan Element Pattern
Scan Resistance, E-plane

![Graph showing resistance versus angle (in degrees) for different values of $d_x$.]
Scan Resistance, H-plane

- Resistance Ohm ($R_{\text{ref}} = 250 \, \Omega$)

- $\theta$ in degree

- Lines for different values of $\lambda_0$:
  - $0.45 \lambda_0$
  - $0.55 \lambda_0$
  - $0.6 \lambda_0$
  - $0.5 \lambda_0$
Scan Reactance, H-plane

\[ \text{Reactance, Ohm (} R_{\text{ref}} = 250 \Omega \text{)} \]

\[ \theta \text{ in degree} \]

- \( d_y = 0.45 \lambda \)
- \( d_y = 0.5 \lambda \)
- \( d_y = 0.55 \lambda \)
- \( d_y = 0.6 \lambda \)
E-plane Farfield and Comparison

Element Spacing = 0.55 \lambda

<table>
<thead>
<tr>
<th>Spacing</th>
<th>Surface Wave</th>
<th>SEP</th>
<th>Scan Impedance</th>
<th>\beta\text{ effective}</th>
</tr>
</thead>
<tbody>
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<td>0.5\lambda</td>
<td>50</td>
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<td>25</td>
<td>27</td>
<td>28</td>
<td>26.5</td>
</tr>
</tbody>
</table>
Blindness Control

- Surface Wave Suppression
- Perturbing and PBG Idea
- Electrical Wall + Via

Diagram:
- Patch
- Top Layer of Filter
- Via

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Wall’s Functionality

18 GHz

24 GHz

10 mW/m (+0 dB)
1.996 mW/m (-7 dB)
398 uW/m (-14 dB)
79.44 uW/m (-14 dB)
15.84 uW/m (-28 dB)
3.162 uW/m (-35 dB)

631 nw/m (-42 dB)
125.8 nw/m (-42 dB)
25.12 nw/m (-56 dB)
5.012 nw/m (-63 dB)
1000 pW/m (-70 dB)
Near Field Interference

Frequency Up-shift

Single Element Tuning

Match Improvement from Suppressed Surface Wave
Wall Effect on Blindness

Element Spacing = 0.55 λ

Grating Lobe at 55

β close to 1

Surface Wave is Suppressed

SEP Analysis

Blind spot is moved toward grating lobe.
Farfield Comparison

Element Spacing = 0.55 λ
Waveguide Simulator

Waveguide Mode

Plane Wave with Specific Angle 28°

One Polarization E-plane

One Frequency 24 GHz

Null Positions, Array Symmetry Plane

Waveguide Port $S_{11}$

$TM_{11}$

Element Port

Dipole Array, Spacing 0.5λ

3*3 on a substrate with $h=0.181\lambda$

Frequency in GHz
Farfield pattern of a linear array of 17 dipoles on a substrate with $\varepsilon=4.2$ from Scan Impedance Method.
Conclusion and Future Work

- Blindness prediction for dipoles and patches
- New method based on $\beta$ calculations
- Blindness control
- Waveguide simulation as comparison
- $\beta$ calculations for other single elements
- Optimized feeding network
- Another suppressing structures
Thank you for your attention!
**Patch Serial Feeding**

**Why?**
- Simple Feeding Network
- Easy to introduce phase shifters

**Disadvantages**
- Pin’s Spurious Radiation
- Amplitude Distribution

![Diagram showing electric field distribution with values]

- 4 kv/m (0 dB)
- 3.6 kv/m (-0.91 dB)
- 3.2 kv/m (-1.94 dB)
- 2.8 kv/m (-3.1 dB)
- 2.4 kv/m (-4.44 dB)
- 2 kv/m (-6.02 dB)
- 1.6 kv/m (-7.95 dB)
- 1.2 kv/m (-10.45 dB)
- 801 v/m (-13.97 dB)
- 401.2 v/m (-19.98 dB)
- 1.264 v/m (-70 dB)