Wide Band Single Pixel Feed

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Outline

WB+SPF and SKA
HIA WB+SPF
How WB+SPF?
Now WB+SPF?
Building WB+SPF
Testing WB+SPF
Conclusions
Peter Dewdney et al. Proceedings of the IEEE, Aug. 2009:

• "It is likely that two different arrays of antennas will be needed to cover the frequency range up to 500 MHz.
• From 500 to 1000 MHz, there are three possibilities: dense AAs, parabolic antennas with PAFs, and parabolic antennas with SPF.
• From 1000 MHz to 10 GHz, parabolic antennas with SPF are chosen."

<table>
<thead>
<tr>
<th></th>
<th>BANDWIDTH</th>
<th>BEAMWIDTH</th>
<th>PHASE CENTER</th>
<th>RETURN LOSS</th>
<th>SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tecom</strong></td>
<td>&gt; 20:1</td>
<td>100 deg</td>
<td>Strong</td>
<td>&gt; 6 dB</td>
<td>$(0.7\lambda_{max})^2 \times 1.8\lambda_{max}$</td>
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<td></td>
<td></td>
<td></td>
<td>Frequency</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Dependence</td>
<td></td>
<td></td>
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<tr>
<td><strong>ATA</strong></td>
<td>23:1</td>
<td>43 deg</td>
<td>Strong</td>
<td>&gt; 14 dB</td>
<td>$(0.5\lambda_{max})^2 \times 2.4\lambda_{max}$</td>
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<td>Frequency</td>
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<td></td>
<td>Dependence</td>
<td></td>
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<tr>
<td><strong>Lindgren</strong></td>
<td>8:1</td>
<td>&gt; 60 deg</td>
<td>Moderate</td>
<td>&gt; 8 dB</td>
<td>$(1.1\lambda_{max})^2 \times 1.2\lambda_{max}$</td>
</tr>
<tr>
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<td>freq.</td>
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<td>Frequency</td>
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<tr>
<td></td>
<td>dependent</td>
<td></td>
<td>Dependence</td>
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<td></td>
</tr>
<tr>
<td><strong>Chalmers</strong></td>
<td>11:1</td>
<td>62 deg</td>
<td>Frequency</td>
<td>5 dB</td>
<td>$(0.65\lambda_{max})^2 \times 2.1\lambda_{max}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Independent</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>QSC</strong></td>
<td>&gt; 10:1</td>
<td>65 deg</td>
<td>Frequency</td>
<td>10 dB</td>
<td>$(0.75\lambda_{max})^2 \times 0.2\lambda_{max}$</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Independent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conical Sinuous</td>
<td>&gt; 10:1</td>
<td>65 deg</td>
<td>Frequency</td>
<td>5 dB</td>
<td>$(2.0\lambda_{max})^2 \times 0.25\lambda_{max}$</td>
</tr>
<tr>
<td>GP</td>
<td></td>
<td></td>
<td>Independent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FS</td>
<td>&gt; 10:1</td>
<td>100 deg</td>
<td>Small</td>
<td>&gt; 16 dB</td>
<td>$(0.5\lambda_{max})^2 \times 0.25\lambda_{max}$</td>
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<td></td>
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<td>Dependence</td>
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</tr>
</tbody>
</table>

HIA WB+SPF

- Bandwidth: >10:1
- Beamwidth: ~60 deg
- Phase center: some dependence
- Return loss: >8 dB
- Size: \( \left(0.57 \lambda_{\text{max}}\right)^2 \pi \times 0.57 \lambda_{\text{max}} \)
- Cross polarization: <-9 dB
HIA WB+SPF's: Beamwidth: ~60 deg
HIA WB+SPF

Return loss: >8 dB

S-Parameter Magnitude in dB

• Differential-mode reflection coefficient:

\[ \frac{1}{2} \left( s_{11} - s_{14} - s_{41} + s_{44} \right) \]

• For port 1 and 4 in same polarization
How WB+SPF?
Far field pattern

- Two similar antennas (scaled in spatial dimensions) have same radiation properties at the inversely scaled frequency.
- A self-similar antenna has scaled structures embedded
  - Equiangular, aka., logarithmic spirals
    - Entire structure scales with $\Phi$
  - Log-periodic antennas
    - “Cells” scale by “tau”
- Aperture size scales
  - Low pass filter behaviour
- For finite structures:
  - Eliminate “end-effect”
    - Traveling waves
How WB+SPF?
Impedance

- Complementary structures
  - Babinet's principle
    \[ Z_{metal} Z_{air} = Z^2_{freespace} / 4 \]
    \[ Z_{slot} = Z^2_{freespace} / \left( 4 Z_{dipole} \right) \]

- Self-complementary structures
  - Mushiake's relation
    \[ Z_{metal} = Z_{air} \]
    \[ Z_{metal} = Z_{freespace} / 2 = 188.5 \text{[ohms]} \]
Self-complementary
Now WB+SPF?

- Aluminum 1100 cone and antenna “petals”
- Eccostock SH-8 foam
- Eccosorb 268E paint along edge of cone?
Building WB+SPF

- Low dielectric constant epoxy
- Low dielectric constant and low dissipation factor foam
- Conductive epoxy (large fraction of colloidal silver)
- Complete this month
Testing WB+SPF

Near field range and/or far field anechoic chamber

• Two petals per polarization
• Exciting one petal with three others terminated in 50 ohms
• Complete end of next month
Conclusions

• Comparable bandwidth and beamwidth
• Some phase-center frequency dependence
  – Can be minimized, at cost of return loss
• Poor return loss (though comparable to some)
• Size is smaller than most
• Cross polarization is not as easily comparable, but likely a little worse than average
• Cost is lower, we think:
  – “all the complicated parts in one plane”
  – PCB or milling technology
• Ground plane size is maximized
• Room for improvement with many free variables
Thank you for your attention.

Questions or comments?