Antenna system -
Status & progress report

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for the antenna work package group
General specifications

Tunable frequency range \hspace{1cm} 80-300 MHz

Instantaneous frequency range \hspace{1cm} ≥ 32 MHz

Collecting area \hspace{1cm} ≥ 10 m² over as much of frequency range as possible

Field of view \hspace{1cm} As wide as possible (within constraints of collecting area & physics)

Polarization \hspace{1cm} Dual linear

System temperature \hspace{1cm} Sky noise dominated
Key design features

- 16 dual-polarization, bowtie antenna elements over a ground screen
- Elements arranged in compact planar array with $\lambda/2$ spacing at 140 MHz ($= 1.07$ m)
- Low-noise amplification integral to each element
- Analog RF beamformer with PCB tapped delay lines
One section of 5 sections of switchable delay line – lengths differ by factors of 2

identical circuit for Y signals
Prototype antenna element used in ED tiles
Antenna element redesigned for low-cost manufacture

- Mechanical redesign done by Burns Industries of Nashua, New Hampshire, U.S.A., in collaboration with Haystack, in November 2006
- Primary change from ED prototype is to support antenna element at the bottom of the bowties rather than via a central column
- Changes should have minimal effect on electrical performance
- Prototype redesigned element delivered on 12 December
- Prototype 16-element tile to be built using final production processes (e.g., extruded central hub and bowtie keys, molded feet) in China, with delivery by late February 2007
- Projected cost of 16 elements + groundscreen, installed in WA, is <1K $US in 500-tile quantities
- To do:
  - Minor changes to LNA board layout
  - Determine required overlap between groundscreen pieces
Redesigned antenna element details
Redesigned antenna element details - cont’d

NOTE: USE MODEL DATA TO DEFINE PART.

MATERIAL: modify MW0-010 extrusion

Dimensions: mm/inches
Tolerance ± .1 mm

Heckstack Observatory
Massachusetts Institute of Technology

DRAWN
11/22/2006

CHECKED

TITLE

SCALE

REV

SIZE

A

REV

MWA-010

Sheet 1 of 1
Redesigned antenna element details – cont’d
**Redesigned antenna element details - cont’d**

<table>
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<td>LEG, CURVED</td>
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<td>2</td>
<td>ISO 4032 - M3</td>
<td>Hex Nut</td>
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18 December 2006  
MWA-LFD Project Meeting in Melbourne  

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Redesigned antenna element – the movie
Low-noise amplifier

- Balanced design using two ATF-54143 HEMTs
- Measured noise temperature 14-17 K with 50 ohm loads on inputs, in agreement with simulation
- Measured OIP2 > +63 dBm, OIP3 = +27 dBm
- With LNA connected to prototype element, simulated noise temperature < ½ x sky temperature
RF analog beamformer, ED prototype

- 4-channel prototype board constructed using coplanar waveguide in 4-layer PCB with 10-ns max delay
- Isolation > 40 dB between channels and between switched lines within a channel
- Delay reproducible between channels to ~0.1 ns (1σ)
- Gain reproducible between channels to ~0.3 dB (1σ)
- Gain independent of delay selected to <1 dB
RF analog beamformer, version 2

- Test board with different pitches between delay line traces shows >40 dB isolation for pitch of 0.200 inch (prototype board value), 0.100 inch, and 0.075 inch.
- Expect therefore to be able to put delay lines for 16 channels on one, or perhaps two, boards, rather than the four required in the prototype ED beamformer.
- Lengthening the lines to increase the max delay from 10.6 ns (ED prototype) to 13.1 ns may drive cost point to favor two boards per polarization.
- Most of M/C logic will go on delay line boards, rather than on a separate interface board as in the ED prototype, to reduce interconnect costs.
Beamformer: sky coverage of ED prototype

- Should the max delay be increased from 10.6 ns to 13.1 ns, to allow observations with all 16 elements down to 60° ZA for all azimuths?
Measured antenna tile patterns for five steering directions

110MHz, Eplane, 1.07m spacing, 4x4

Amplitude (dB)

Elevation (degrees)

200MHz, Eplane, 1.07m spacing, 4x4

Amplitude (dB)

Elevation (degrees)

110MHz, Hplane, 1.07m spacing, 4x4

Amplitude (dB)

Elevation (degrees)

200MHz, Hplane, 1.07m spacing, 4x4

Amplitude (dB)

Elevation (degrees)
Monitor/control: functions

- **Monitor functions:**
  - Beamformer internal temperature

- **Control functions:**
  - For each polarization of each antenna element (32 per tile), set:
    - 5 sets of delay line switches
    - on/off switch
  - For each polarization (2 per tile), toggle 180° phase shift with Walsh function

- To monitor health of LNAs and beamformer, rely on:
  - Instrumental calibration
  - Satellite transmissions
Monitor/control: implementation

- To minimize interference problems, BF digital circuitry that controls delay line switches will be active only when switch settings are being changed.

- Four RS-485 lines from node to BF:
  - Clock
  - Data
  - xWalsh
  - yWalsh

- Two RS-485 lines from BF to node:
  - Clock
  - Data (acknowledgement with BF temperature)
Miscellaneous issues

- Is RoHS compliance a requirement?
- How far must the BF chassis be located from the tile to avoid degrading the beam patterns appreciably? Check with simulations.