Development of 150 MHz to 4 GHz Inverted Conical Sinuous Feed for 140 Ft Radio Telescope

Rohit Gawande
PhD Student, Electrical and Computer Engineering Dept, University of Virginia

Dr. Richard F. Bradley
Scientist / Research Engineer, National Radio Astronomy Observatory, Charlottesville, VA

Atacama Large Millimeter/submillimeter Array
Expanded Very Large Array
Robert C. Byrd Green Bank Telescope
Very Long Baseline Array
Outline

• Motivation
• Antenna Assembly
• Antenna Characterization
• Low Noise Amplifier
• System Noise Measurement
• Cryogenic and low frequency versions
Motivation

- Sweeping Large Frequency ranges
- Frequency Agility
- Detection of short duration pulses
- Multi frequency imaging
- Simultaneous observation of several spectral lines
- Increasing interest in wideband feeds for future radio telescopes
  - Frequency Agile Solar Radiotelescope (FASR)
  - Square Kilometer Array (SKA)
  - Green Bank Lunar Interferometer for Neutrino Transients (GLINT)
- MIT LL / NRAO Bi-static Radar Collaboration to Study Earth’s Ionosphere (140 Ft Radio Telescope in Green Bank)
Planar Sinuous Antenna

\[ \Phi = \alpha \sin \left( 2\pi C \frac{\ln r - \ln r_{\text{min}}}{\ln r - \ln r_{\text{max}}} \right) \]

(a) Sinuous curve
(b) Sinuous arm
(c) Four arm structure
Antenna Assembly and Working

Laboratory version for modeling and measurements

500 MHz to 3 GHz for tests on 140 Ft telescope in GB

• In order to eliminate the back-lobe, sinuous pattern projected onto a cone, and a ground plane is placed directly behind the cone’s apex.
• Each sinuous resonator a quarter wavelength above the ground plane.
• Lightweight feed due to foam support structure
Simulated Input Reflection Coefficient

- $S_{11}$ better than 9 dB over the whole frequency range.
Measured E Plane and H Plane Far Field Pattern in Green Bank anechoic chamber
Measured Co and Cross Polarization in 45 degree plane
Simulated on axis directivity from 1 to 4 GHz.
Simulated sub-efficiencies using BOR1 components as a function of parabola flare angle.

- BOR1 efficiency = 0.94
- Aperture efficiency better than 0.7 over 43 to 57 degrees
Pseudo Differential Amplifier

- A single ended LNA attached to each of the four arms. The outputs of the LNAs in opposing arms combined using $180^0$ hybrid
- Avoids any crossover before the LNAs
- Provides low impedance path for even mode.
Low Noise Amplifier Assembly

Photograph of the LNA

Inventor drawing of chassis holder
Gain and Noise for 50 Ohm input
Device: 280um gate width Fujitsu FHX45X
Vd = 1V, Id = 20mA for 300 K Optimal Bias

Noise temperature drops from 35K to 6K when cooled from 300K to 15K around 2 GHz.
System Noise measurement using Sky and absorber method

Measured and modeled system noise

Noise Measurement Setup in Green Bank

![Graph showing measured noise and modeled noise with 0.3 dB loss against frequency.](image)

![Noise Measurement Setup in Green Bank.](image)
Next Step: Cold version to improve the sensitivity

Photograph of the Dewar

Inventor Drawing showing interior of the Dewar
Next Step: Extending Frequency range down to 150 MHz

Front End Box

High Frequency Section

Ground Plane Extensions

Pourable Foam Support for Low Frequency Outriggers
Development of 150 MHz to 4 GHz Sinuous Feed for 140 Ft Radio Telescope

Thank You!

• Rohit Gawande
  • PhD Student, Electrical and Computer Engineering Dept, University of Virginia

• Dr. Richard F. Bradley
  • Scientist / Research Engineer, National Radio Astronomy Observatory, Charlottesville, VA

Atacama Large Millimeter/submillimeter Array
Expanded Very Large Array
Robert C. Byrd Green Bank Telescope
Very Long Baseline Array
Decade Bandwidth LNA optimized for higher antenna impedance 100 Ohm
Pulsar Data Using 140 Ft from 800 – 1600 MHz