Instrument Development for the Green Bank Solar Radio Burst Spectrometer (GB/SRBS)

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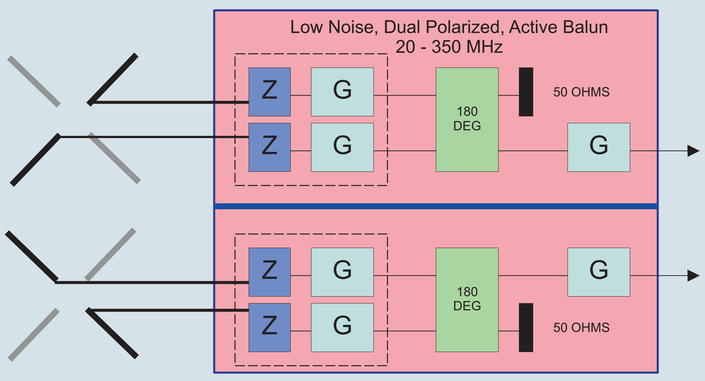
Abstract

In October of 2003, NRAO-U.Md. in collaboration with NRL and ETH-Zurich received an NSF MRI grant to develop a high performance instrument to receive solar radio emissions with adequate temporal and spectral resolution to probe a wide variety of active solar phenomena from the base of the corona. These include energy released from flares, particle acceleration and escape, coronal shocks, and electron beams. The instrument will consist of three radio spectrometers that together provide contiguous frequency coverage from 10 - 3000 MHz: GB/SRBS-L (10-30 MHz), GB/SRBS-M (25-350 MHz), and GB/SRBS-H (300-3000 MHz). The goals of this instrument are three-fold: provide a basic research tool in solar radiophysics for use by the wider community, remedy the lack of an important component of the U.S. Space Weather effort, and provide a platform for research and development work on broadband antennas, feeds, and receivers needed for the upcoming Frequency Agile Solar Radiotelescope (FASR) project.

Phase I of the GB/SRBS project has been monitoring solar activity on a daily basis for more then 98% of the time since its deployment in Green Bank on January 7, 2004. This initial system consists of a single polarization inverted-vee style antenna, a high dynamic range, low noise amplifier, and a specially developed sweep-frequency spectrometer covering the 20-70 MHz band. The frequency and temporal resolutions are 30 kHz and 1 sec, respectively. Unprocessed data and data products from GB/SRBS are currently being archived at the NRAO and will be made available to the scientific community in the near future.

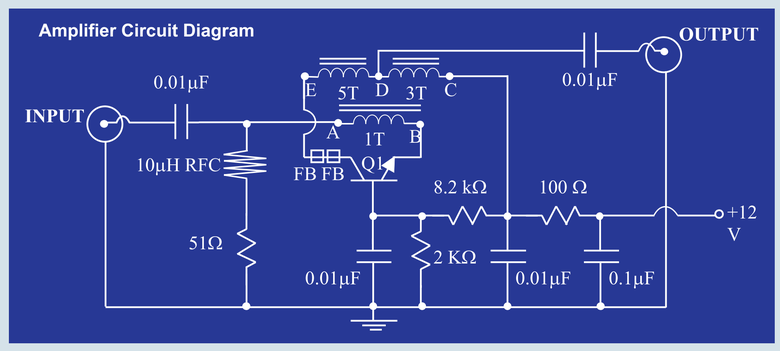
Details of the on-going technical development projects for GB/SRBS are presented below. These include 1) a broadband, high dynamic range, low noise active balun, and 2) a broadband pyramidal-type log periodic antenna/feed.

High Dynamic Range Active Balun for GB/SRBS - M

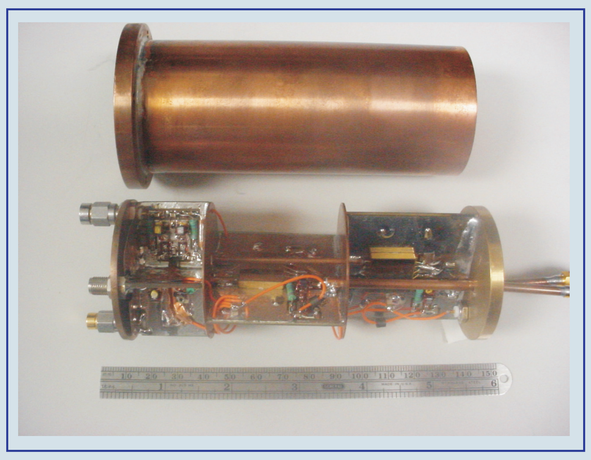


Block diagram of the active balun showing the push-pull first stage, 180-degree hybrid, and second gain stage.

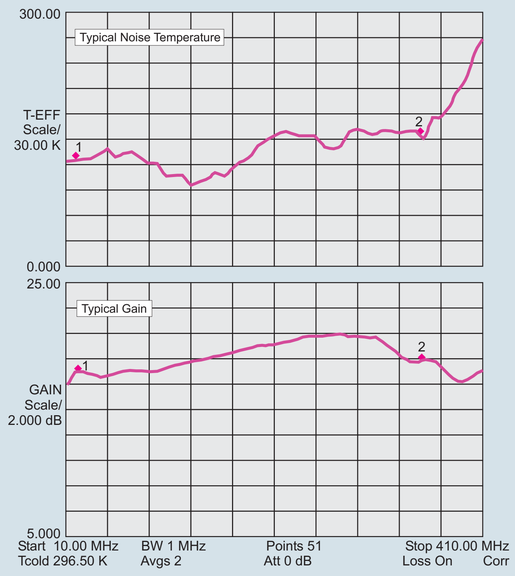
An active balun provides signal amplification along with a balanced-to-unbalanced transmission line transition at the feed point of the antenna. This balun makes use of an NEC NE461 bipolar junction transistor in a common-base circuit to create a voltage amplifier having low-loss, voltage-series feedback as shown on right in schematic form. The first stage of amplification contains a cascade of two transistors such that one provides impedance matching from 125 ohms to 50 ohms and the other provides about 9 dB of gain. In addition, a pair if these circuits in a push-pull configuration together with a 180-degree hybrid junction and second gain stage yields an unconditionally stable active balun with moderate signal gain, high dynamic range, low noise temperature, low power dissipation, good temperature stability, and low cost. Two complete active baluns, one for each polarization, reside in a cylindrical housing that is 5 cm in diameter and 8 cm in length. Total power dissipation is about 2.5 watts. Isolation between polarizations is better then 75 dB.

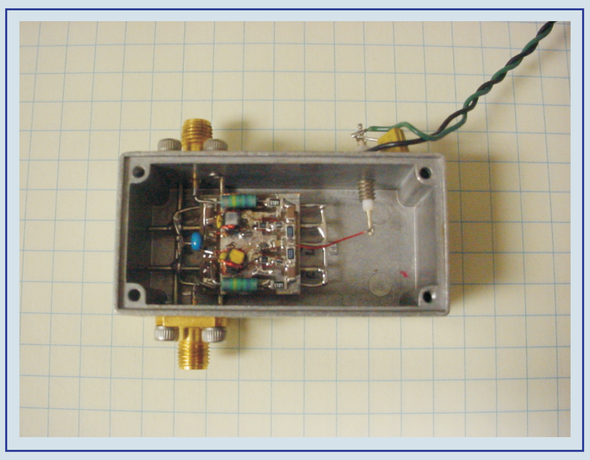


Schematic diagram of the basic circuit configuration used in the active balun.

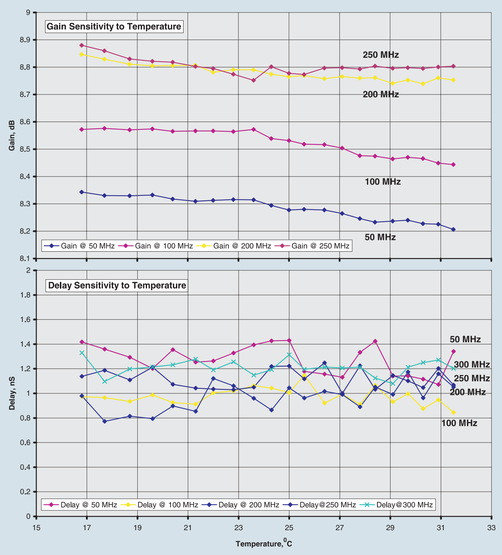


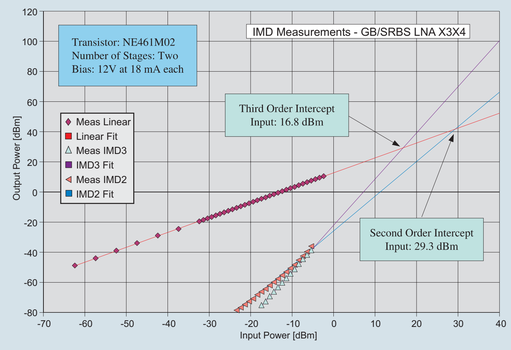
Photograph of the active balun with the cylindrical housing removed. Measured noise and gain are shown at right.





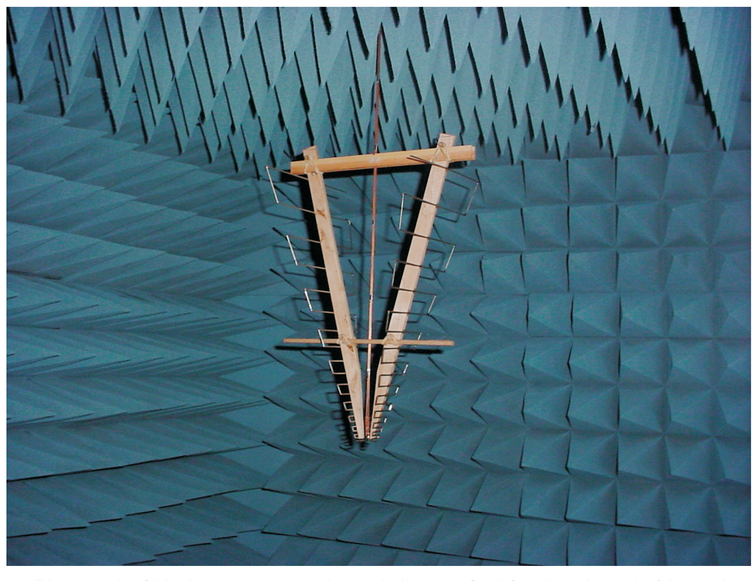
Photograph of the first stage prototype. Measured performance is shown at right.





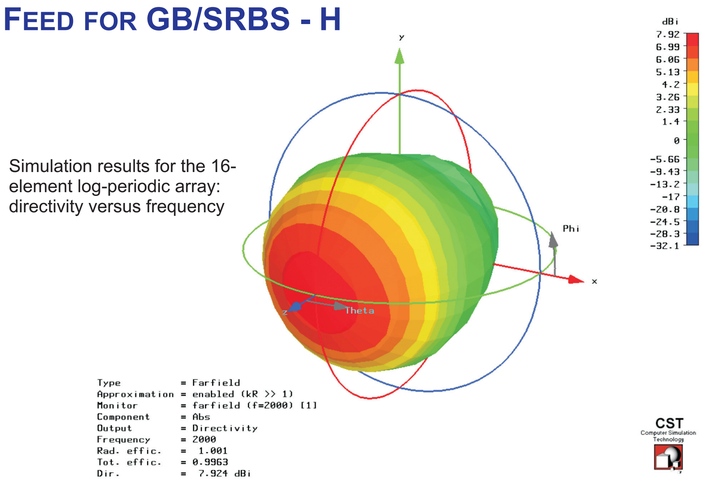
Log Periodic Array Prototype Feed for GB/SRBS - H

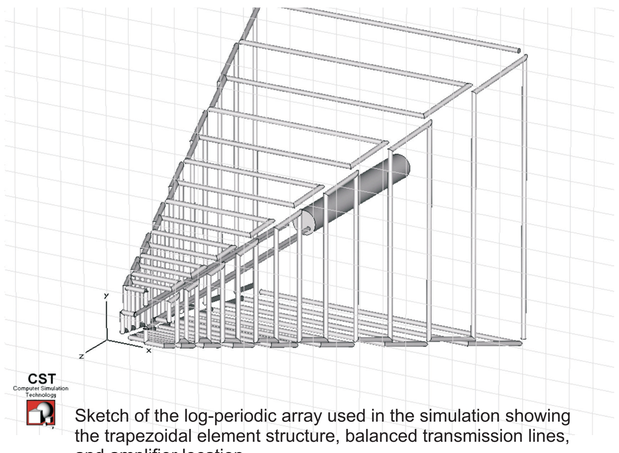
A wide bandwidth feed is being developed for the 45-foot radio telescope. A scaled version of the feed will also serve as a stand-alone low frequency antenna. A three-dimensional, log-periodic structure was chosen for these applications. The elements are trapezoidal shaped with a 20 degree opening angle off bore sight and a scaling factor of 0.875. Microwave Design Studio, an electromagnetic simulation software package by Computer Simulation Technology (CST), was used extensively for the design and analysis of the structure. A prototype feed was fabricated and evaluated in the small anechoic chamber located at the NRAO Technology Center.



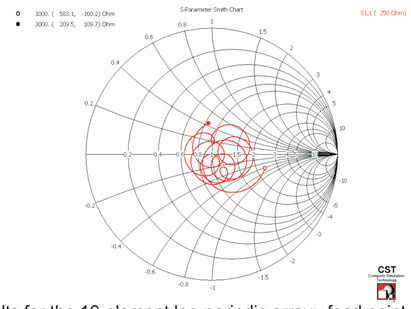
Photograph of 20-element prototype log periodic array feed (single polarization) located inside the anechoic chamber for impedance measurements.

Simulation results for the 16-element log-periodic array: directivity versus frequency

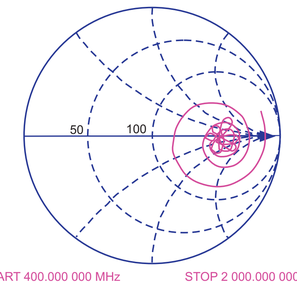




Sketch of the log-periodic array used in the simulation showing the trapezoidal element structure, balanced transmission lines, and amplifier location.



Simulation results for the 16-element log-periodic array: feed point impedance versus frequency



START 400.000 000 MHz STOP 2 000.000 000 MHz

Measured performance of the 20-element log-periodic array: feed point impedance versus frequency