

Testing a Prototype Blade Antenna at the LWDA Site

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August 30, 2005 – September 1, 2005

I. INTRODUCTION

This report summarizes the testing done on a prototype LWDA blade antenna at the VLA on August 30, 2005 – September 1, 2005. As the LWDA project transitions from the planning and design phases to the construction phase, field measurements on the components of the array will be crucial to understanding the operation of the LWDA station upon its completion. In this series of tests, measurements were performed on a prototype 1m blade antenna with a Hicks balun. The goals of these tests were to characterize the RFI present at the LWDA site, and to determine if the system was sensitive enough to detect diurnal variations in sky noise.

A photograph of the fully assembled blade antenna is shown in figure 1. The Hicks balun, mounted inside the antenna mast, is shown in figure 2.

II. EXPERIMENTAL SET-UP

A diagram of the experimental set-up is shown in figure 3. Signals received by the blade antenna were transmitted through the Hicks balun and a 30 dB second stage amplifier to a spectrum analyzer. The spectra were recorded by a laptop computer that was connected to the spectrum analyzer. This system was used to determine the degree to which sky noise is dominant over the noise power of the balun. These results are presented and compared with simulated predictions in section III.

III. MEASUREMENT DATA

Figure 4 shows the first spectrum taken using a 1m blade antenna and the Hicks balun at the LWDA site from 10 – 100 MHz. Subsequent measurements were taken between 40 MHz and 90 MHz since the 1m blade antenna was optimized for use in this frequency range.

Spectra from 40 – 90 MHz were recorded approximately every 2 hours from the afternoon of Wednesday, August 31st until early morning on Thursday, September 1st. Figure 5 shows samples of two recorded spectra. Variations in the noise floor were observed from measurement to measurement, suggesting that the system is sensitive enough to detect diurnal variations in the sky noise. This would have to be verified, however, with longer-term measurements in the near future. Planning for such measurements at the NRAO facility in Green Bank, WV is already underway.

Sky noise-to-balun noise ratios were measured by comparing 40 – 90 MHz spectral profiles obtained when the balun inputs were terminated with 50Ω with those obtained when the balun was connected to the blades.

In the loaded case, we expect a system noise level, T_s , of:

$$T_s = T_b + T_o$$

where $T_b = 250K$ is the excess balun noise, and $T_o = 290K$ is the noise from the 50Ω loads.

When the balun is connected to the blades, T_s is given by:

$$T_s = T_b + T_g$$



Fig. 1. Prototype blade antenna at the LWDA site.

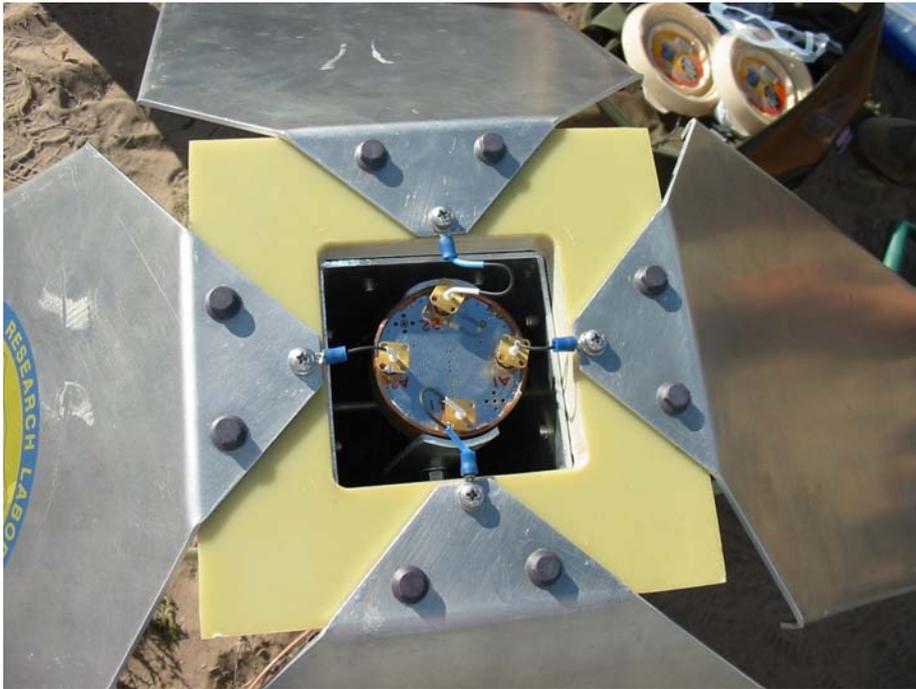


Fig. 2. Hicks balun mounted in mast of prototype blade antenna.

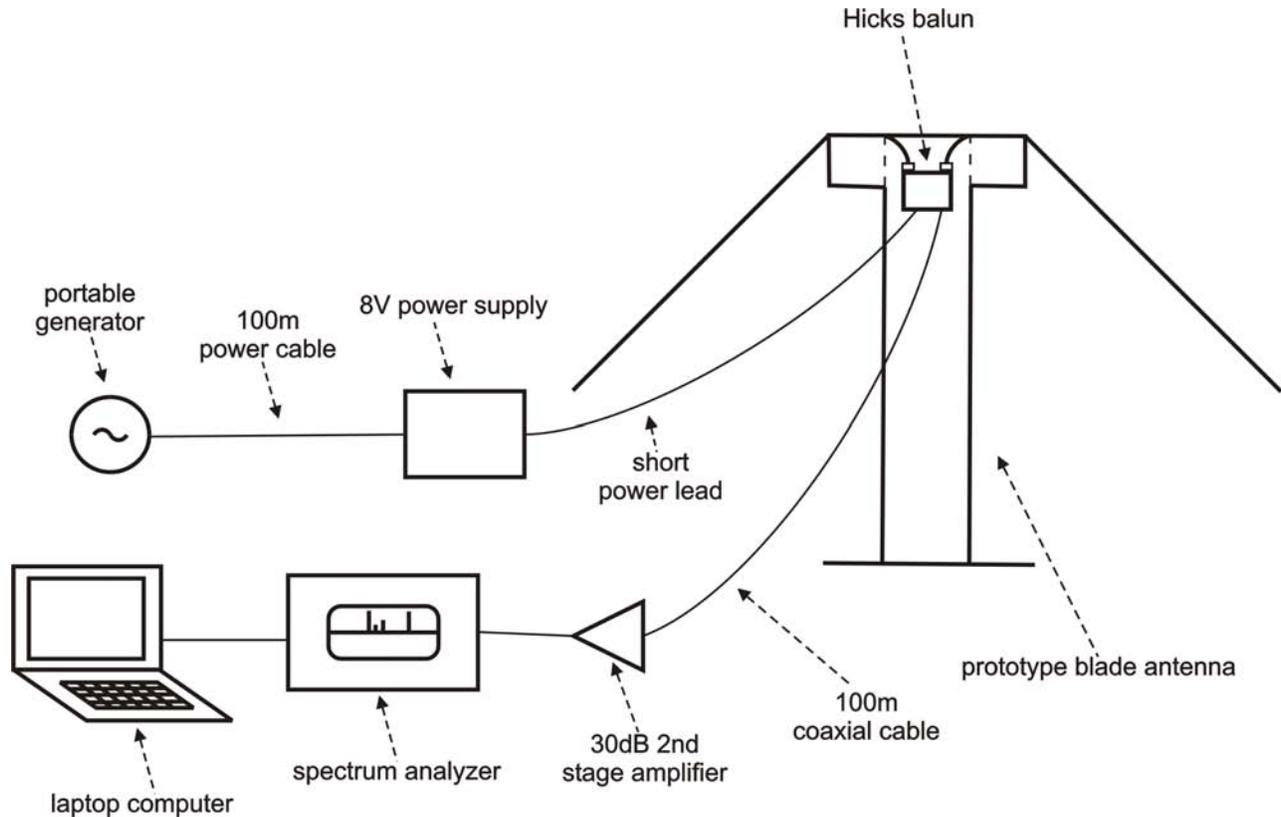


Fig. 3. Measurement system used in testing blade antenna at the LWDA site.

where T_g is the level of the Galactic noise coupled into the balun. We define the sky noise dominance to be:

$$D = \frac{T_g}{T_b}$$

Figure 6 compares the results from the August 31st 9:50 pm measurement with simulated predictions from NEC and CST. There is excellent agreement between measurement and simulation. Both show a minimum of 6 dB sky noise dominance over the 40 – 80 MHz range.

Some time between 4:00 am and 6:00 am on September 1st, it was discovered that the blade antenna and the cables had been damaged by animals. As shown in Figures 7, 8, 9, and 10, some fairly large animal broke one of the blades off the antenna. There were no cattle tracks in the area, but some antelope tracks. Other animals, probably rabbits, rats, or gophers had gnawed the cables and, in particular, had broken the 8V power lead to the balun. For future work it will be necessary to protect all antennas with a fence, presumably a field fence topped with several strands of barbed wire, and to protect all wires and cables with conduit.

IV. CONCLUSIONS AND FUTURE WORK

This first round of testing of the blade antenna at the LWDA site yielded valuable results. Sky noise measurements agreed well with simulated predictions, but more measurements must be made to verify that diurnal variations in the sky noise are indeed being observed. This would most efficiently be done by developing an automated data collection system that could be set up on the LWDA site and allowed to run over an extended period of time. An automated data collection system is currently being developed. The NRAO facility at Green Bank, WV will be used as a staging ground to test the system before it is used at the LWDA site.

August 31, 2005, 12:40 pm

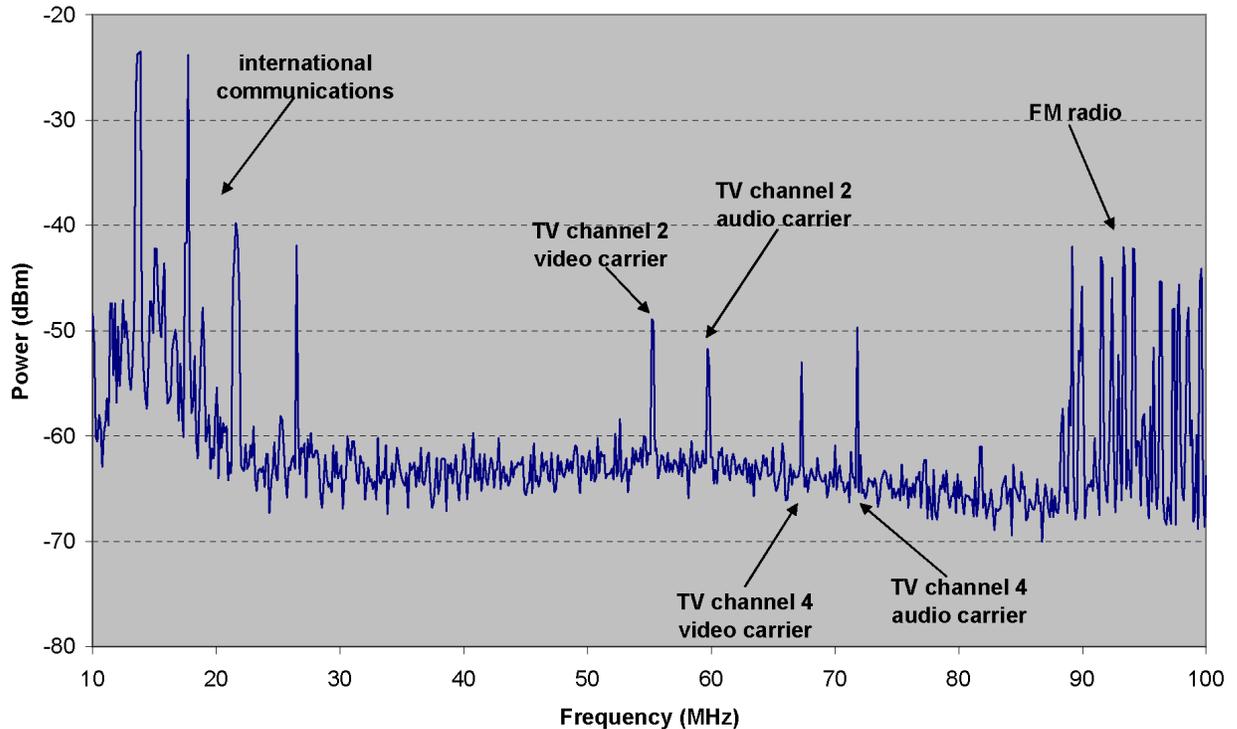


Fig. 4. The first spectrum (from 10 – 100 MHz) recorded at the LWDA site using a blade antenna and a Hicks balun.

Currently, power at the LWDA site is provided by a portable generator, which must be refuelled frequently. In order for long-term sky noise measurements to be feasible, power lines must be provided to the LWDA site that would eliminate the need for the portable generator. It is also imperative that an internet connection be established at the LWDA site so that antenna testing can be monitored remotely. Some provision for protecting equipment from wildlife must also be provided.

Finally, testing must be initiated on the next generation of LWDA antennas. A 2m blade dipole antenna has already been designed to achieve broader frequency coverage than the 1m blade dipole antenna [1]. The 2m blade antenna is intended to provide 6 dB sky noise dominance from 20 – 80 MHz, the intended frequency range of the LWA. Initial characterization work of the 2m blade antennas will be done by Bill Erickson at the Bruny Island Radio Spectrometer site in Australia.

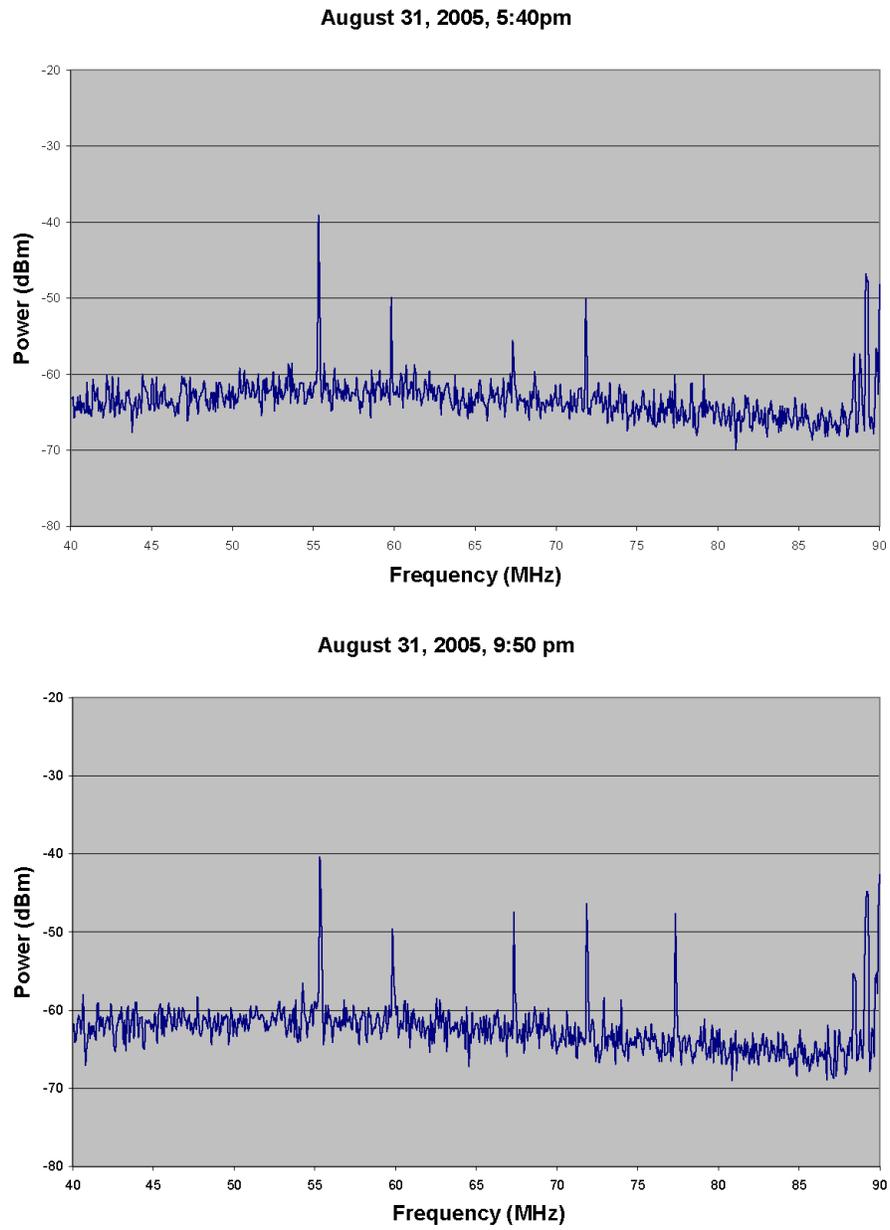


Fig. 5. Two samples of sky noise spectra (from 40 – 90 MHz).

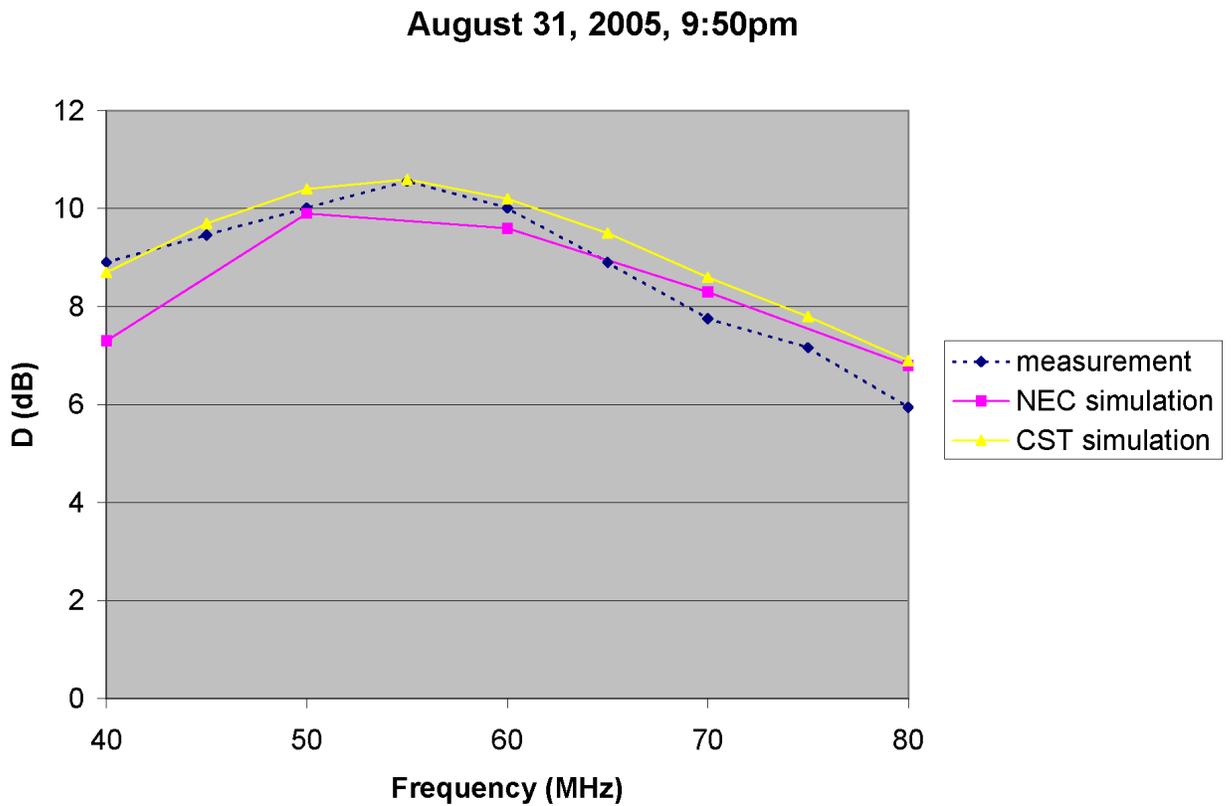


Fig. 6. Sky noise-to-balun noise ratio versus frequency. Both simulations assumed a perfect ground plane under the antennas, whereas the measurements were done on Earth ground. Measurement and simulation shows a minimum of 6 dB sky noise dominance over the entire 40 – 80 MHz range.



Fig. 7. The damaged blade antenna. One blade was detached from the mast.

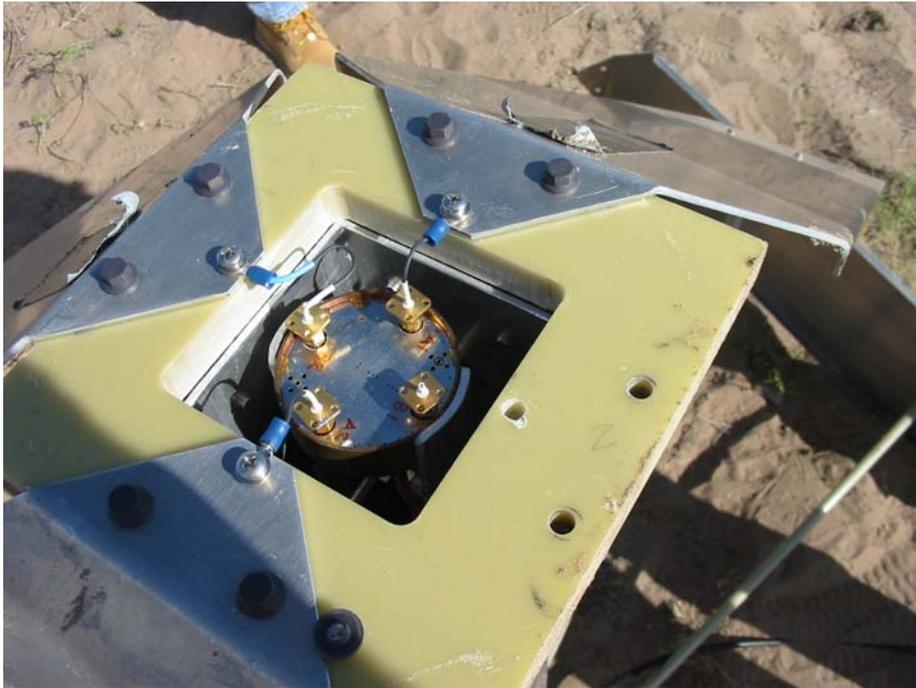


Fig. 8. The Hicks balun post antenna damage. One wire connecting one input port to the detached blade had been severed. Otherwise, the balun remained in tact.



Fig. 9. The 8V power supply for the Hicks balun. The duct tape that had been wrapped in was chewed in several places, and the thin wire connecting the power supply to the balun had been chewed through completely (indicated by white arrow).

Power cable



Coaxial cable



Fig. 10. The power cable (right) and coaxial cable (left) exhibited bite marks along their full lengths. Damage was extensive enough for the copper wiring inside to be exposed in some places.

APPENDIX

This appendix contains spectra that were taken to characterize the measurement equipment. Connections to the Hicks balun are designated using the labelling system shown in figure 11. All data sets were taken from 40 – 90 MHz with a 30 kHz resolution bandwidth. All spectra were averaged over 10 traces. Since measurement results for balun polarizations A and B were similar, results for polarization A are shown here.

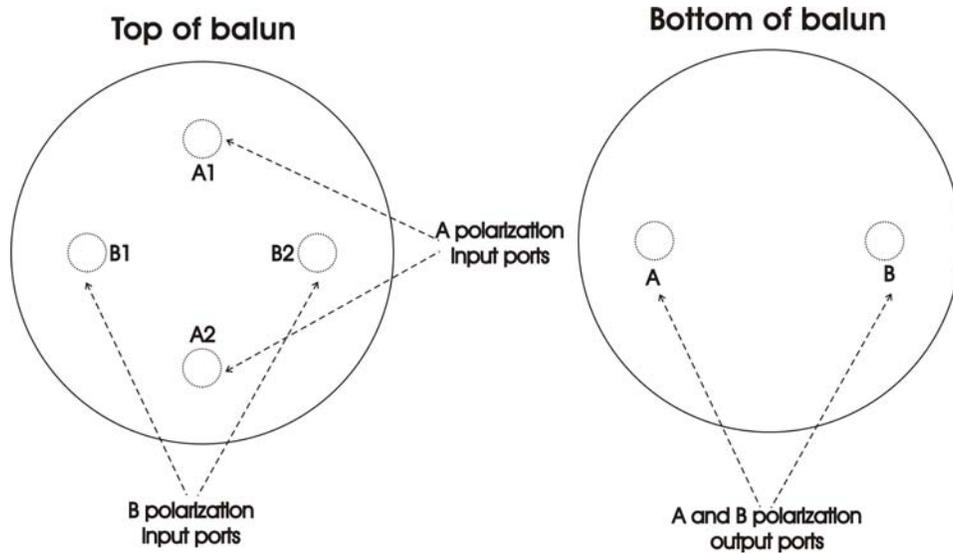


Fig. 11. A schematic of the top and bottom of the Hicks balun. Balun port designations in captions for subsequent figures in this appendix are referred back to this schematic.

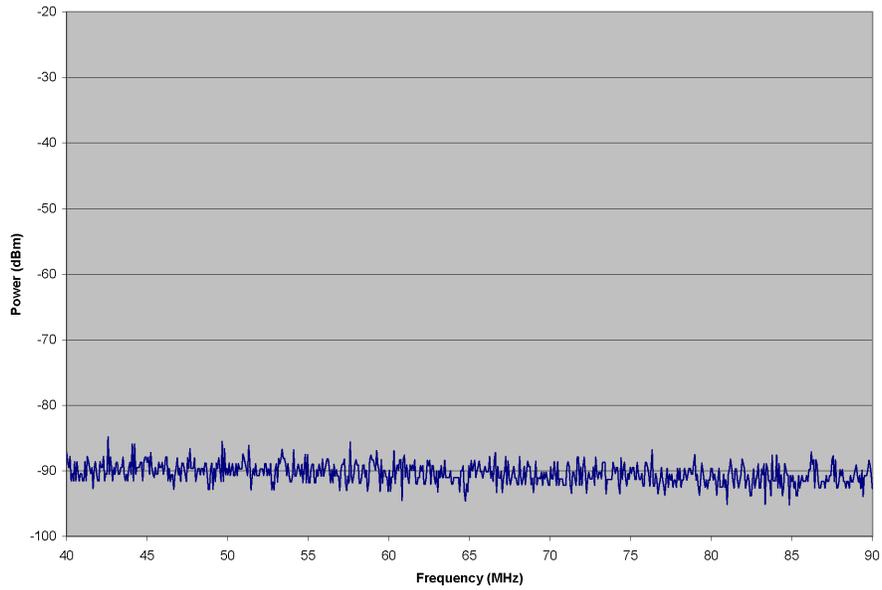


Fig. 12. The noise floor of the spectrum analyzer.

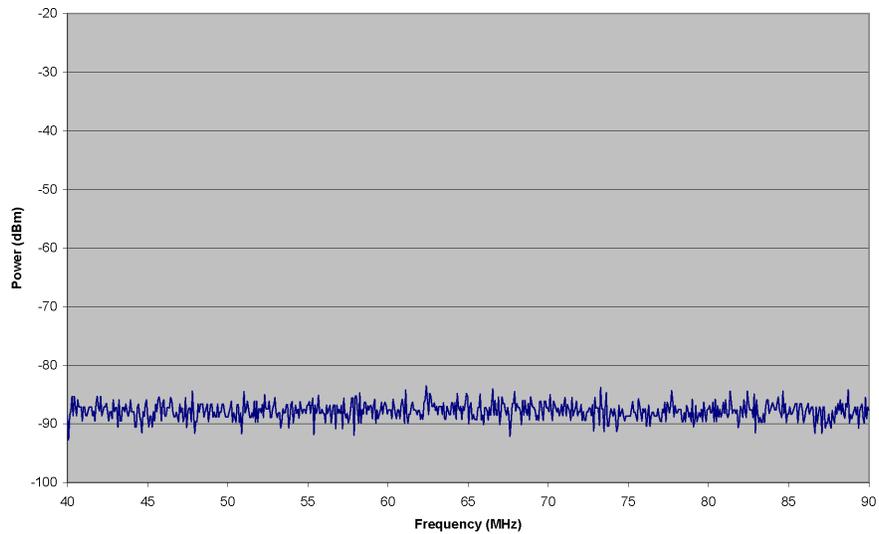


Fig. 13. Spectrum analyzer + 30 dB 2^{nd} stage amplifier (input terminated with a 50Ω termination). Although the gain of the 2^{nd} stage amplifier was 30 dB, its noise figure was so much lower than the spectrum analyzer that the noise floor in this spectrum is only a few dB above the noise floor in figure 12.

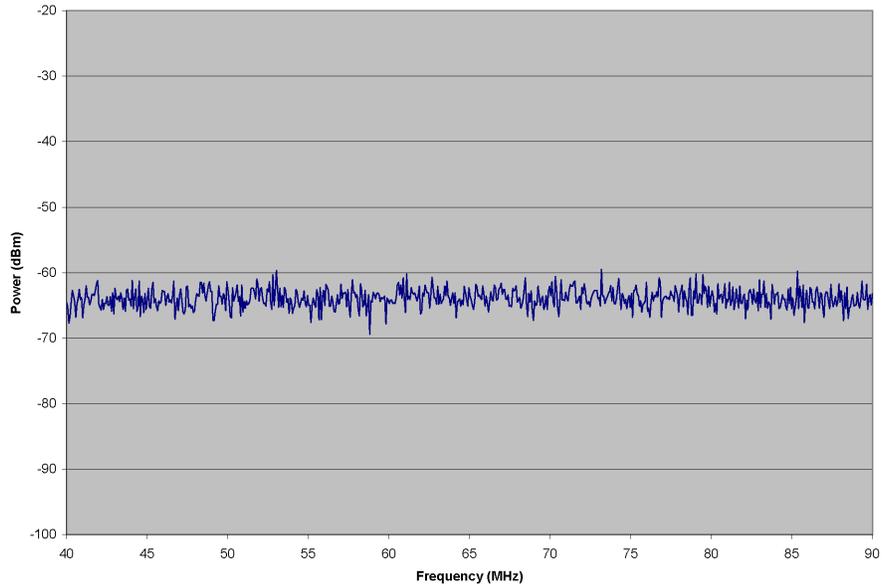


Fig. 14. Spectrum analyzer + 30 dB 2^{nd} stage amplifier + noise source with 10 dB attenuator.

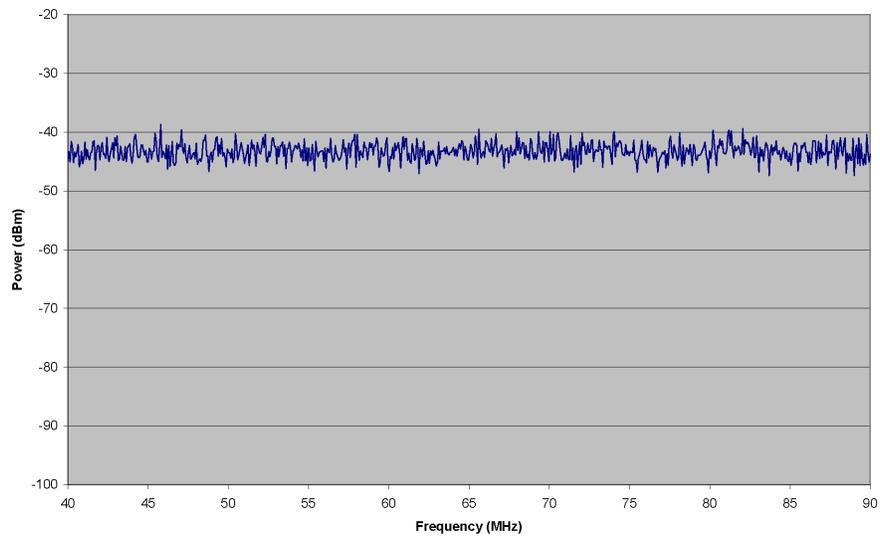


Fig. 15. Spectrum analyzer + 30 dB 2^{nd} stage amplifier connected to balun output port A + noise source with 10 dB attenuator connected to balun input port A1 + 50Ω terminations on balun input ports A2, B1, B2, and output port B.

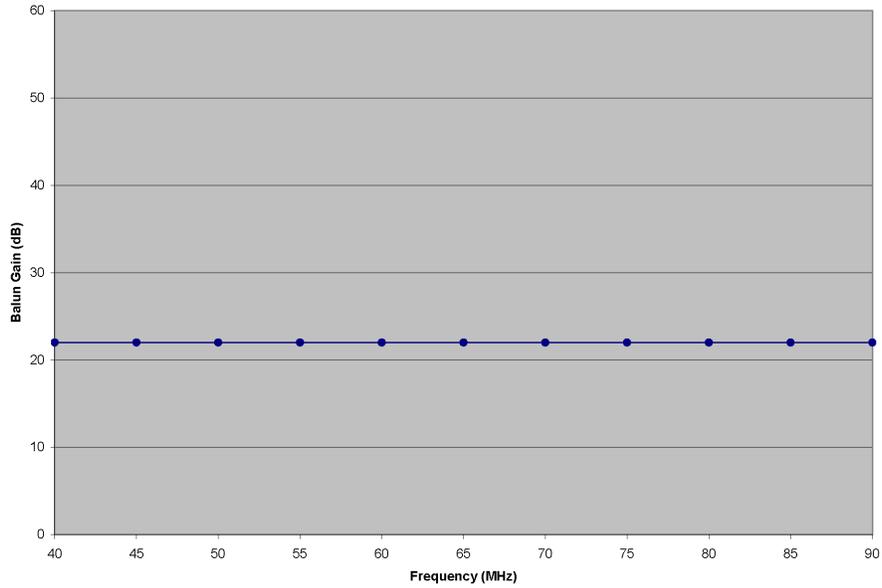


Fig. 16. The average gain of the Hicks balun was ~ 22 dB over the 40 – 90 MHz frequency range. These values were obtained by taking the average difference in the noise floors between figures 15 and 14.

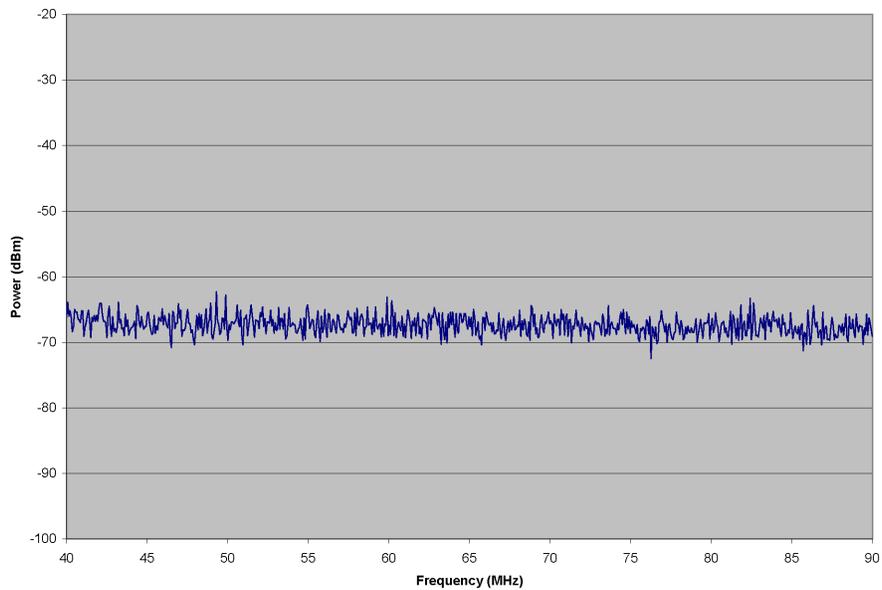


Fig. 17. Spectrum analyzer + 30 dB 2^{nd} stage amplifier + 100 m coaxial cable + noise source with 10 dB attenuator.

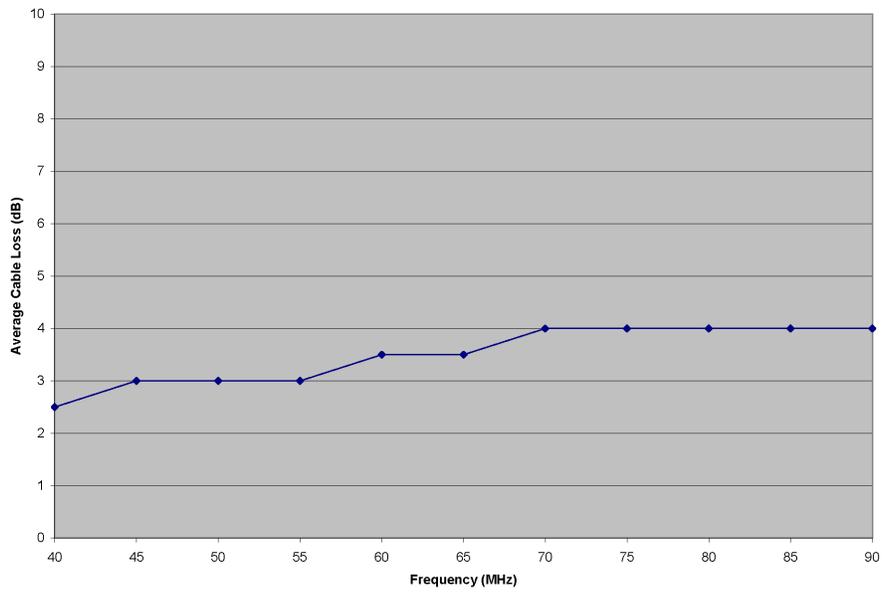


Fig. 18. Average loss in the 100 m coaxial cable. These values were obtained by taking the average differences in the noise floors between figures 14 and 17. LMR-400 coaxial cable was used in these measurements, and is specified to have an average loss of 3dB/100m, which is consistent with the results shown here.

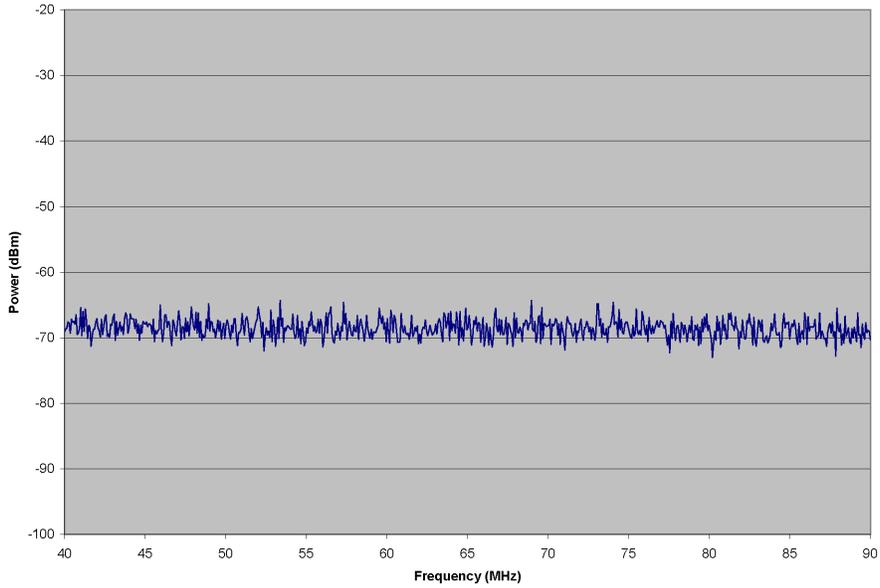


Fig. 19. Spectrum analyzer + 30 dB 2nd stage amplifier + 100 m coaxial cable connected to balun output port A + 50Ω terminations on balun input ports A1, A2, B1, B2, and output port B.

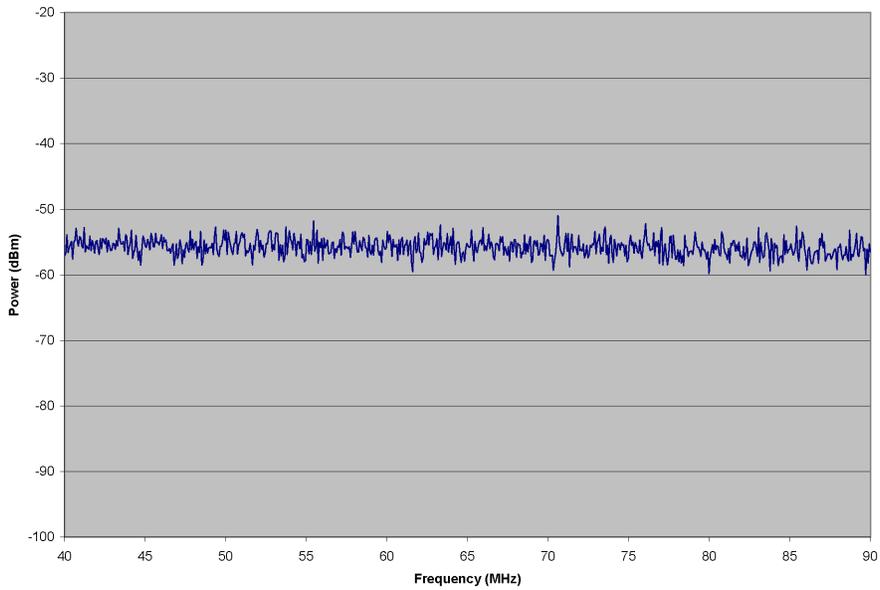


Fig. 20. Spectrum analyzer + 30 dB 2nd stage amplifier + 100 m coaxial cable connected to balun output port A + noise source with 20 dB attenuation on balun input port A1 + 50Ω terminations on input ports A2, B1 and B2, and output port B.

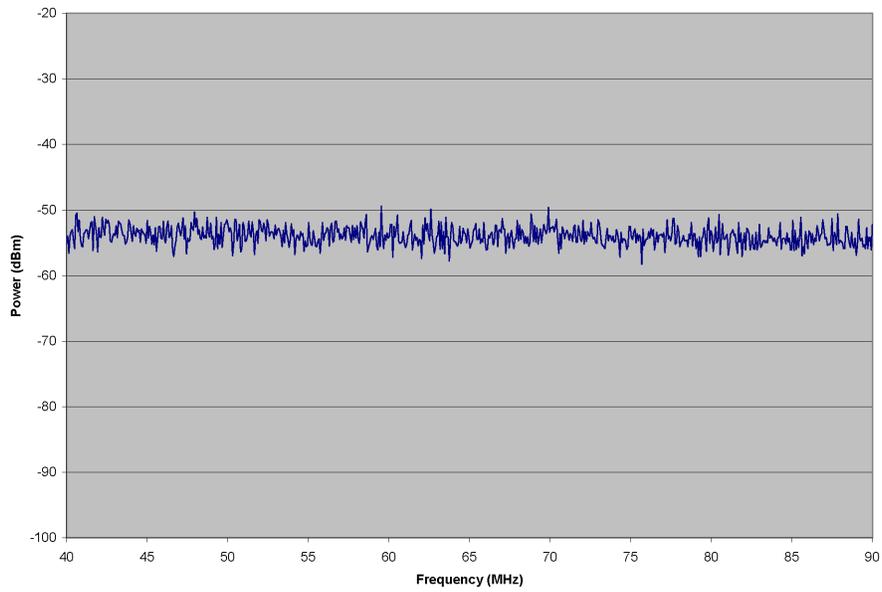


Fig. 21. Spectrum analyzer + 30 dB 2^{nd} stage amplifier + 100 m coaxial cable connected to balun output port A + noise source with 20 dB attenuation connected to the balun inputs A1 and A2 through a 3dB power splitter + 50Ω terminations on balun input ports B1 and B2 and balun output port B.

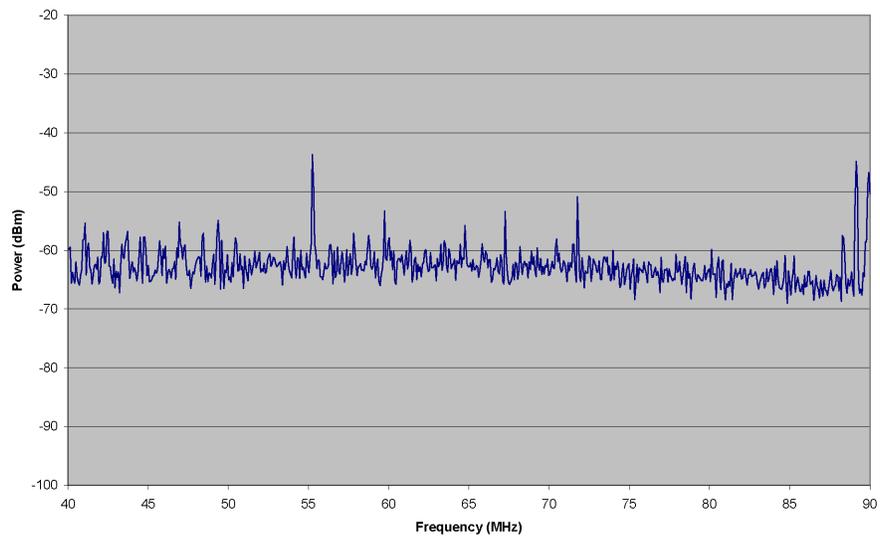


Fig. 22. Spectrum analyzer + 30 dB 2^{nd} stage amplifier + 100 m coaxial cable connected to balun output port A + balun input ports A1, A2, B1 and B2 connected to blade antenna. + 50Ω termination on balun output port B.

ACKNOWLEDGMENT

Basic research in radio astronomy at the Naval Research Laboratory is supported by the Office of Naval Research.

REFERENCES

- [1] N. Paravastu, "LWDA Blade Antenna Redesign," July 2005.