The X-Band Low-Noise Antenna Measurement Cone

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An X-band low-noise receiving cone with 17-MHz instantaneous bandwidth has been built to evaluate the 26-m antenna at the Venus Station (DSS 13), Goldstone, California, at X-band frequencies, and also to provide a means for precise radio source calibrations in this frequency range. These measurements are necessary to provide more accurate antenna gain performance calibrations for the 64-m antenna subnet. The zenith system temperatures with the cone on the ground and on the antenna are 17.5 and 20.8 K, respectively.

The X-band low-noise antenna (XLA) measurement cone has been built to evaluate the 26-m antenna at the Venus Station (DSS 13, Goldstone, California) at X-band frequencies, and also to provide a means for precise radio source calibrations in this frequency range. These measurements will provide the means to improve the calibration accuracy of the gain performance of the three antennas in the 64-m subnet.

The block diagram of the XLA cone is shown in Fig. 1. The X-band traveling wave maser (TWM) described in Ref. 1 has been modified, with a superconducting magnet in place of the permanent magnet and push-push pumping at 19 and 24 GHz. This modified maser, which has 45-dB gain and 17-MHz instantaneous bandwidth, has been installed in the XLA cone. As there is no waveguide switch between the horn and the input to the TWM, all Y-factor system temperature measurements are made with an aperture load. The 33-dB coupler provides an access port which is normally terminated in a load, as shown in Fig. 1. This port allows the injection of test signals to the input of the maser.

Three noise diodes, ND1, ND2, and ND3 in the diagram, have been provided which, when activated, inject approximately 90, 6.5, and 190 K, respectively, into the system. The diagram also shows that a switch and 10-dB coupler have been built into the ND2 path to provide an optional reduction in ND2's equivalent noise temperature to approximately 0.6 K. The concept of a low-level noise diode is to provide a capability for a noise-adding radiometer (NAR) (Ref. 2) during spacecraft tracking with minimum system performance degradation. A requirement for on-line system temperature measurement in the network during spacecraft tracking could be satisfied by a NAR, provided the noise diode injected level was

sufficiently low. The switched 10-dB coupler potentially provides the required noise diode calibration under high-level operation.

Figure 2 shows a block diagram of the cone receiver. There are four input ports and two output ports. A 5-MHz reference signal, derived from a frequency synthesizer, drives a times 20 multiplier, and thence a phase-locked multiplier, to provide a local oscillator signal for the mixer module, as shown in the diagram. The mechanical tuning range of the phase-locked multiplier is 1.5 GHz. The high stability of this local oscillator signal chain provides a very long baseline interferometry capability for the cone. The radio frequency (RF) input is fed from the receiver port shown in Fig. 1, and the output from the mixer module is the intermediate frequency (IF) signal, which is processed in a convenient manner determined by each experimenter. The signal generator module provides two separate methods of generating the beacon signal from a 50-MHz source. The beacon signal is fed into the system, as shown in Fig. 1.

Figure 3 shows the upper section of the cone feed. The gears and drive motor assembly are not used and not connected. They form part of the right and left circular polarization change equipment that was used in the multifrequency X- and K-band (MXK) cone which was removed from DSS 14 earlier this year. The upper feed section shown in the photograph was taken from the MXK cone and used in the building of the XLA cone without modification in order to keep the construction costs down.

Figure 4 shows the lower section of the XLA cone feed. The 33-dB coupler is shown on the input to the maser.

Figure 5 is a photograph of the maser showing both input and output sections. Figure 6 is a photograph of the noise box, which is also shown in the block diagram (Fig. 1).

The system temperature, measured at zenith with the cone on the ground at 8.45 GHz, was 17.5 K. The reference point for system temperature measurements is the maser input reference flange, which is shown in Figs. 1, 4, and 5. The follow-up contribution was 0.5 K, with a maser gain of 41 dB. The noise temperature of the maser is 7.5 K. When the cone was mounted on the 26-m antenna at DSS 13, the zenith system temperature was 20.8 K, with a follow-up contribution of 0.16 K. This results in an effective differential temperature between the cone on the ground and the cone on the antenna of 3.6 K.

When the XLA cone is not being used on the 26-m antenna, it will be operated on the ground at DSS 13. These ground measurements will verify and back up the X-band atmospheric noise temperature statistics program (described in Ref. 3).

References

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3. Reid, M. S., Parham, O. B., and Gardner, R. A., "An X-band Radiometer for the Microwave Weather Project," in *The Deep Space Network Progress Report 42-29*, pp. 54–59, Jet Propulsion Laboratory, Pasadena, Calif., Oct. 15, 1975.

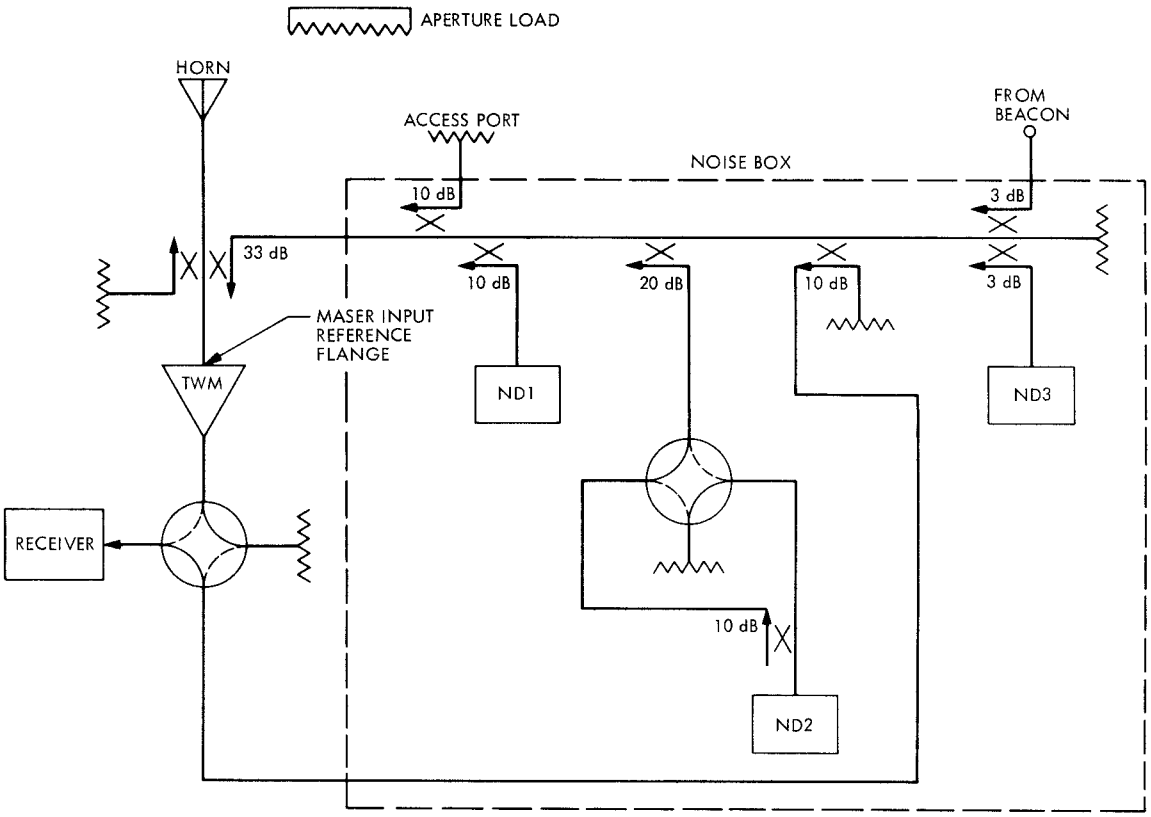

Fig. 1. Block diagram of the XLA cone

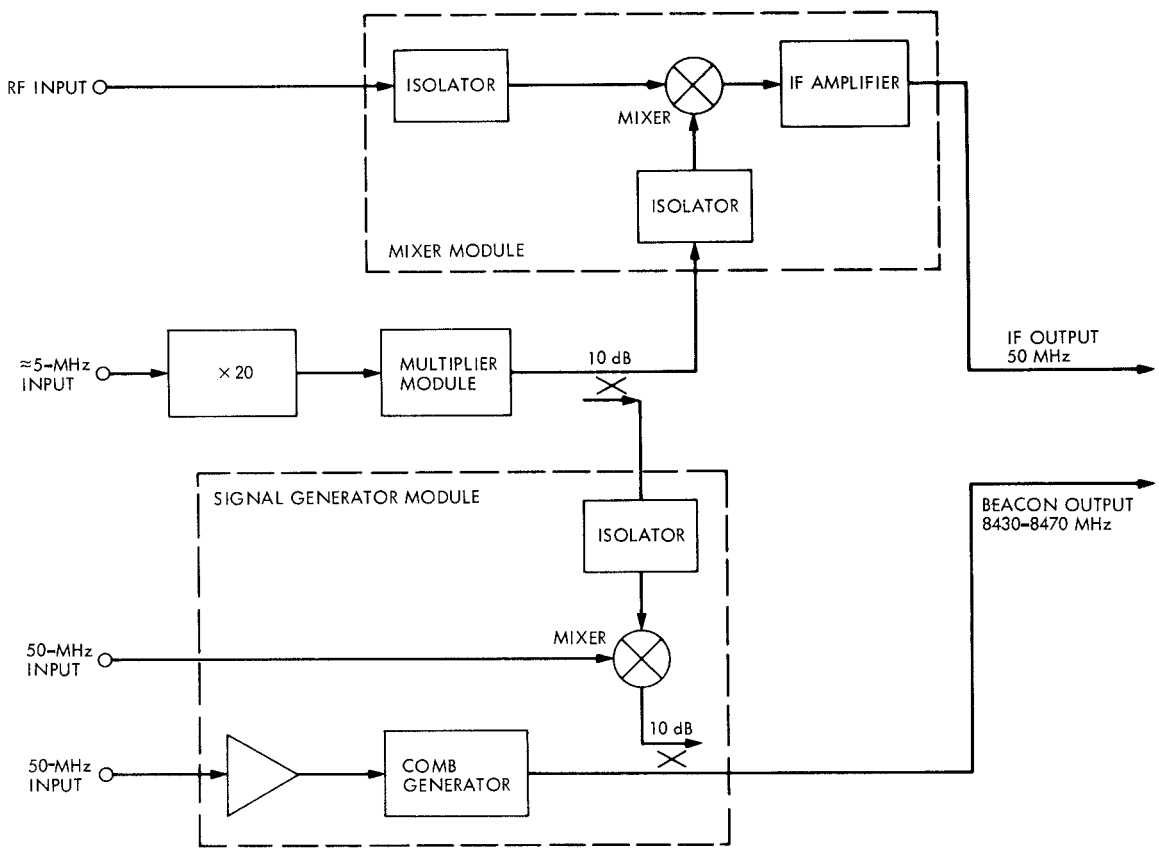

Fig. 2. The XLA cone receiver

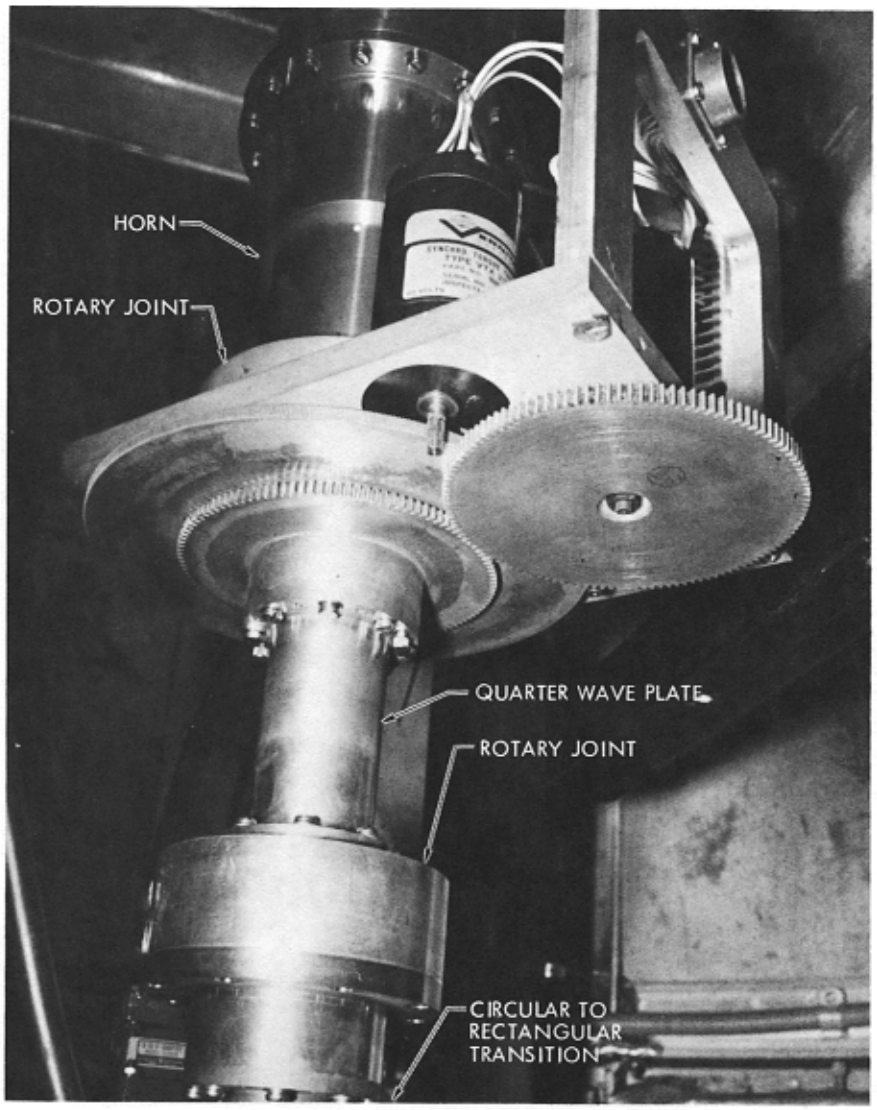

Fig. 3. Upper section of the XLA cone feed

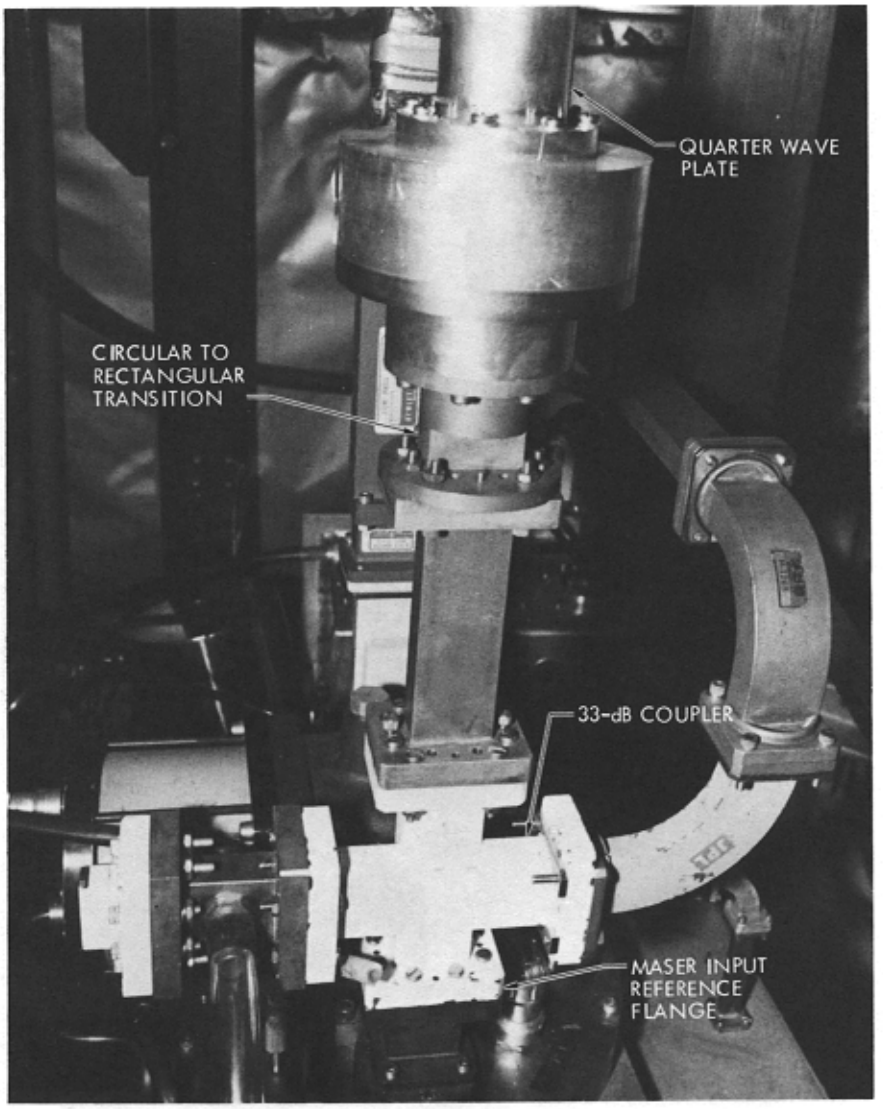

Fig. 4. Lower section of the XLA cone feed

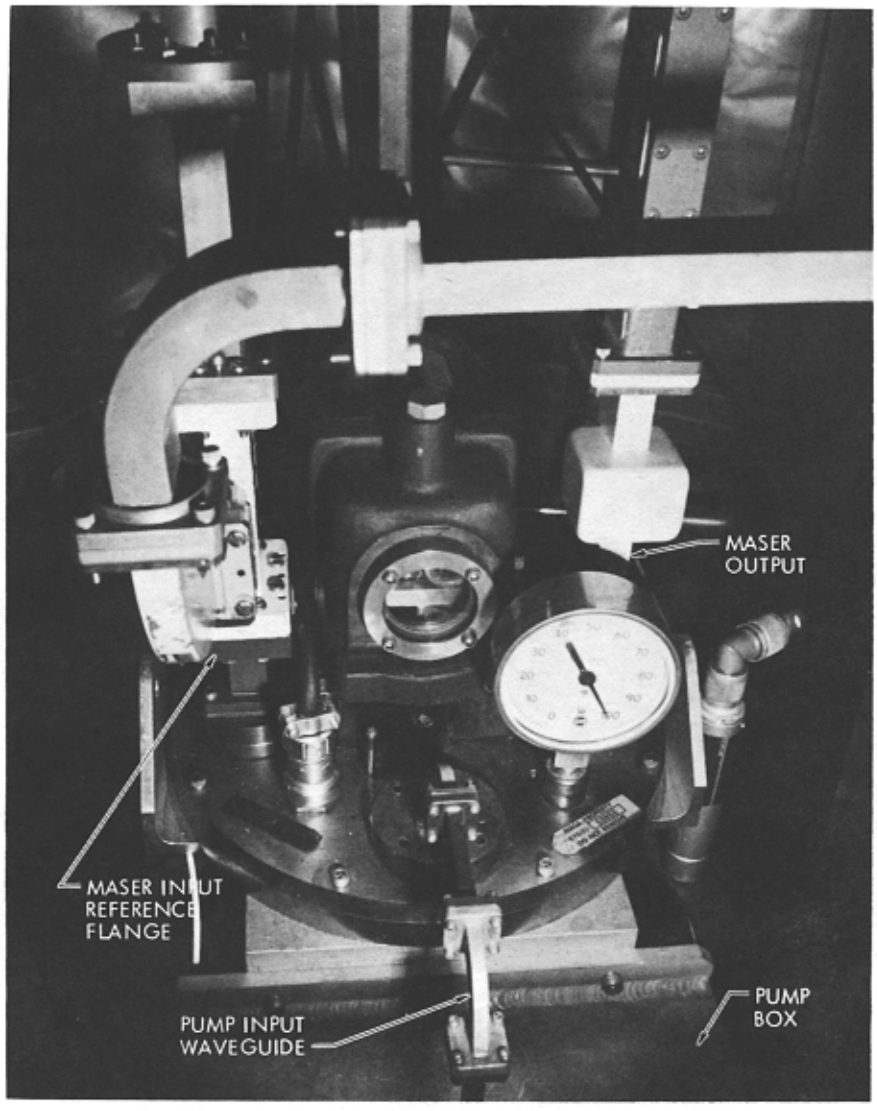

Fig. 5. XLA cone maser

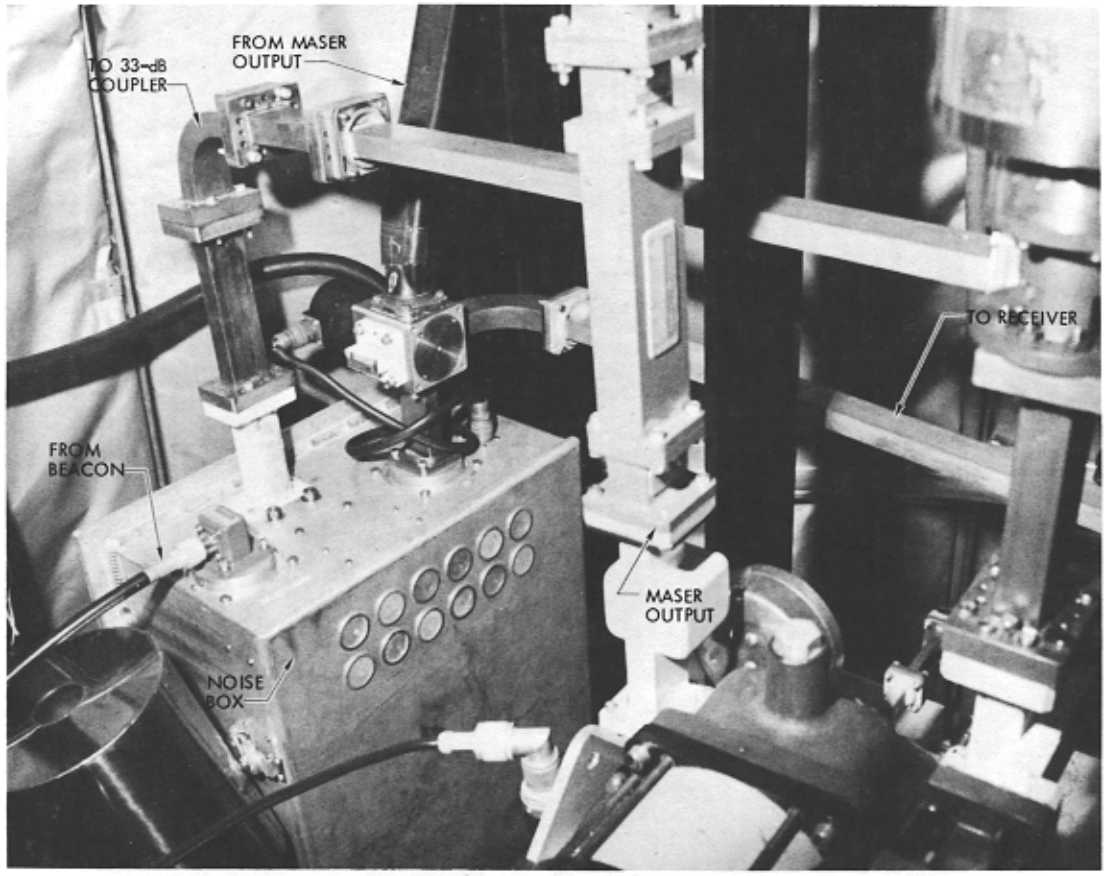

Fig. 6. XLA cone noise box