Operational Time Sync Microwave Subsystem

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The prototype Operational Time Sync (OTS) Microwave Subsystem has been redesigned to accommodate the change in operational frequency and to increase its power handling capability. The completed system has been successfully tested to 115 kW CW at 7150 MHz and is expected to operate at 150 kW CW, the design goal.

The increase in transmitted power from 20 kW CW in the prototype Operational Time Sync (OTS) Microwave Subsystem to the present level of 100 kW CW, together with the 1300-MHz change in frequency from 8450 to 7150 MHz, required extensive redesign of the antenna feed system. The prototype system used a dual-mode horn of the Potter type (Ref. 1) and obtained circular polarization with a waveguide turnstile junction. Since the Potter horn is not broadband, it would have required a replacement for the new frequency. It was decided to use the corrugated horn instead, since it has been perfected at X-band frequencies for prior JPL projects (Ref. 2).

The turnstile junction is not a satisfactory waveguide device for extremely high power applications. It was, therefore, replaced with a quarter-wave plate polarizer similar to those proven successful in 500-kW CW S-band systems. An optimum design at 2295 MHz was scaled to 7150 MHz and mechanically adapted to be suitable for X-band flange hardware. The resulting circular waveguide size had a diameter of 4.11 cm (1.618 in.). After examination of the propagation characteristics of this size waveguide at 7150 MHz, it was decided to adopt this as standard (WC-162 would be the correct EIA nomenclature) for all the circular waveguide components, rather than transforming to other diameters by means of cosine tapers.

Since previous X-band work at JPL had been at frequencies around 8448 MHz, existing microwave components and test equipment were all in 3.477-cm (1.369-in.)-diameter waveguide (WC-137). Accordingly, some work had to be done to accommodate the new size. A cosine taper between the two diameters was designed and two units were fabricated. Their voltage standing wave ratio (VSWR) was determined to be less than 1.010, thus permitting the use of existing sliding loads and other equipment to be used without significantly degrading measurement accuracy.

The corrugated X-band horn also had a throat diameter of 3.477 cm (1.369 in.) and a VSWR of about 1.11 at 7150 MHz, this frequency being below its optimal bandwidth. It was expected that a matching section would have to be added next to the input of the horn in order to lower this mismatch. Before any attempt was made to design this matching section, the horn throat was opened to 4.11 cm (1.618 in.), thus removing the internal taper between the input and the large matching iris. It was assumed that the effect of this machining operation would be slight with respect to impedance and beneficial with respect to power handling capacity. When the horn was measured, the VSWR had decreased to 1.07, apparently due to the more gradual change in diameter seen by the propagating field. This improvement in performance eliminated the need for a matching section.

Another design problem was posed by the need for a transition between circular and rectangular waveguide capable of handling 100 kW CW (previously, the turnstile junction performed this function as well as generating circular polarization). Consideration was given to designing a five-step transition similar to those previously used at S- and X-band, but it was decided to use this type of transition as a backup while a higher power design was attacked. A mathematical design was obtained[1] for a uniform taper transition between the WC-162 (round) waveguide and the WR-137 (rectangular) waveguide. A computer program was written,[1] from which punch cards were obtained to operate a programmable machine tool. A master tool was cut, several duplicates were made on a copying lathe, and the final transition was formed out of solid OFHC copper by electron discharge machining.

[1]With the assistance of Dr. J. R. Radbill.

The VSWR of the 12.7-cm (5-in.) transition is less than 1.04 over the frequency band of 7150 to 8500 MHz. Because it has no discontinuities of any kind other than the gradual change of shape, it should be capable of carrying the same power as the rectangular waveguide input.

All of the above components must be water-cooled for full power operation. Instead of fabricating the water-cooling passages as an integral part of the microwave component, as is usually the practice, it was decided to design water-cooling blocks which bolt onto the waveguide parts. The advantages of this approach are twofold: (1) the final component is less expensive since the microwave part is precision made out of OFHC copper, while the cooling block is a low-tolerance brass or aluminum part and is identical for several different waveguide components; and (2) replacement or redesign of a microwave part does not involve the water cooling part and vice versa.

The completed feed cone assembly, with the outer shell partially removed, is shown in Fig. 1. At the time of this writing, the microwave system has transmitted 115 kW CW without incident. The transmitter back power indicates a system VSWR of 1.045. It is expected that test runs to 150 kW CW will be completed in the near future.

References

1. Potter, P. D., *A New Horn Antenna with Suppressed Sidelobes and Equal Beamwidths,* Technical Report 32-354. Jet Propulsion Laboratory, Pasadena, Calif., Feb. 25, 1963.

2. Brunstein, S. A., "A New Wideband Feed Horn with Equal E- and H-Plane Beamwidths and Suppressed Sidelobes," in *The Deep Space Network,* Space Programs Summary 37-58, Vol. II, pp. 61–64. Jet Propulsion Laboratory, Pasadena, Calif., July 31, 1969.

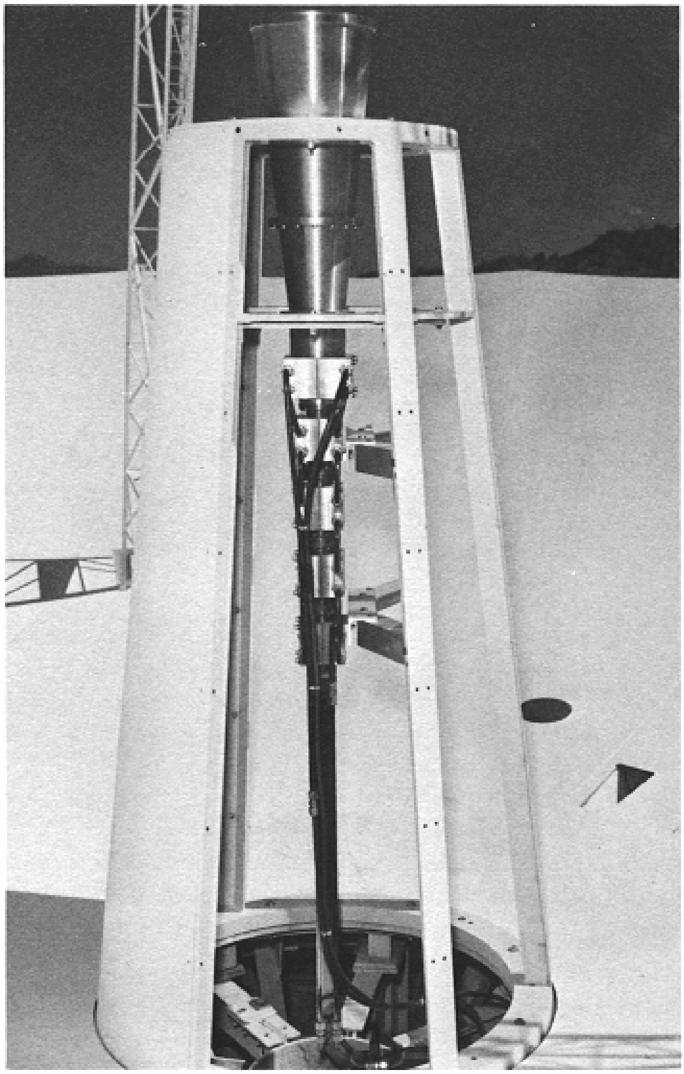

Fig. 1. Completed feed cone assembly with outer shell partially removed