X-Band Hybrid Combiner

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A four-port hybrid junction is being developed to combine the outputs of two 200-kW klystron amplifiers to achieve a 400-kW radiated signal at X-band. Progress to date in developing the hybrid under contract is reported.

I. Introduction

To achieve a 400- to 500-kW radiated signal at X-band for spacecraft uplink development and planetary radar applications, two 250-kW klystron tubes will be combined in phase. This technique avoids the costly and time-consuming development of a single klystron with the desired power output, but requires the development of a waveguide combiner that can handle the extreme power densities involved with high isolation, low voltage standing wave ratio (VSWR), and good balance.

Because of limitations on the dc power available, the expected maximum power level that the hybrid will experience will be 400 kW at 8495 MHz. System considerations require that the working isolation be at least 30 db to protect each tube window from coupled power from the other tube. Allowing for impedance mismatches on the antenna feed side of the hybrid, which effectively lower the isolation, a specification of 36 db was placed on hybrid isolation, with a design goal of 40 db.

II. Hybrid Development

As a result of a competitive procurement, Varian Associates was awarded a contract to develop the hybrid combiner. Delivery of two units is scheduled during the next reporting period. At the time of this report, development is essentially complete and some preliminary tests have been run on the first unit before hydrogen furnace brazing of the parts. The results are shown in Table 1.

The unbrazed hybrid made of oxygen-free copper is shown in Fig. 1. After brazing, the ends will be machined

to permit attachment of the waveguide flanges. The threaded boss in the center of the unit will provide for water cooling under power.

Figure 2 shows the top plate removed, revealing the water-cooling passages. The hybrid is symmetrical top to bottom as well as left to right, with another identical set of water passages underneath.

The waveguide passages and the coupling iris can be seen in Fig. 3, where the top wall has been removed. The two tubes in the center of the unit are posts that electrically determine the exact size of the coupling iris. They are hollow to permit water to flow through them.

III. Future Activities

During the next reporting period, final low-power tests will be performed on the first unit and the water passages will be vacuum tested to ensure their integrity. Preparations will begin for first stage high-power testing of the delivered unit using a single transmitter and multiple loads.

Table 1. Preliminary test results on hybrid No. 1 before brazing

Parameter	Frequency, MHz		
	8460	8495	8530
Isolation	$>$ 40 dB	$>$ 40 dB	40 dB
VSWR	1.015	1.015	1.03
Balance	$\pm$0.20 dB	$\pm$0.15 dB	$\pm$0.10 dB

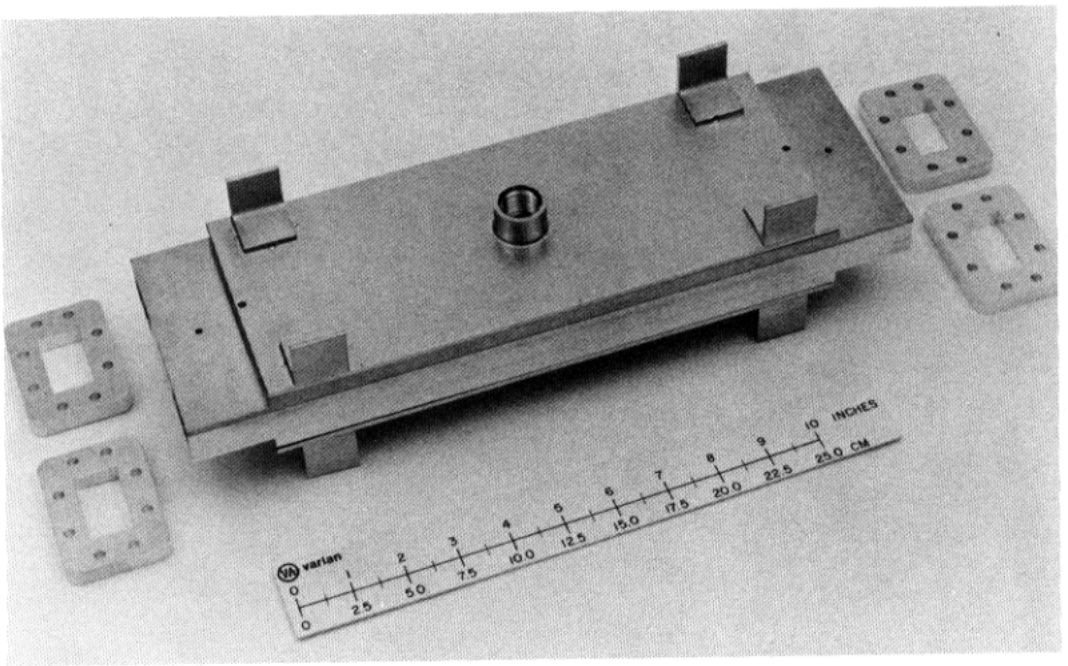

Fig. 1. Hybrid before brazing

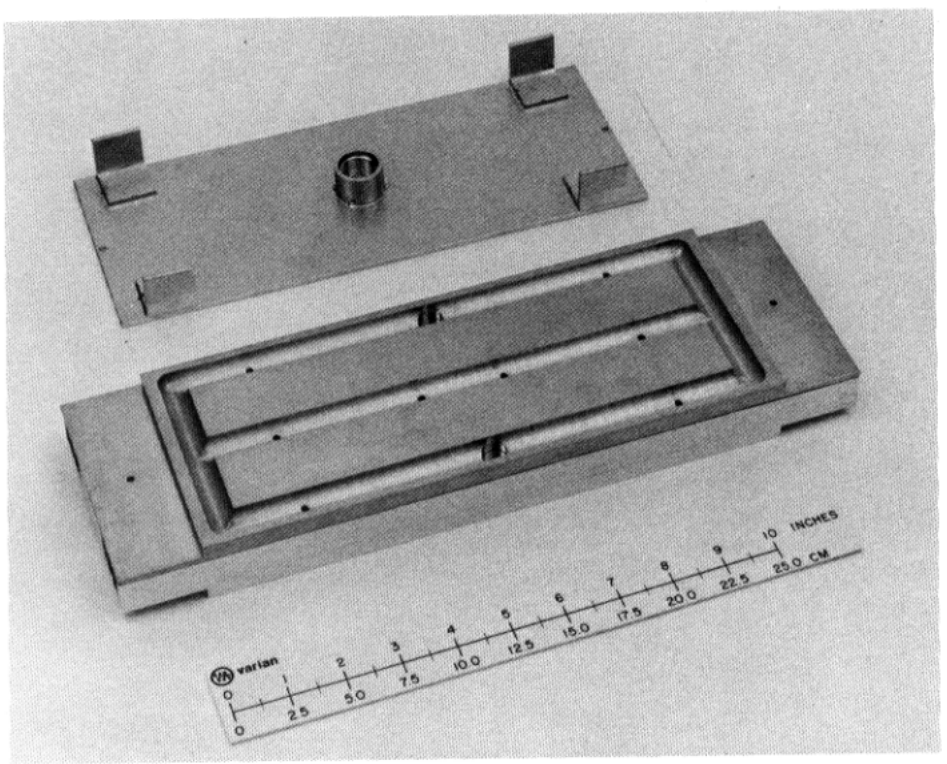

Fig. 2. Hybrid with top plate removed

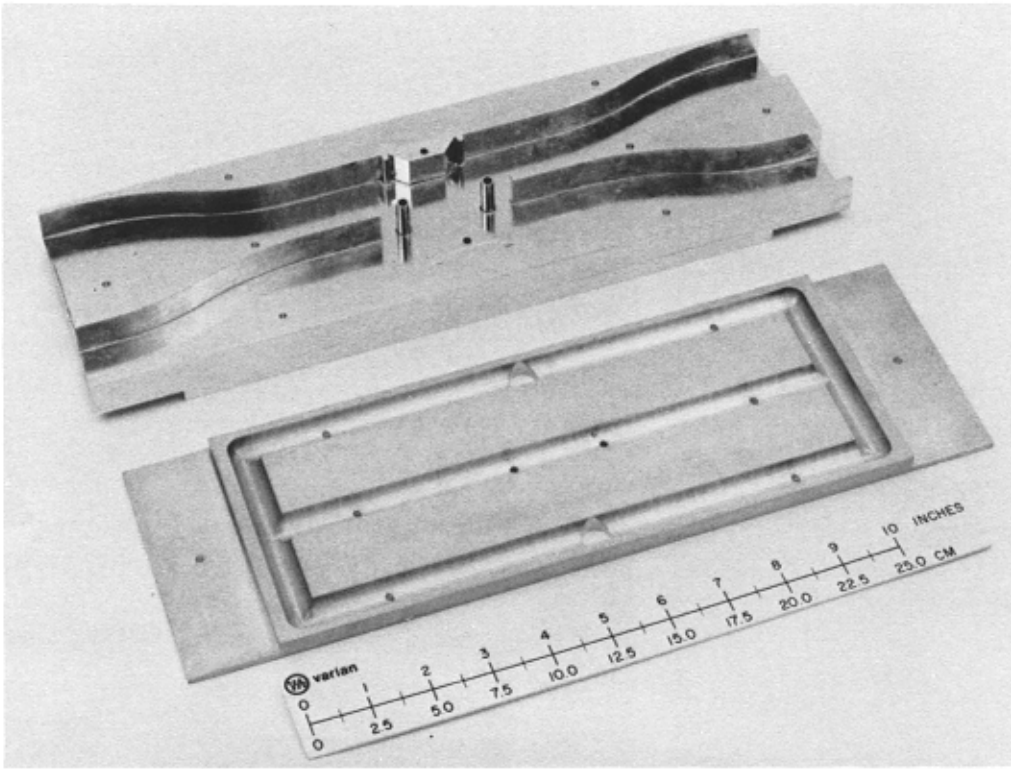

Fig. 3. Hybrid with top wall removed