10-W S-Band Amplifier

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A more powerful S-band amplifier was needed to drive the high-power transmitters of the Deep Space Network. Two types of 10-W solid-state amplifiers with 23-dB gain and operating at 2115 MHz for the DSN 400-kW transmitter and 2388 MHz for the 450-kW R&D transmitter were developed.

I. Introduction

This report covers the development of two S-band amplifiers for operation with high-power DSN and R&D transmitters. During the development of the 400-kW transmitter and the development of the 450-kW R&D transmitter it was determined that a more powerful buffer amplifier than the triode amplifier used in the Block IIIC receiver/receiver exciter chain was needed. Two S-band 10-W solid-state amplifiers were developed for this purpose (Fig. 1.) The specifications for these two amplifiers are listed in Table 1 for the 2115-MHz DSN amplifier, and Table 2 for the 2388 R&D amplifier.

II. Description

A three-stage Class C amplifier was developed (Fig. 2.) This Class C amplifier turns on very abruptly at approximately 50 mW of drive and is completely saturated 2 or 3 mW beyond this point. The first stage consists of a single transistor with a gain of 12 dB. The second stage is also a single transistor with a gain of 9 dB. The third stage consists of two transistors with inputs and outputs combined by hybrids. A circulator with a load is placed on the output of the second hybrid. The circulator is used to maintain a constant 50-Ω load to the last stage of the amplifier and to protect it in the event of an open- or short-circuit load. Normally the amplifier is intended to operate into a VSWR of 1.2:1.

The two amplifiers are identical with two exceptions. The first exception is that the circuitry is scaled to appropriate frequency for each amplifier. The second exception is a resistor in the supply circuit used to drop the voltage to the first and second stages, thereby reducing the gain of these stages for the 2115-MHz DSN amplifier.

III. Performance

Fourteen 2115-MHz DSN amplifiers have been evaluated. Six of these have outputs between 11 and 12 W. Five have outputs between 12 and 13 W. Two have outputs between 13 and 14 W, and one has an output in excess of 14 W. Six 2388-MHz R&D amplifiers have been evaluated. Two amplifiers have an output between 11 and 12 W, and four units have an output in excess of 12 W. A typical frequency response is shown in Fig. 3. The units have a response that is flat within 0.5 dB from 2070 to 2200 MHz. The requirement is ± 1 dB from 2105 to 2125 and ± 0.5 dB from 2110 to 2120 MHz. All spurious harmonics up to the fifth are at least 40 dB down from the fundamental.

IV. Problem Area

During the development of the two amplifiers several problems were encountered. All of them have been solved with the exception of one. The first problem encountered was with the 2388-MHz R&D amplifier. When the first 2388-MHz R&D amplifier was being bench-tested at JPL, the output of the amplifier dropped to zero. An extensive investigation showed that the circulator used would handle only 4 W CW, and that the 10-W output level of the amplifier had burned out the circulator. A new higher-power circulator was installed by the manufacturer and the amplifier was retested. No problems with the circulator have occurred since this change. The first 2115-MHz DSN amplifier was tested at JPL and installed for evaluation at DSS 13. After several weeks of operation the output of the amplifier dropped to zero. An investigation made into the problem showed that the first two stages were overdriving the third stage. To correct this problem a resistor was used to drop the supply voltage to the first and second stages thereby reducing their gain. A second 2115-MHz amplifier was placed on evaluation test at DSS 13. This amplifier performed properly for about two weeks at which time the output dropped 3 dB due to a defective solder connection on one of the two output transistors. Overdriving the input to the amplifiers above 100 mW may cause the first-stage base emitter junction to break down. A warning has been issued to all operating personnel using these amplifiers to be very cautious in applying drive to the amplifiers.

All the problems encountered have occurred with very few hours of operation accumulated on each amplifier. A policy of testing each amplifier on the bench for 14 straight days, running 24 h a day, has eliminated these early failures.

Table 1. 2115-MHz amplifier specifications

Output	10 W (+40 dBmW) min
Input	50 mW (+17 dBmW) max
Supply voltage	+28 ±0.5 Vdc
Supply current	2 A max
Frequency response	
2105 to 2125 MHz	±1 dB
2110 to 2120 MHz	±0.5 dB
Spurious harmonics (2, 3, 4 and 5 down from fundamental)	−35 dB
Stability	Unconditional
Load VSWR	1.2:1 max
No damage	Any VSWR
Temperature operation	10 to 50°C

Table 2. 2388-MHz amplifier specifications

Output	10 W (+40 dBmW) min
Input	50 mW (+17 dBmW)
Supply voltage	28 ±0.5 Vdc
Supply current	2 A max
Frequency response	
2383 to 2393 MHz	±1 dB
Spurious harmonics (2, 3, 4 and 5 down from fundamental)	−35 dB
Stability	Unconditional
Load VSWR	1.3:1 max
No damage	Any VSWR
Temperature operation	10 to 50°C

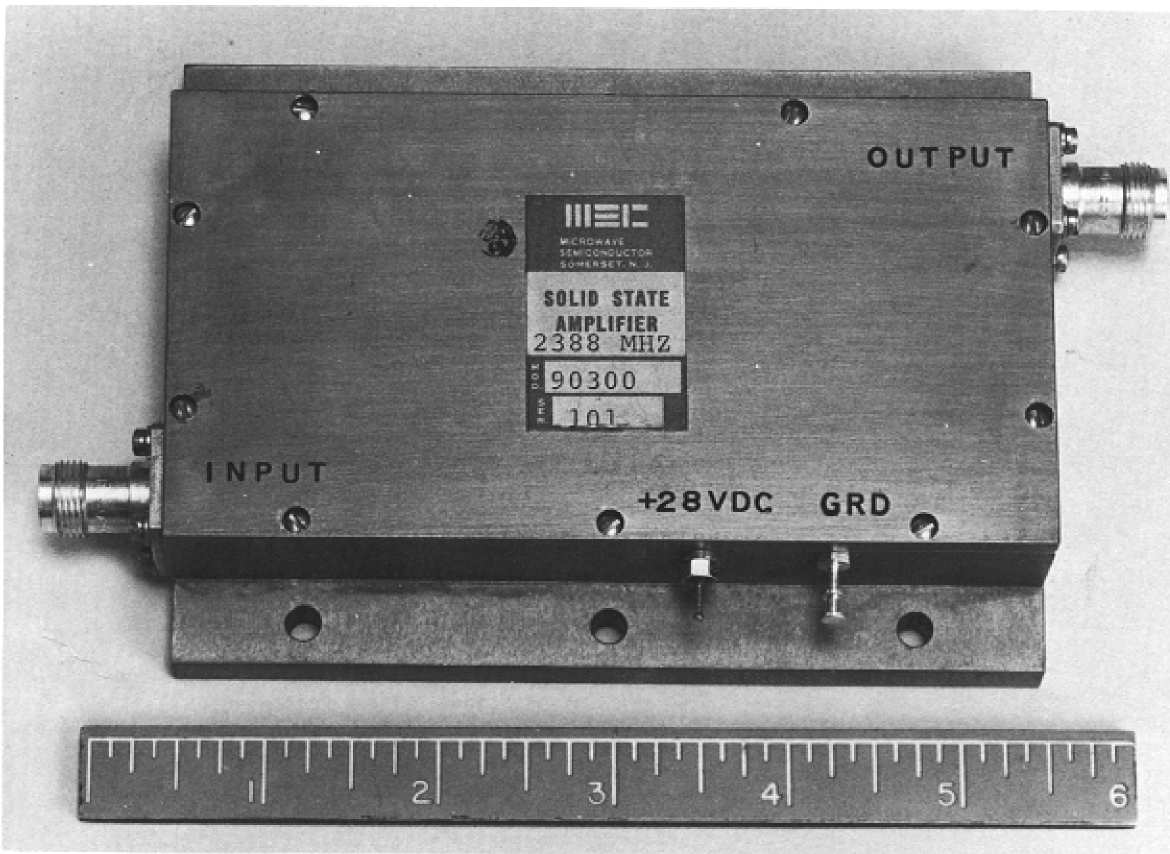

Fig. 1. Solid-state 10-W S-band amplifier

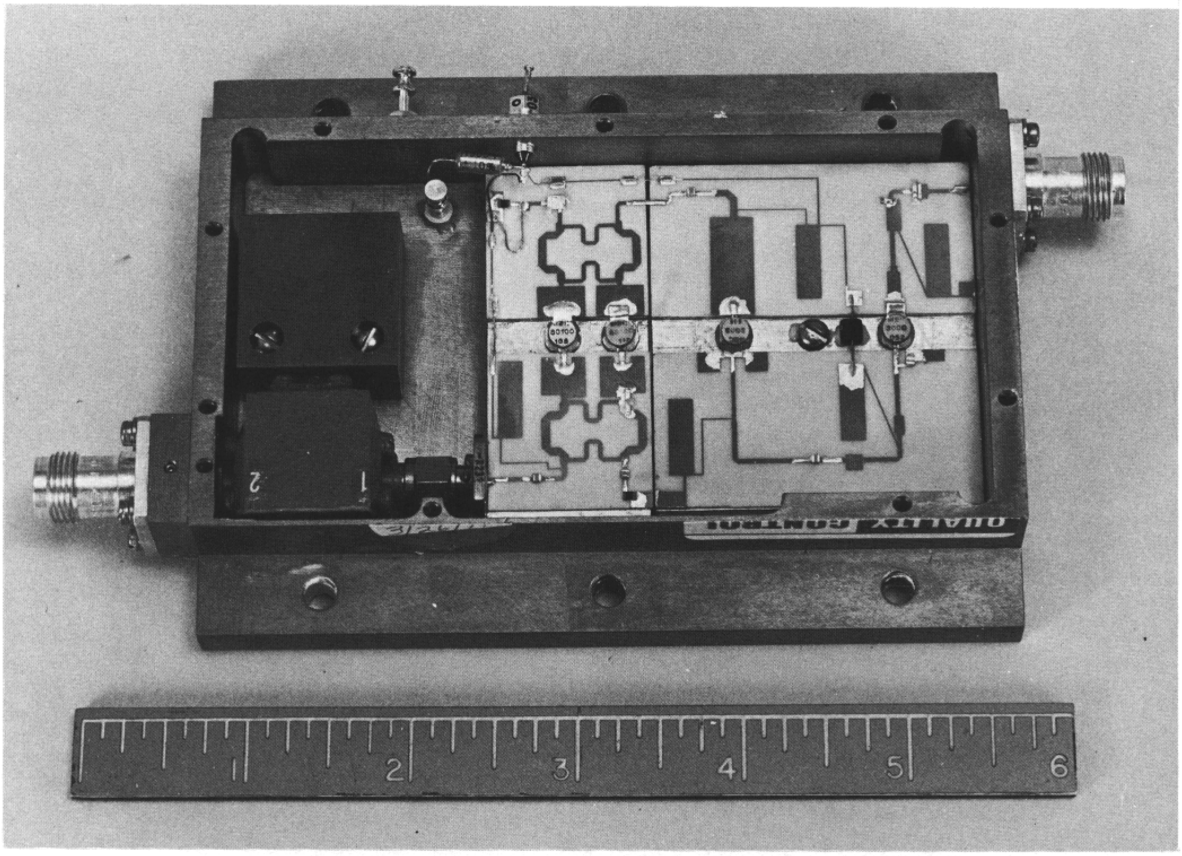

Fig. 2. Solid-state 10-W S-band amplifier with cover removed

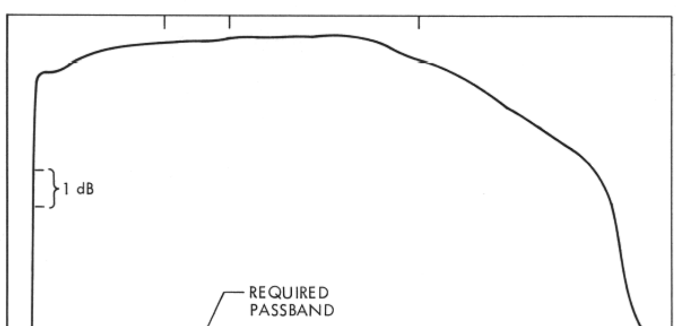

Fig. 3. S-Band amplifier output and passband output versus frequency