EHF SOLID STATE TRANSMITTERS FOR SATELLITE COMMUNICATIONS

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ABSTRACT

During the past three years, interest in satellite communications in the frequency bands above Ku-band has expanded dramatically. As a result, a number of key technology developments, targeted to meet specific next generation spaceborne needs, were undertaken. The state-of-the-art in solid state power transmitters, including critical passive component technology, is presented. This includes filters as well as a series of rugged high performance ferrite components such as isolators, circulators and latching switches.

SUMMARY

In the solid state power transmitter area, several key development efforts are summarized in Table 1.

Table 1. Summary of Solid State Power Transmitter Developments for Space Applications

Type	Frequency	Power Output	Comment/Status
FET Amplifier	15 GHz	7 Watts	1 GHz BW. Complete and space qualified (TRW)
FET Amplifier	20 GHz	8 Watts	Eight 1.25W modules. 8W achieved March 1983
IMPATT Amplifier	20 GHz	20 Watts	19 Watts achieved, gain 10 dB, 100 MHz BW (TRW)
IMPATT Amplifier	38 GHz	5 Watts	10 dB gain, 500 MHz BW. 8% efficiency. Completed 1979 (TRW)
IMPATT Amplifier	41 GHz	11 Watts	30 dB gain, 400 MHz BW, 7% efficiency. Completed 1981 (TRW)

IMPATT Amplifier	44 GHz	0.5 Watts	2 GHz BW. First 6 stages, with 40 dB gain and 0.5W output power completed June 1982 (TRW)
IMPATT Amplifier	44 GHz	5 Watts	2 GHz BW. Status: 3.5 Watts achieved.

Each of the above amplifiers will be described in detail, three of them are shown in Figures 1 to 3 below.

Since 1975, a series of ferrite high performance components have been developed at TRW. The rugged design employed in both circulators and switches was readily space qualifiable and has been selected and used on a number of space programs. Table 2 and Figure 4 summarize this hardware.

Table 2. Typical Performance of Space Qualified High Power Ferrite Components

Frequency Range (Ghz)	Type	Insertion Loss (dB)	Isolation (dB)	VSWR	Bandwidth (%)	CW Power (Watts)
7-10	Circulator	0.1	-25	1.10	35	100
7-8.5	Latching Switch*	0.35*	-37*	1.05	3	100
18-23	Circulator	0.2	-25	1.2	24	75
17.5-20.5	Latching Switch*	0.3	-20	1.2	15	75
27.5-30	Latching Switch*	0.4*	-40*	1.2	9	6
26.5-34	Circulator	0.1	-20	1.2	26	12
32-40	Circulator	0.1	-20	1.2	23	12
37-46	Circulator	0.15	-20	1.2	22	12
59-62	Circulator	0.3	-20	1.25	3	**
92-99	Circulator	0.5	-20	1.3	7	**

* Two Junctions
** Not Tested for High Power

In the filter area, we have evaluated a number of different transmission media in constructing filters, but have found only waveguide filters to be acceptable for demanding space applications. A comparison of the different types of filters evaluated is shown in Figure 5.

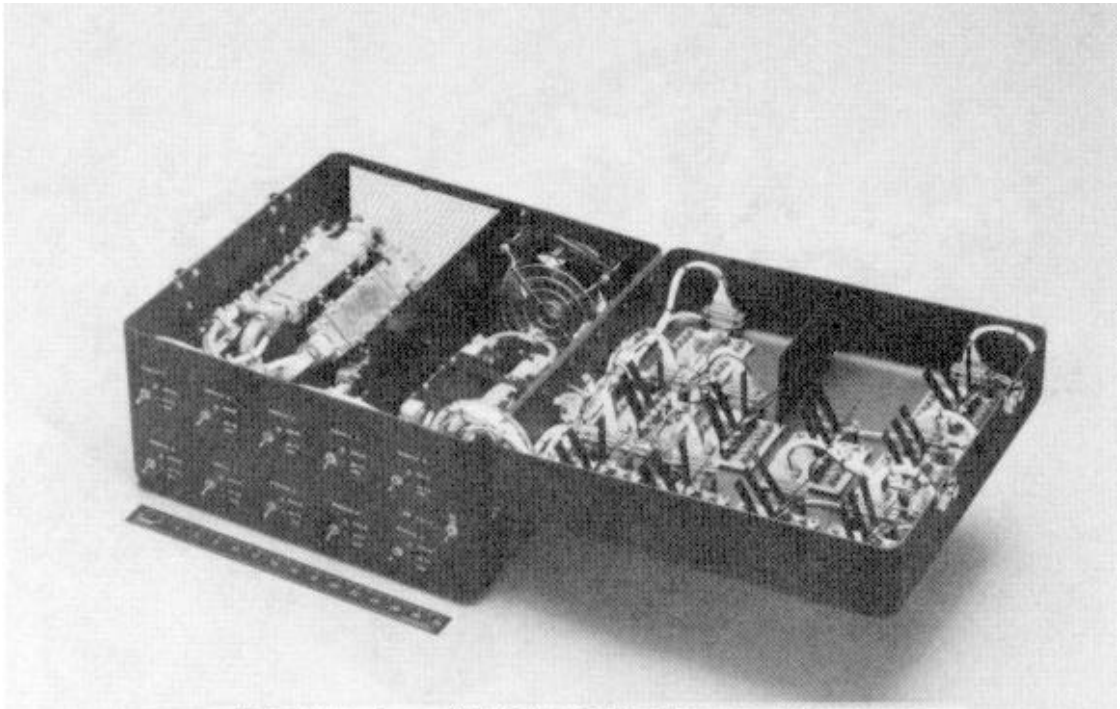


FIGURE 1. 20 GHz FET POWER AMPLIFIER, 8 WATTS

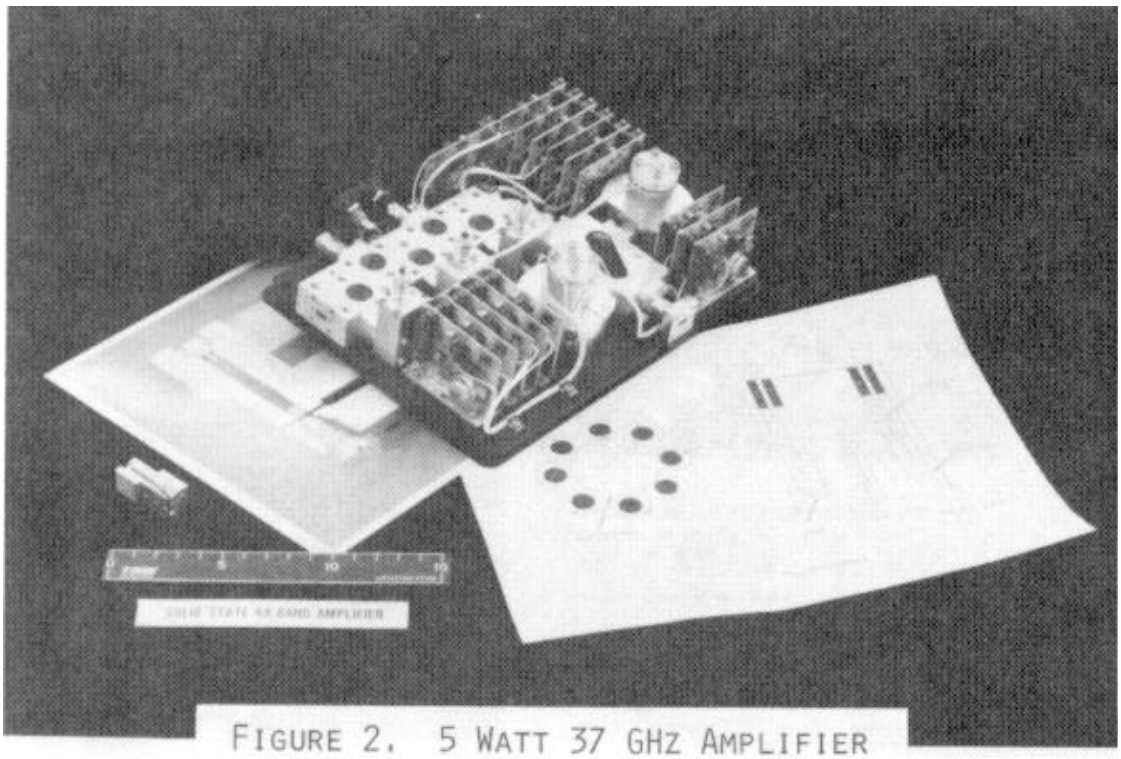


FIGURE 2. 5 WATT 37 GHz AMPLIFIER

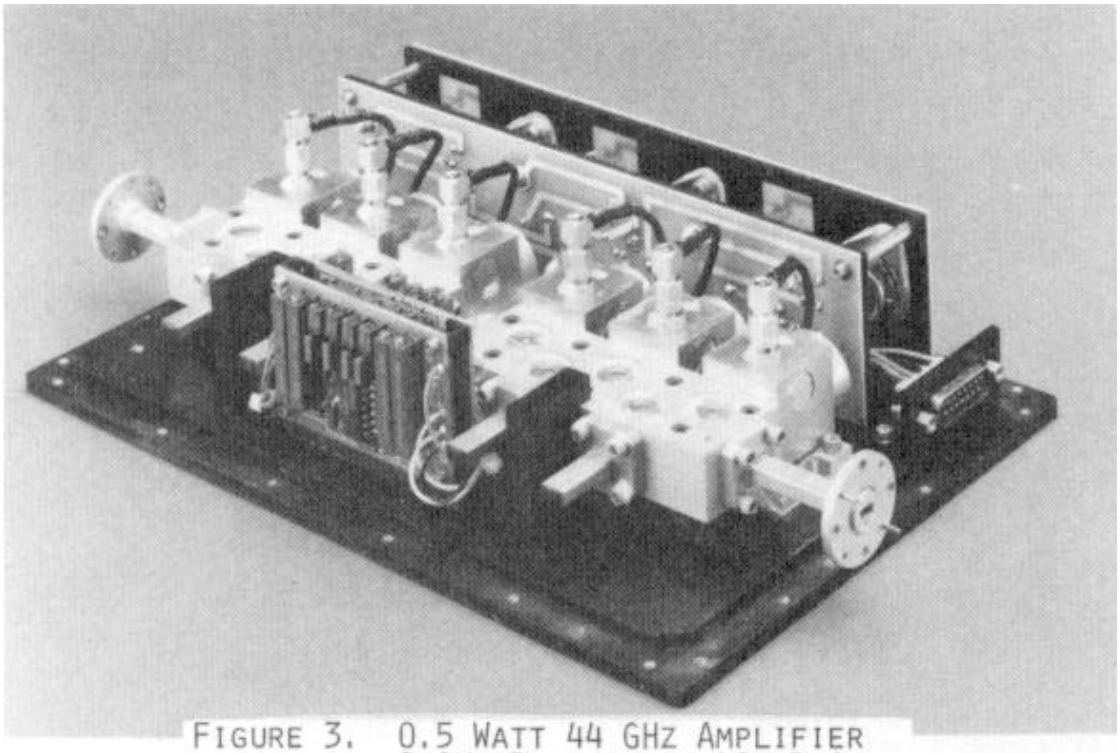
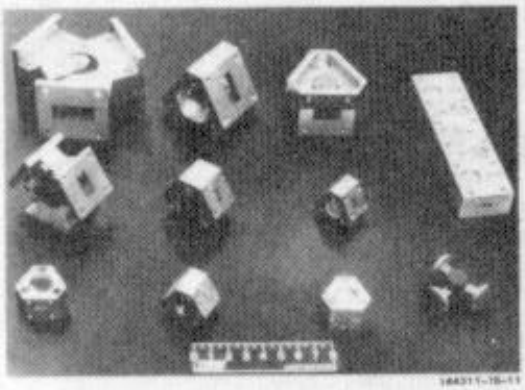


FIGURE 3. 0.5 WATT 44 GHZ AMPLIFIER
2 GHZ BANDWIDTH, 40 DB GAIN

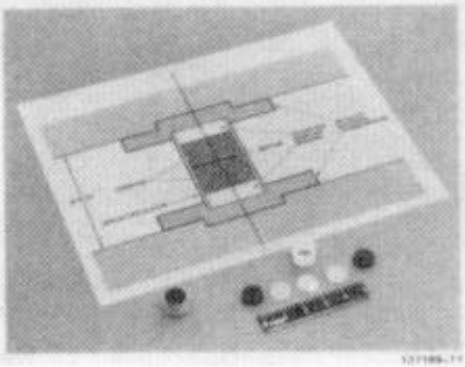
TRW

FIGURE 4.
LOW LOSS BROADBAND CIRCULATORS



FEATURES

- NOVEL CYLINDRICAL JUNCTION DESIGN
- LOW LOSS WIDEBAND
- LOW VSWR, HIGH ISOLATION
- THERMALLY STABLE
- SIMPLE, STRUCTURALLY RUGGED
- ONE TO FIVE JUNCTIONS
- NO INTER-STAGE MATCHING REQUIRED
- DESIGN SELF-INDEXING – NO EPOXIES OR ADHESIVES
- DESIGN PROVEN 7 TO 47 GHz



TYPICAL PERFORMANCE

CENTER FREQUENCY, GHz	10	20	30	40	60	95
INSERTION LOSS, dB	0.1	0.2	0.1	0.2	0.25	0.5
ISOLATION, dB	25	25	25	25	20	20
VSWR	1.1	1.1	1.1	1.15	1.2	1.2
BANDWIDTH, %	25	28	27	22	5	10

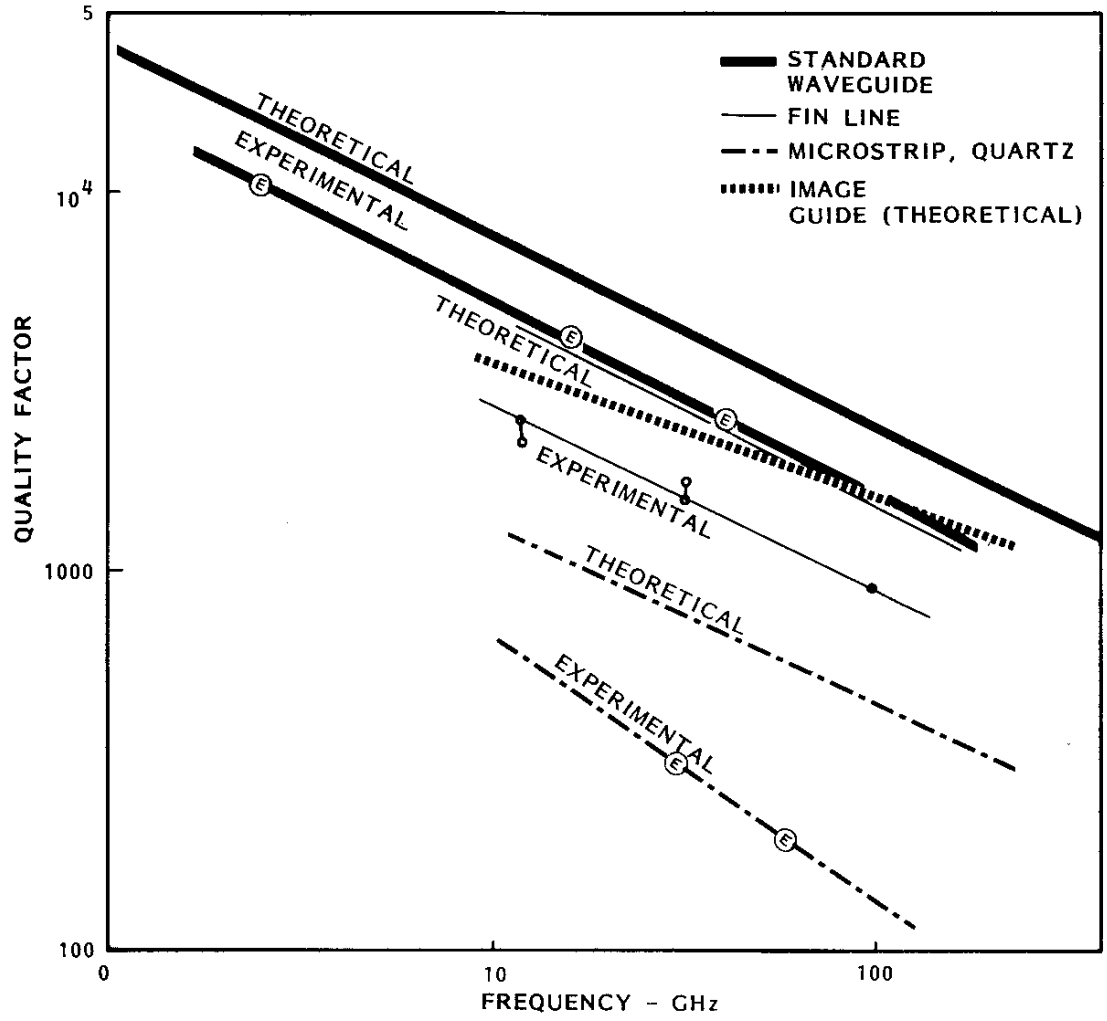


FIGURE 5. THEORETICAL vs. EXPERIMENTAL TRANSMISSION RESONATOR (FILTER) FOR VARIOUS TRANSMISSION MEDIA (FUNDAMENTAL MODE)