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30/20 GHz Technology at TRW

W. M. Holmes
Systems Engineer

30/20 GHz TECHNOLOGY AT TRW

Mr. W. Morris Holmes
Systems Engineer
TRW, Inc.
Redondo Beach, California

ABSTRACT

TRW is developing two types of 20 GHz solid state power amplifiers:

1) an extremely complex 30 GHz receive antenna with both fixed and scanning beams, and

2) the electrical power conditioners (EPC) for a dual mode 7.5 and 75 watt 20 GHz travelling wave tube (TWT).

The solid state amplifiers are a GaAs FET unit with 7.5 watt output and an impatt diode amplifier with 20 watts output. The impatt unit uses a 12 diode combiner with a combining efficiency of 80%. The current breadboard unit provides 17.18 watts output in the injection locked mode.

The antenna uses an 80.5 inch carbon filament reinforced plastic offset parabola to produce 0.3° beams. The feed is polarization diplexed. Both polarizations are utilized to provide fixed and scanning beam with the feed set interspersed to solve the feed crowding problem. The feed assembly and waveguide structure are being integrated. The reflector tooling is nearly complete.

The status and early test results will be reported for all 4 technology items.

30/20 GHz Technology Development at TRW

W. Morris Holmes, Jr.
TRW Defense and Space Systems Group
One Space Park
Redondo Beach, CA 90278

ABSTRACT

TRW is developing: two types of 20 GHz solid state power amplifiers; an integrated 30 GHz receive complex with both fixed and scanning beams; and, the electrical power conditioner (EPC) for a dual-mode 7.5 and 75 watt 20 GHz traveling wave tube amplifiers (TWTA).

The solid state amplifiers, employing GAs technology devices, utilize FET amplifiers to provide a 7.5 watt output, and IMPATT diodes to provide a 20 watt output . The IMPATT unit uses a 12 diode combiner with a combining effeciency of 80%. The current breadboard unit provides 17.18 watts output in the injection-locked mode.

The antenna uses an 80.5 inch carbon-filiment-reinforced plastic offset parabola to produce 0.3° beams. The feeds are polarization-diplexed. Both polarizations are utilized to provide fixed and scanning beams, with the feed-sets interspersed to solve the feed crowding problem. The feed assembly and wave-guide structure are being integrated. The reflector tooling is nearly complete.

The status and early test results will be reported for all four technology items.

INTRODUCTION

As part of the NASA's proof of concept (POC) technology development activity for the 30/20 GHz program, TRW is currently engaged in breadboarding several major payload components for operation in this frequency band. Two types of solid state power amplifiers (SSPA) under development, are currently in the component test and fabrication stage scheduled for completion later this year.

IMPATT SSPA

One SSPA utilizes GAs IMPATT devices which are power combined to achieve a minimum power output of 20 watts and a 500 mhz bandwidth with an overall efficiency of 20%. During the early stages of the development activity, the design concept was centered on developing a 6 diode combiner employing 4.5 watt devices to achieve these breadboard objectives. The device manufacturer fell far short of these original development goals and the resultant power output of this combiner stage was limited to 7.67 watts even though the breadboard combining efficiency was 80%. Thus the development of a 12 diode combiner was initiated and an alternate device manufacturer was selected to achieve the proof of concept breadboard objectives. The new IMPATT devices, supplied by Varian, currently have a nominal 1.6 watt power output.

This 12 diode combiner employing the new diodes (as shown in figure 1) is currently in the final design stage, scheduled for completion at the end of May of this year. The initial results of the 12 diodes combining experiment produced the following characteristics:

- Po = 17.18 watts (injection locked)
- fo = 19.61 GHz
- combining efficiency = 80%
- locking bandwidth = 200 MHz
- locking gain = 9.3 db

This design activity is currently centered on increasing the bandwidth to 500 MHz in achieving the P.O.C. objectives.

The IMPATT transmitter when integrated will consist of two driver stages followed by the 12 diode combiner power output stage for an overall gain of 30.db. The first stage has a gain of 14 db and the second stage gain is 9 db with a power output of 2.5 watts. A high degree of confidence in achieving the P.O.C. objectives has been demonstrated by the design and test activities conducted early this year.

GAs FET SSPA

The second SSPA in development at TRW utilizes GAs FET technology to achieve wideband (2.5 GHz) power output of 7.5 watts with an overall efficiency of 10%. This SSPA employs two driver stages to produce a power output of 1.2 watts followed by a third stage consisting of 8 amplifier stages in parallel to achieve the projected power output with an overall gain of 3 db. The key development activity centered on developing the wideband driver stages and the final power splitter/combiner output stage of 7.5 watts.

The design characteristics of the driver stages were centered on achieving the following characteristics:

FREQUENCY BAND	17.7 TO 20.2 GHz
INPUT POWER LEVEL	+7 dBm
OUTPUT POWER LEVEL	+31 dBm
GAIN	24 dB + 0.5 dB
INPUT AND OUTPUT VSWR	1.4:1
NOISE FIGURE	<15 dB
THIRD ORDER IMD	<20 dBc AT 1 dB COMPRESSION
GROUP DELAY	<0.4 nsec/500 MHz
AM/PM CONVERSION	<3°/dB AT 1 dB COMPRESSION
PHASE LINEARITY	<4° PEAK-PEAK DEVIATION
HARMONIC SUPPRESSION	<30 dBc AT 1 dB COMPRESSION
SPURIOUS RESPONSE	<60 dBc AT 1 dB COMPRESSION
RF EFFICIENCY	>18%

The test power modules, when cascaded with these drivers exhibited an overall gain of 30 db with an overall 1.7 GHz bandwidth. Current design activities are centered on increasing the 19.5 GHz cutoff frequency in achieving the 2.5 GHz bandwidth.

The power module (shown in figure 2) is comprised of a 8 way power splitter imput followed by individual amplifier modules. Each amplifier module (shown in figure 3) has a power output of 1.2 watts with an efficiency of 12%. An 8 way power combiner provides a power output waveguide port which is projected to achieve the 7.5 watt output.

The P.O.C. SSPA is currently in the final fabrication phase scheduled for completion by the end of May, 1982.

Power Processing Unit for TWTA

The power processing unit design at TRW is centered on reconfiguring an existing design (developed for CTS) to support a 20 GHz multi mode TWT operation.

This design features: a series inductor inverter with a 28v DC input to produce the high voltage levels; a variable voltage control amode to control beam current and RF output for multimode operations. New component technology incorporated into this design entail FET devices, high voltage magnetics and high voltage diodes, capacitor and resistor,

The first power processor brassboard modifications together with the test support equipment, are in the first stages of completion scheduled for integration with the TWT for May of this year.

Multi Beam Antenna System

A 30 GHz receive MBA proof of concept development is currently in the fabrication stage at TRW scheduled for integration as a subsystem during the latter part of this year. The key elements in this design, illustrated in figure 4, are the reflector and subreflector elements to establish a dual, polarization diplexed, focal plane for accurately positioning narrow beams (0.3°) over a broad field of view (>20 beamwidths). The interlaced, fixed and scanning beam feed assemblies located in the orthogonal polarization planes are uniquely configured to minimize the feed crowding problem while providing a high degree of spatial and polarization beam isolation; thus maximizing the frequency reuse in providing narrow beam coverage over a broad area. This complex of reflectors, subreflectors and beam forming assemblies will be configured to demonstrate simultaneous operation with area coverage in a scanning beam mode and dispersed fixed beam operation.

The 80.5 inch main reflector is constructed of a carbon-filament-reinforced-plastic material because of its light weight and low thermal distortion properties for space applications. The parabolic reflector surface will be machined to tight tolerance maintaining a .003 inch RMS surface smoothness. The 35 inch, dual shaped subreflectors (one solid and one gridded) are mounted in tandem such that two secondary focal planes are formed; one for each polarization. The vertically polarized signals are reflected off the gridded hyperbolic surface to interact with one feed assembly while the horizontally polarized signals are passed thru the gridded surface and reflected by the canted solid hyperbolic surface to form an orthogonal secondary focal plane where the second feed assembly is located.

One of the feed assemblies, currently being integrated, is a 16 element, diplexed, multi beam feed to form three separate fixed 0.3° beams for operation with user locations separated by as little as one beamwidth. This three beam isolated complement simulates the North East corridor coverage conditions scanning the Boston, New York and Washington areas with (>30 db) isolation between received beams. The center beam (New York) is orthogonally polarized from the two outer beams, utilizing a polarization diplexer in the waveguide assembly. The three beams are shaped using a combination of phase shifters, power dividers and a "magic T" hybrid component imbeded in the waveguide structure.

The second feed assembly, currently being fabricated, consists of a 19 element scanning beam feed complement. These horn feed elements are combined in a relatively simple waveguide structure consisting of combiners, switches and variable power dividers to provide complete coverage of a 19 beam (0.3° each) area. Each beam area, established by combining the feed element outputs individually or in combinations, can be selected in a 0.5 micro second switching time.

The integrated antenna subsystem is scheduled for completion in the September/October time frame. This P.O.C. hardware complement will demonstrate the basic fixed and scanning beam performance issues for an integrated MBA complement.

FIGURE 1.
IMPATT TRANSMITTAL POWER OUTPUT STAGE

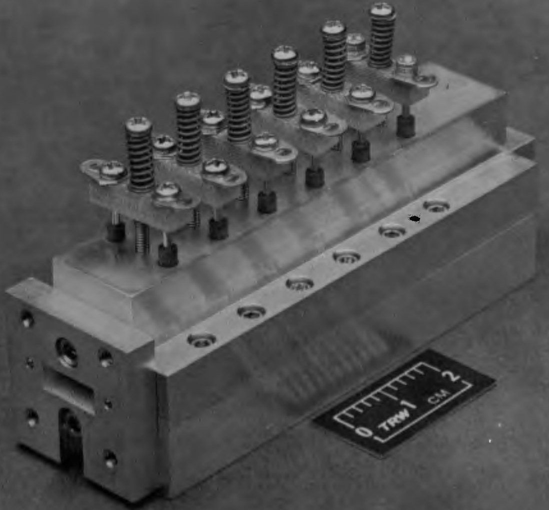
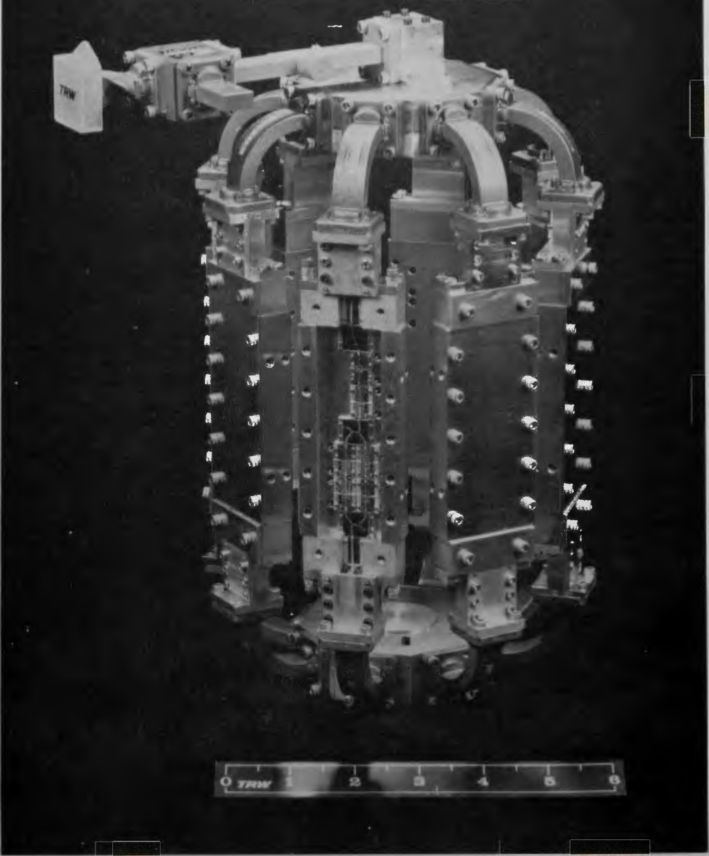


FIGURE 2.
AMPLIFIER MODULE (ONE OF EIGHT)



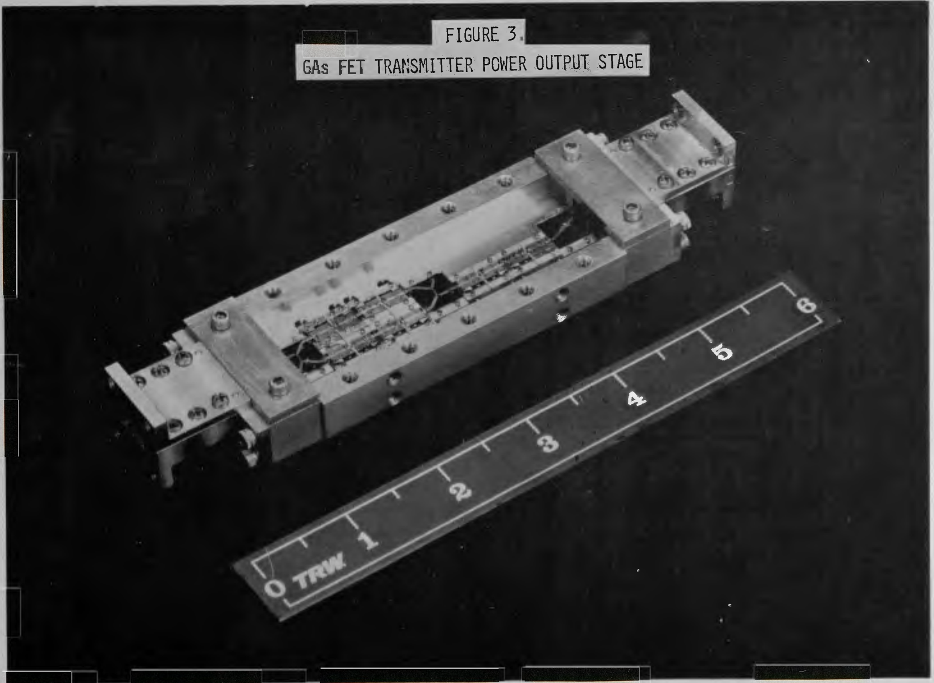


FIGURE 3.
GAs FET TRANSMITTER POWER OUTPUT STAGE

FIGURE 4.

P.O.C. ANTENNA CONFIGURATION