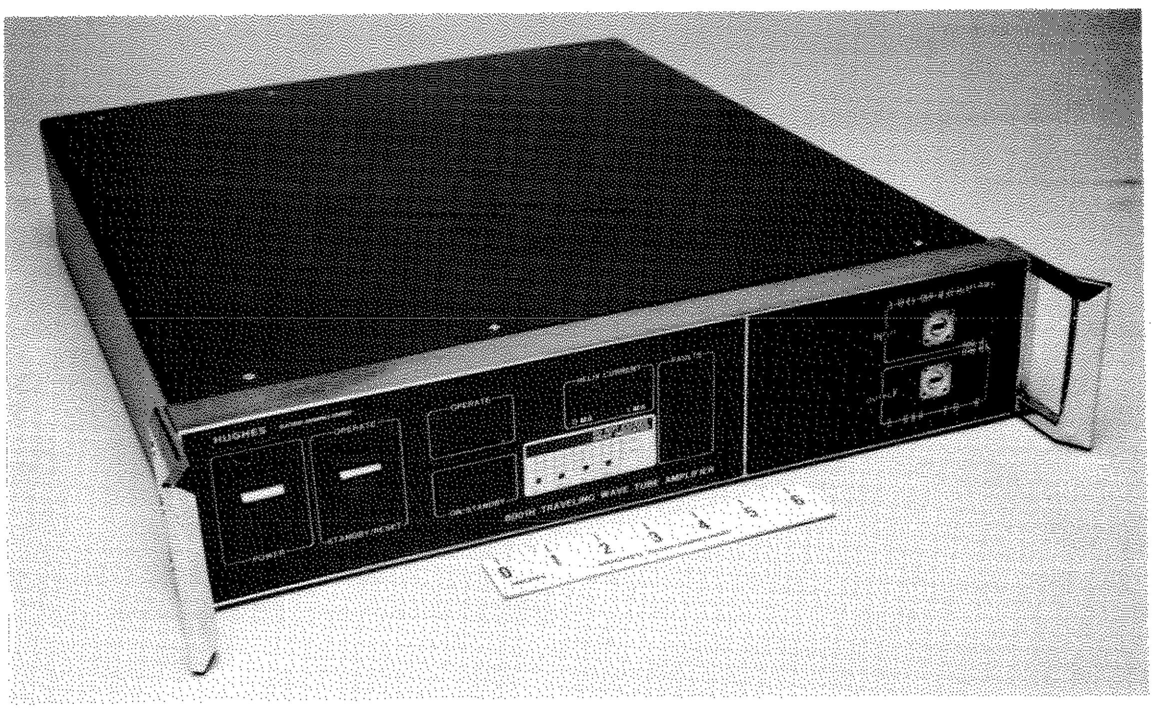
OPERATION AND MAINTENANCE MANUAL

FOR

8000H INSTRUMENTATION AMPLIFIER

APRIL 1987



INSTRUMENTATION SERIES
TRAVELING-WAVE TUBE AMPLIFIERS

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M-82

1.0 GENERAL DESCRIPTION

1.1 INTRODUCTION

1.1.1 Purpose of the Equipment

The 8000H Series Instrumentation Amplifiers are broadband laboratory instruments designed for general purpose microwave applications. Each amplifier consists of a traveling wave tube (TWT) and an efficient solid state electronic power conditioner (EPC). RF power output of the basic 8000H models are 1, 10, 20 or 30 watts. Modifications are available for special applications as options to the standard models.

1.1.2 Scope of This Manual

This manual describes the standard Communications Amplifier and the options available.

It is concerned with initial installation and operation of the amplifier. The amplifier is described in terms of application and performance capabilities. Operation instructions, functional purposes of major circuits of interest to the operator, and preventive maintenance and repair are set forth. Unpacking and packing for shipment or storage, initial installation and warranty information are included.

1.1.3 Use of This Manual

This manual is limited to standard amplifiers and the most common options. Amplifiers ordered with special options will have addenda pages included with the basic manual, containing material applicable for their special operation and maintenance.

1.2 SPECIFICATIONS AND STANDARD AMPLIFIER OPTIONS

Table 1.2-1 gives the performance characteristics of the standard amplifier. Table 1.2-2 sets forth the modifications available as options to the standard amplifier.

1.3 PHYSICAL DESCRIPTION

Each amplifier consists of a PPM-focused metal-ceramic traveling wave tube, a highly regulated, solid state power supply, and an integral air cooling system assembled within a compact case. The amplifier may be mounted in a standard 19-inch rack. Figure 1.3-1 (installation control drawing) shows the outline and mounting dimensions of the standard amplifier with identification of front and rear panel features. The amplifier is modularly assembled to facilitate maintenance and replacement. Figure 1.3-2 (interconnect diagram) is an electrical wiring diagram showing interconnections of the major components. Table 1.3-1 lists the operating modules of the amplifier. Critical drawings, such as schematics and assembly drawings for the overall unit as well as the individual modules, are included in Sections 7.0 and 8.0 of this manual.

TABLE 1.2-1

SPECIFICATIONS

TWTA Model Number	TWTA Rated Output (Watts)	Frequency (GHz)	TWT Model Number	RF Connectors (In/Out)
8001H11F-000	1	18.0-26.5	911H	UG-596
8001H12F-000	1	26.5-40.0	912H	UG-600
8010H09F-000	10	1.0-2.0	417HD	Type "N"
8010H01F-000	10	2.0-4.0	564H	Type "N"
8010H13F-000	10	3.0-8.0	646H	Type "N"
8010H16F-000	10[1]	3.9-11.7	664H	Type "N"
8010H02F-000	10	4.0-8.0	648HD	Type "N"
8010H06F-000	10[1]	4.0-10.5	648HDS	Type "N"
8010H07F-000	10	6.5-13.5	771HDS	Type "N"
8010H03F-000	10	8.0-12.4	771HD	Type "N"
8010H04F-000	10	12.4-18.0	848HD	SMA
8010H11F-000	10	18-26.5	991H	UG596
8010H12F-000	10	26.5-40	992H	UG600
8010H15F-000	10	8.0-18.0	846H	SMA
8020H09F-000	20	1.0-2.0	418H	Type "N"
8020H10F-000	20	1.4-2.4	419H	Type "N"
8020H01F-000	20	2.0-4.0	568H	Type "N"
8020H02F-000	20	4.0-8.0	640H	Type "N"
8020H03F-000	20	8.0-12.4	783H	Type "N"
8020H04F-000	20	12.4-18.0	856H	SMA/UG-419
8020H15F-000	20	8.0-18.0	889H	SMA
8030H02F-000	30	4.0-8.0	670HA	Type "N"

Electrical		
Gain at Rated Power Output		30 dB minimum
Duty		CW
Input Voltage		99-132 VAC
Input Frequency		47-63 Hz
Power Consumption	8001H	115 Watts[2]
	8010H	250 Watts
	8020H	280 Watts
Noise Figure		35 dB maximum
Spurious Modulation (at saturation)		-50 dBc
Coax Input/Output Impedance		50Ω nominal
Gain Stability		0.25 dB/24 hours[3]
Load VSWR (no damage)		2.5:1 maximum[4]
Mechanical		
Size/Configuration		(See Figure 1.3-1)
Weight		20 pounds (9.1 kg)
Environmental		
Operating Temperature		0 to 50°C ambient

*Specifications subject to change without notice.

1. Power and gain slightly lower at band edges.
2. This indicates maximum power consumption of any model in that series. For information on a specific model consult factory.
3. At constant drive and temperature after warmup period.
4. Option J is required for higher load VSWR applications.

TABLE 1.2-2

STANDARD OPTIONS

Option A - 220/240 V Input Voltage
Provisions for 198 - 264 VAC at 50/60 Hz Operation.

Option D - Unattended Operation
In the event of helix overcurrent, the TWTA will power down, removing all voltages from the TWT. A manual reset of the prime power switch is required to resume normal operation.

Option E - Rackmounting
Rack mount ears for standard EIA 19-inch cabinets.

Option F - Local/Remote
Provides remote control of the amplifier's ON/OFF prime power switch and the OPERATE/STANDBY switch. Fault status and an analog voltage, proportional to the amplifier's helix current, are also made available. This option requires user to supply 15 VDC at 300 mA for remotely operating the unit. In the local control mode, internally supplied power is used.

Option H - TTL Remote Interface
This option replaces the standard Option F with TTL interface logic. The user may supply either 28 VDC or 15 VDC externally to the remote control circuitry. Maximum current is 400 mA for either voltage.

Option J - Output Isolator
Protects the traveling wave tube from high external load VSWR conditions.

Option K - High Gain
Adds a solid state amplifier at the input to the traveling wave tube for higher gain when only minimal drive power is available. Consult the factory for specific requirement.

Option N - Variable Attenuator
A variable front panel RF attenuator provides gain control over more than a 20 dB range.

Option P - IEEE Std. 488-1978 Interface
Allows digital control of the amplifier through an industry standard interface bus. Useful in automated stations.

TABLE 1.3-1

BASIC MODULES, INSTRUMENTATION AMPLIFIER

Display Board	B737507
Regulator Board[1]	B737630
High Voltage Board[1]	B704156
Remote Interface Board (Option F)	B724485

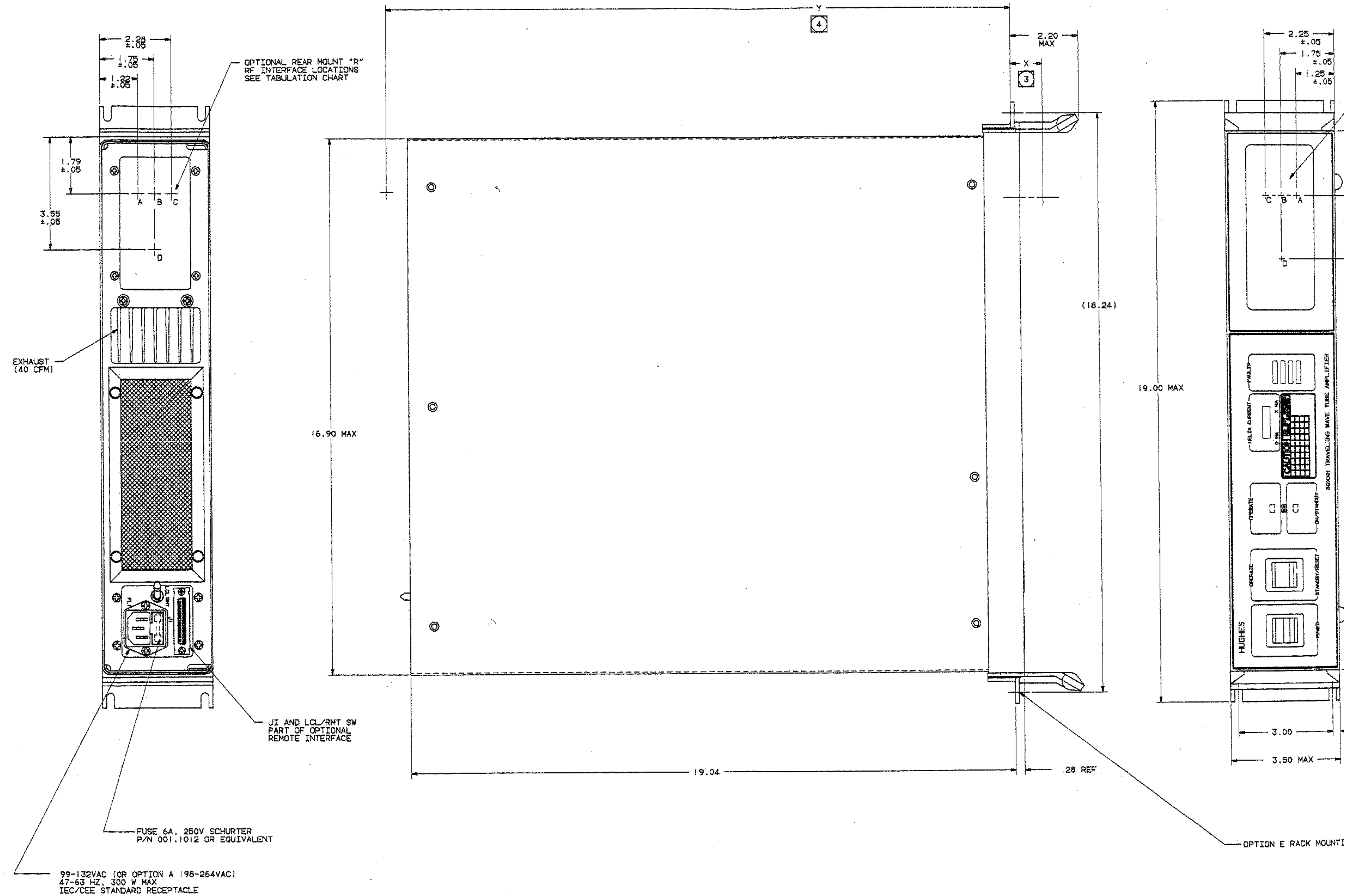
[1]These printed wiring boards contain model dependent components. When ordering spares or replacements, please specify the TWTA model number for compatibility. Spare boards part numbers for each model are shown in Table 1.3-2.

TABLE 1.3-2

SPARE PARTS

TWTA Model Number	Regulator Board	High Voltage Board
8001H11F-000	B737630-111	B704156-111
8001H12F-000	B737630-112	B704156-112
8010H09F-000	B737630-109	B704156-109
8010H01F-000	B737630-101	B704156-101
8010H13F-000	B737630-113	B704156-113
8010H16F-000	B737630-116	B704156-116
8010H02F-000	B737630-102	B704156-102
8010H06F-000	B737630-106	B704156-106
8010H07F-000	B737630-107	B704156-107
8010H03F-000	B737630-103	B704156-103
8010H04F-000	B737630-104	B704156-104
8010H15F-000	B737630-115	B704156-115
8020H09F-000	B737630-129	B704156-129
8020H10F-000	B737630-120	B704156-120
8020H01F-000	B737630-121	B704156-121
8020H02F-000	B737630-122	B704156-122
8020H03F-000	B737630-123	B704156-123
8020H04F-000	B737630-124	B704156-124

For 198-264 VAC input the regulator board dash number should be changed to the 200 series with the same last 2 digits. (Example B737630-124 becomes B737630-224.)



RF INTERFACE

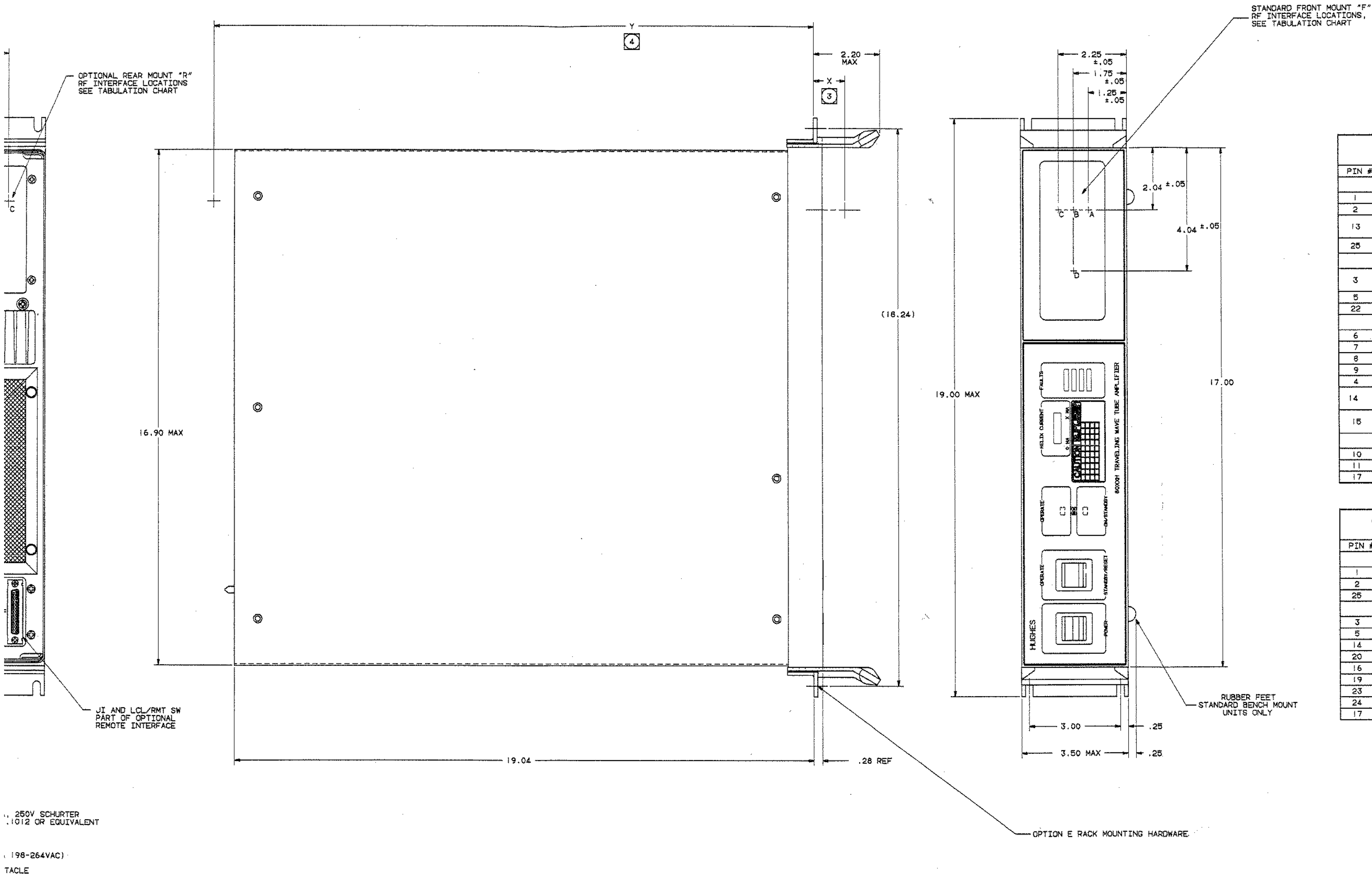
UNIT DESIG.	INPUT		OUTPUT	
	LOCATION	TYPE	LOCATION	TYPE
8001H11	C	WR42, UG596	A	WR42, UG596
8001H12	C	WR28, UG600	A	WR28, UG600
8010H01	D	N	B	N
8010H02	D	N	B	N
8010H03	D	N	B	N
8010H04	D	SMA	B	SMA
8010H06	D	N	B	N
8010H07	D	N	B	N
~~8010H08~~	~~D~~	~~SMA~~	~~B~~	~~SMA~~
8010H09	D	N	B	N
8010H11	C	WR42, UG596	A	WR42, UG596
8010H12	C	WR28, UG600	A	WR28, UG600
8010H13	D	N	B	N
~~8010H14~~	~~D~~	~~N~~	~~B~~	~~N~~
8010H15	D	SMA	B	SMA
8010H16	D	N	B	N
8010H17	D	N	B	N
8010H19	D	N	B	N
8020H01	D	N	B	N
8020H02	D	N	B	N
8020H03	D	N	B	N
8020H04	D	SMA	B	WR62, UG419
~~8020H05~~	~~D~~	~~N~~	~~B~~	~~N~~
8020H09	D	N	B	N
8020H10	D	N	B	N
8020H15	D	SMA	B	SMA
8030H03	D	N	B	N

[4] DIM Y FOR:
WAVEGUIDE = 18.65 ±.05
TYPE N CONN = 19.47 ±.05
SMA CONN = 19.00 ±.05

[3] DIM X FOR:
WAVEGUIDE = .22 ±.05
TYPE N CONN = 1.03 ±.05
SMA CONN = .57 ±.05

2. COAXIAL CONNECTORS ARE TYPE N OR SMA (FM).
1. UG419/U FLANGES ARE MODIFIED TO PROVIDE MOUNTING HOLES, THREADED #6-32 UNC-2B.

NOTES: UNLESS OTHERWISE SPECIFIED



JI REMOTE CONTROL INTERFACE (OPTION F) CANNON DBMA-25S OR EQUIVALENT		
PIN #	NOMENCLATURE	CHARACTERISTICS
	COMMANDS	
1	POWER ON	FORM "A" CONTACT TO GROUND 150 MA MAX
2	OPERATE	FORM "A" CONTACT TO GROUND 65 MA MAX
13	COMMAND ENABLE +15VDC	15V ±.5V @ 215 MA MAX USER SUPPLIED
25	BEAM OFF (VPC/RCU SUBSYSTEM USE)	FORM "A" CONTACT TO GROUND 65 MA MAX
	STATUS	
3	POWER ON	OPEN COLLECTOR DARLINGTON OUTPUT. (EMITTER GROUNDED) +15V MAX STANDOFF
5	OPERATE	
22	REMOTE INDICATOR	FORM "A" CONTACT TO GROUND 100 MA MAX
	FAULTS	
6	LINE UNDER VOLTAGE	OPEN COLLECTOR DARLINGTON OUTPUT. (EMITTER GROUNDED) +15V MAX STANDOFF
7	INTERLOCK	
8	THERMAL	
9	HELIX CURRENT	
4	SUMMARY FAULT	
14	SUMMARY FAULT (VPC/RCU SUBSYSTEM USE)	LOW=FAULT(<1V), Z OUT=1KΩ, HIGH=NORM(APX 14V)
15	LOW RF (RCU OPTION)	HIGH=FAULT(APX 14V), LOW=NORM(<1V) Z OUT=1KΩ
	ANALOG	
10	HELIX CURRENT	0 TO 5V FULL SCALE, Z OUT=1KΩ
11	RF PWR (RCU OPTION)	SAME
17	GROUND	CHASSIS

JI TTL REMOTE CONTROL INTERFACE (OPTION H) CANNON DBMA-25S OR EQUIVALENT		
PIN #	NOMENCLATURE	CHARACTERISTICS
	COMMANDS	
1	POWER ON	1 TTL LOAD, .1μf INPUT, LOW=TRUE
2	OPERATE	
25	RESET	1 TTL LOAD, LOW = TRUE
	STATUS	
3	POWER ON	OPEN COLLECTOR DARLINGTON OUTPUT, (EMITTER GROUNDED) +15V MAX STANDOFF
5	OPERATE	
14	FAULT	
20	READY	
16	POWER ON	TTL OUTPUT, FANOUT =2
19	READY	
23	OPERATE	
24	FAULT	
17	GROUND	CHASSIS

Figure 1.3-1 Installation Control Drawing, CDB734601.

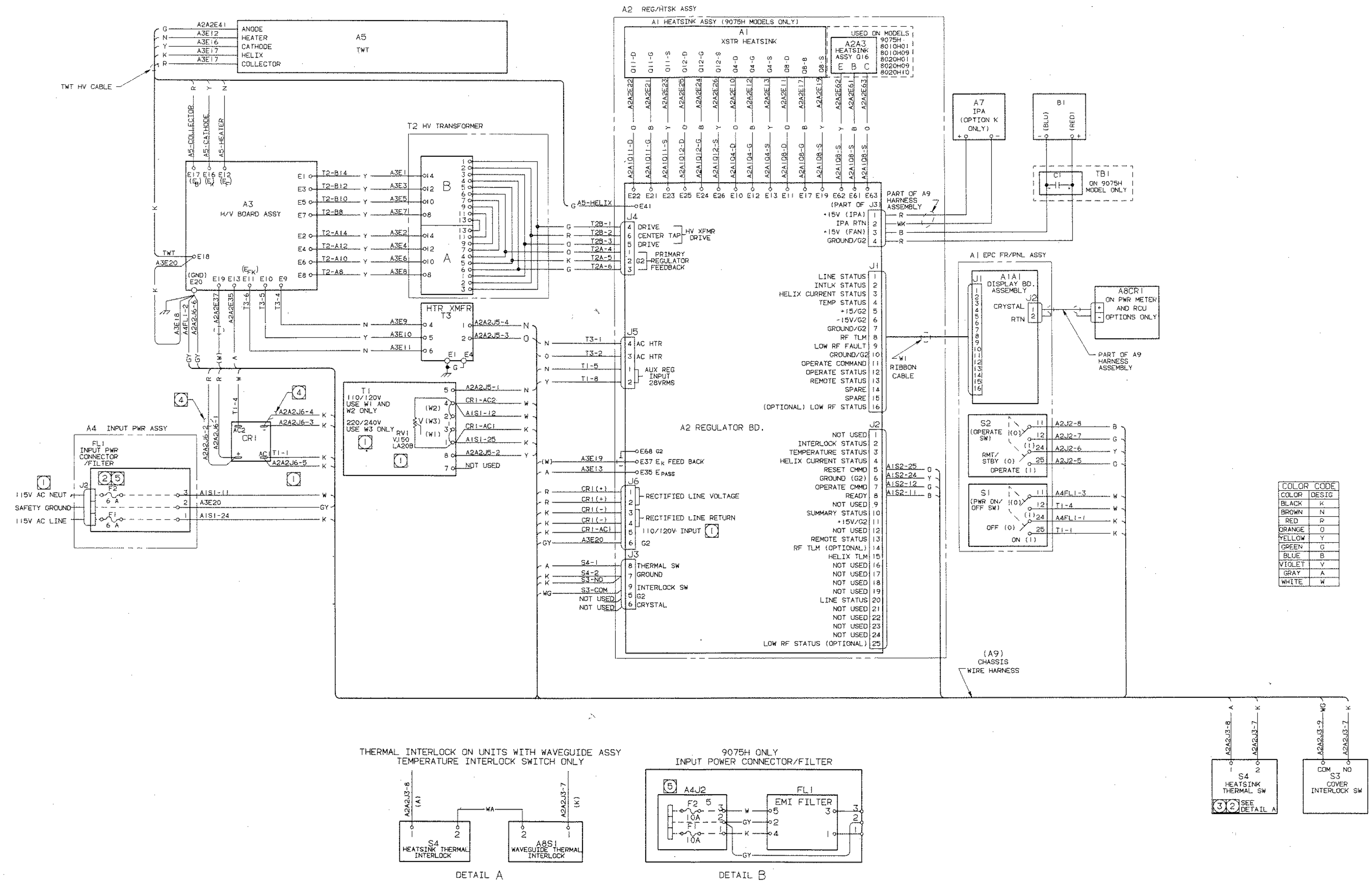


Figure 1.3-2 TWTA Electronic Interconnect Diagram, WDB742425.

2.0 OPERATION

2.1 INTRODUCTION

The 8000HA series amplifiers are reliable, high performance instruments designed for easy and trouble-free operation. It is important to read Sections 2.2 and 2.3, which provide general information about the amplifier, before operating the amplifier. Descriptions of the controls and indicators and operation and shutdown instructions follow in Sections 2.4 and 2.5.

2.2 WARNINGS

The following are general precautions to be taken in operating the amplifier.

WARNING

Lethal voltages exist in the operation of the amplifier. Remove all power connections before performing any work within the amplifier chassis.

WARNING

The traveling wave tube inside the amplifier may contain beryllium oxide ceramics. Do not attempt to disassemble the TWT. Proper disposal of damaged or worn out TWTs is required.

2.3 OPERATING REQUIREMENTS AND CAPABILITIES

2.3.1 Amplifier System Requirements

As a laboratory instrument, the amplifier is designed to function with a variety of systems. The broad bandwidth characteristic of the TWT utilized is the key parameter providing this capability. The TWT is a rugged device but requires care in several areas. Primary concerns in the setup and operation of the amplifier are preventing high VSWR at the amplifier output and avoiding overdriving the input of the amplifier.

CAUTION

Use RF system components that can safely handle the output power of the amplifier.

2.3.2 System RF Output Power Requirements

The amplifiers are rated at a minimum RF output of 1, 10, 20, and 30 watts, depending on the model. They may, however, provide 3 to 4 dB of RF power output above their ratings. Therefore, the components of the RF output system should have the capability of handling this power with a margin of safety.

CAUTION

Never operate the amplifier into a load VSWR greater than 2.5:1.

2.3.3 Amplifier Load VSWR Requirements

A mismatch greater than 2.0:1 VSWR at the RF output of the traveling wave tube (TWT) may cause permanent damage to the TWT. A TWT damaged because of such mismatching may not remain adjustable under the warranty provisions. For systems having a potentially high VSWR or requiring minimum degradation of output due to interaction between system and TWT, Option J (output isolator/circulator) should be specified for TWTA self-protection or performance improvement.

2.3.3.1 Match System Bandwidth to Amplifier Bandwidth - When operating the amplifier into waveguide systems, take care that the cutoff frequency of the waveguide system does not occur within the pass band of the TWTA. This mid-frequency range cutoff point may be seen by the amplifier as a VSWR higher than 2.0:1, resulting in amplifier instability or even permanent damage to the amplifier.

2.3.3.2 Avoid Amplifier RF Load Short Circuits - Never operate the amplifier into a system open or short circuit. This may result in a VSWR higher than 2.0:1, at the amplifier output. Take care that all system connections are fully connected and snug before operating the amplifier. If it is necessary to disconnect the RF lines during operation of the amplifier, always pre-install an isolator to protect the TWT. The RF lines should only be disconnected when the unit is in the standby or off conditions.

2.3.3.3 Properly Terminate TWTA RF Input - While the RF input is not as susceptible to damage due to VSWR mismatch, good practice is to properly terminate with a load not exceeding 3:1 VSWR. The unit can be induced to oscillate if operated with the input not properly terminated, which could cause a TWT failure. Overdrive by 3 dB can damage the input circuit of the TWT.

CAUTION

Never drive the TWT beyond saturation. (See Figure 2.7-1.)

2.3.4 Amplifier Output Power Capabilities

Some amplifier models have gain up to or greater than 50 dB in areas within their bandwidth. Take care that the amplifier is not driven beyond the saturation point.

2.3.4.1 General Procedures to Avoid Oversaturation - Take care to avoid oversaturation by observing the following precautions:

1. Check the frequency of operation and note the output power expected.
2. If in doubt about the gain to be expected, start with a very low level of RF drive and monitor the output power.

3. Increase drive in even steps, while observing output power.

NOTE

Output power should always increase with increasing input power until saturation is reached.

4. If output power begins to decrease with increased drive, immediately reduce the drive.

2.4 AMPLIFIER OPERATION

CAUTION

Read the preceding sections before operating your amplifier.

2.4.1 Controls and Indicators

Figure 1.3-1 shows the front and rear views of the amplifier, calling out the controls, indicators, and connectors. Table 2.4-1 describes the functions of the controls. Table 2.4-2 describes the fault indicators.

TABLE 2.4-1

TWTA CONTROLS

Nomenclature	Function
POWER	Connects prime power to all EPC circuits and initiates filament warm-up cycle for TWT.
OPERATE STANDBY/RESET	OPERATE turns on High Voltage section of EPC and sequences TWT to active state. STANDBY/RESET de-energizes HV circuits and also resets the fault counter.
Remote/LCL (Option F on rear panel)	Transfers the two preceding control functions exclusively to a remote location. This option also provides fault indication and an analog voltage proportional to helix current at the remote location regardless of switch position.

TABLE 2.4-2

FAULT INDICATORS

Nomenclature	Condition
HELIX	Helix current of the TWT has exceeded the factory set SAFE level and protective shutdown has occurred.
INTLK	The mechanical interlock switch has been opened.
TEMP	The thermostat switch located near output end of the TWT has sensed a baseplate temperature exceeding $185^{o}F$ ($85^{o}C$).
LINE	The ac prime power applied to the TWTA is insufficient to maintain the precise regulated voltages. This occurs when the ac input voltage is less than 90 percent of nominal rated voltage.

2.4.2 Initial Operation

2.4.2.1 Installation - If this is the first installation or a reinstallation after repair, refer to Paragraph 6.3 for instructions on mechanical and electrical installation and checkout.

2.4.2.2 Primary Power Requirement - Confirm that the primary power source is of the same type which is specified on the label on the amplifier bottom panel.

2.4.2.3 Connecting to Primary Power - Observe that the front panel POWER rocker switch is off (lower part of rocker switch level with panel). Connect the amplifier line cord to a primary power source that is of the same type as specified on the amplifier bottom panel label.

2.4.3 System Setup

1. Check that the front panel POWER rocker switch is off.
2. Connect the amplifier into the system or setup with the RF source to the RF INPUT connector and a suitable RF load connected to the RF OUTPUT connector.
3. Check that the RF load is capable of dissipating the TWT output power at the intended operating frequency.
4. Check that the exhaust air flow is not blocked.

2.4.4 Power On

On the front panel, switch the POWER rocker switch on. The green ON/STANDBY display LED will light. If the LED does not light, check the fuses and the line cord. The fan should be running. A three-minute delay for the TWT heater to warm up is initiated.

2.4.5 Traveling Wave Tube Amplifier On

1. Check to ensure that the RF drive source is off or, if that is not possible, at a very low level of power output.

2. On the front panel, switch the OPERATE rocker switch on. If the amplifier has completed warmup, the green OPERATE display LED will light.

3. Check to see that there is a low-level current indication on the front panel HELIX CURRENT bar graph display. No other display LED should light.

NOTE

1. Some TWTs have very low helix current with no RF drive. Thus, the helix current meter may not indicate until RF drive is applied.

2. Actuation of the OPERATE switch before complete warmup will not damage the TWTA. The automatic circuits will sequence to operate after latch-in of the internal timer.

2.4.6 Applying RF Source

1. Turn on the RF drive source at a low level.

2. Monitor the RF output by means of a directional coupler and power meter (see Paragraph 4.3).

3. Slowly increase RF drive source power until the RF output power is at its peak. This is the saturation level of the TWT (see discussion in Paragraph 2.7.1) and will vary over the operating band.

4. If possible, monitor the input power. Check the test data sheets provided for the proper drive level to ensure that the unit is not overdriven.

2.4.7 Routine Operation

2.4.7.1 Removing RF Output - During operation, broadband noise is always present in the output of the amplifier. To make adjustments or changes that are difficult or impossible in the presence of this noise, set the OPERATE/STANDBY/RESET switch to STANDBY/RESET. The OPERATE light will go out. The TWTA is now in STANDBY mode.

If making a change that involves removing load termination, always set the TWTA to STANDBY mode.

NOTE

Operation of the TWTA in the STANDBY mode for periods exceeding eight hours may reduce ultimate TWT life. It is recommended that the unit be completely powered down and restarted when needed.

OPTION D (unattended protection) is provided for those applications when the unit is operated in an unattended location, when extended operation in STANDBY after two Helix Faults would otherwise be possible.

2.4.7.2 Helix Fault Reset - Should the amplifier be overdriven by the RF source, the helix protect circuitry will switch the unit to the STANDBY mode. The OPERATE light will go out, and the HELIX fault light will light. Reduce the RF source power level and switch the OPERATE/STANDBY/RESET switch to STANDBY and then back to OPERATE. The TWTA will return to the OPERATE mode in about 10 seconds.

2.4.8 Turn Off

To turn the unit off, remove the RF drive, switch the amplifier to the STANDBY mode, and switch the POWER switch to the OFF position.

2.4.9 Remote Operation (Communications Amplifiers Only)

On standard amplifiers without the remote option, remote on and off operation can be achieved as follows:

1. Connect the amplifier as in Paragraphs 2.4.1 and 2.4.2.
2. Switch the amplifier to OPERATE and establish the RF drive and output levels as in Paragraphs 2.4.2 through 2.4.4.
3. The amplifier can now be turned on and off by switching the primary power on and off. With primary power applied through the line cord, the amplifier will automatically time through its warmup period and sequence to the OPERATE mode.
4. Should an RF overdrive condition cause the amplifier to go to the Heater Shutdown (Option D) mode, removal and reapplication of the primary power will reset the unit. It will return to the OPERATE mode following the automatic warmup sequence.

2.5 EMERGENCY PROCEDURE

Immediately set the POWER rocker switch to the OFF position for emergency power shut down.

2.6 REMOTE CONTROL

The optional remote control capability can be used to monitor and control the amplifier from a remote location. Option F provides relay interface for control, Option H provides TTL logic interface for remote control, and option P provides a digital IEEE 488 interface bus for remote control.

Switching between local and remote mode of operation can only be done at the amplifier rear panel. When the REMOTE switch is set to the remote position, the turn-on sequence is controllable only from the remote location. Status and Fault indicators are always present, buffered through the remote board.

2.7 TRAVELING WAVE TUBE AMPLIFIER CHARACTERISTICS

Traveling-wave tube amplifier characteristics which directly affect your operation of the amplifier are described in this section. For more general information about the way TWTAs work, see Section 3.2.1.

Characteristics important to operation are: RF input versus RF output, noise performance, RF duty cycle, RF modulation, and gain variations.

2.7.1 RF Input Versus Amplified RF Output

A plot of the amplified RF output power versus the RF input driving the amplifier is called a "compression" or "gain transfer" curve. An example of a compression curve is shown in Figure 2.7-1.

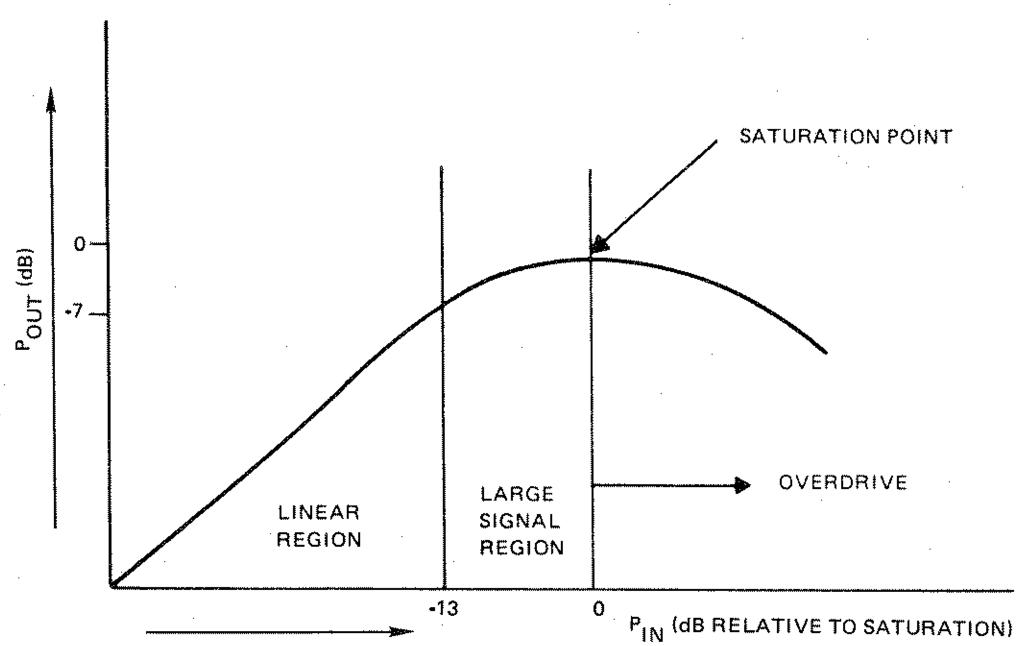


Figure 2.7-1 Sample "gain transfer" or "compression curve".

Note that the compression curve is linear at lower power input values, and a change in RF input drive causes an equal increase in power output. This linear region is where maximum gain is achieved. It is called the "small signal gain" region.

Beyond this region, further increases in input drive result in smaller and smaller increases in output. Finally, a point is reached when further increases in drive cause no increase in output. This is the "saturation point" of the compression curve. Note that the saturation area is rather broad, and small changes in input power result in almost no change in output power.

As the RF drive is further increased, the power output will begin to decrease. This is called the "overdrive" region. Continued operation in this region may damage the TWT.

2.7.2 Noise Performance

Thermal noise is present at the input of the amplifier. This is increased at the output by the characteristic noise figure, bandwidth, and gain of the amplifier. In operation, the resulting noise power output of a TWT amplifier can be a high as -30 dBm/MHz.

In addition, AM and PM (or FM) noise is generated by ripple voltage on the cathode or beam power supply of the TWT and consists of combinations of modulation frequencies of the power line and converter switching frequencies. This noise is typically 50 dB below the carrier (-50 dBc).

2.7.3 RF Duty Cycle

The TWT used in the Hughes' amplifier is non-gridded and operates continuous wave. The RF duty cycle can be varied from zero to 100 percent duty by pulsing the RF drive. The maximum peak pulsed power will equal the saturated continuous wave power.

2.7.4 RF Modulation

With FM and PM, operate the amplifier at saturation to attain the maximum RF output at low distortion. With AM, operate the amplifier in the linear region for lowest distortion.

2.7.5 Intermodulation Distortion

As broadband devices, TWTAs can be used to amplify more than one carrier at a time because of their instantaneous bandwidth characteristic.

When amplifying multiple carriers, intermodulation (IM) products will occur with levels dependent on the region of operation. Because their frequency placement comes closest to the desired carriers, third order products are of greatest concern. Figure 2.7-2 shows a typical third-order IM product curve. Note that in the linear gain region, a change of one dB RF output causes a 3-dB change in the third-order IM product level. In addition, note that the RF output power is distributed among the carriers and their IM products. Therefore, if the saturated output power for a single carrier is 20 watts and the TWTA is driven to saturation by two carriers, the output of each amplified carrier will be somewhat less than 10 watts because of the power absorbed by generation of the IM products.

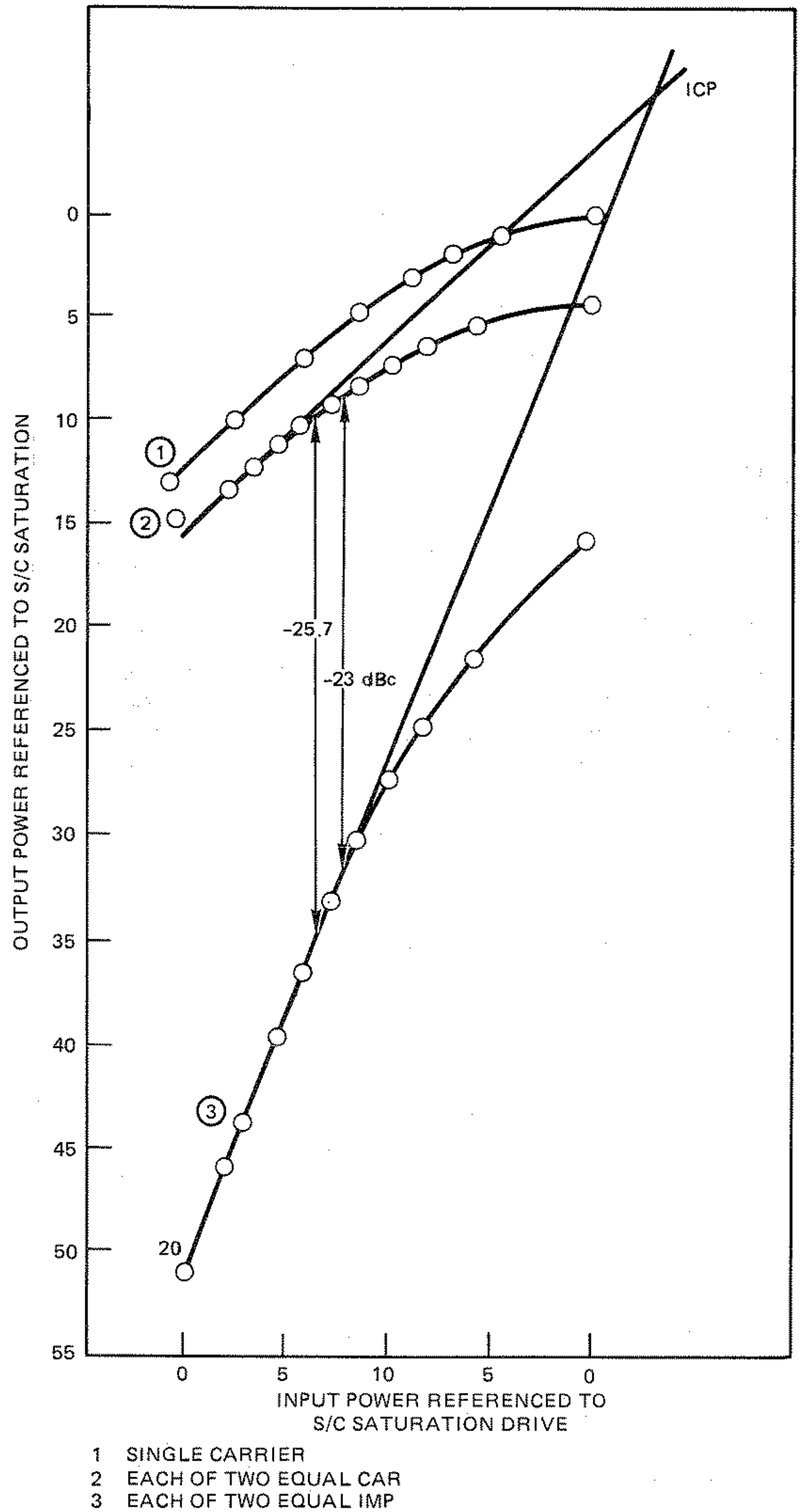


Figure 2.7-2 Typical third-order product curve.

2.7.6 Harmonics

The second harmonic content will be maximum when the TWTA is operated at the saturated level and is typically 8 to 12 dB below the fundamental frequency output. In some cases, when the bandwidth is an octave (that is, the upper edge of the band is twice the frequency of the lower edge) the level of the second harmonic may be higher.

2.7.7 AM/PM Conversion

Variations in RF input will cause low-level phase modulation on the carrier. This is called AM to PM conversion. Typically, a one-dB drive change will result in 6 degrees of phase change. Worst case occurs approximately 5 dB below the saturated drive level and is reduced at saturation or in the linear region.

2.7.8 Gain Variations

Because the TWTA's gain varies across its frequency range, the gain transfer curve shown in Figure 2.7-1 shifts accordingly. As a result it is necessary to use different drive levels to achieve maximum RF output at different frequencies. Check the test data provided with each unit to determine the gain at rated power.

When the amplifier is used with a constant drive sweeping source, adjust the drive level at the frequency of maximum gain. This procedure alleviates overdrive problems when the frequency is swept across the band. In applications when gain variations cannot be tolerated, employ other techniques. One technique is to apply a feedback signal from the RF output back to a gain control circuit at the RF source to reduce the variations in output. Another is to use an equalizer between the RF source and the amplifier.