rf/microwave instrumentation

Operating and Service Manual

2000TP2G8B

Model

10013130

Part Number

Serial Number

160 School House Road, Souderton, PA 18964 • 215-723-8181 • Fax 215-723-5688 • www.ar-worldwide.com

rf/microwave instrumentation

EC Declaration of Conformity

We; AR RF/Microwave Instrumentation
160 School House Road
Souderton, PA 18964

declare that our product;

the Model 2000TP2G8B amplifier

to which this declaration relates is in compliance with the requirements of the EEC EMC Directive (89/336/EEC) and Low Voltage Directive (73/23/EEC) in accordance with the relative standards listed below:

EMC:
EN 50082-1: 1992
Electromagnetic compatibility – Generic immunity standard
EN 50081-1: 1992
Electromagnetic emissions requirements for Industrial, Scientific, and Medical (ISM) Equipment

Safety:
EN 60950 (1995)

The CE marking is affixed on the device according to the EC Directives.

Donald R. Shepherd
President

INSTRUCTIONS FOR SAFE OPERATION

BEFORE APPLYING POWER

Review this manual and become familiar with all safety markings and instructions.

Verify that the equipment line voltage selection is compatible with the main power source.

Protection provided by the equipment may be impaired if used in a manner not specified by Amplifier Research.

INTENDED PURPOSES

This equipment is intended for general laboratory use in a wide variety of industrial and scientific applications. It is designed to be used in the process of generating, controlling, and measuring high levels of electromagnetic Radio Frequency (RF) energy. Therefore, the output of the amplifier must be connected to an appropriate load such as an antenna or field-generating device. It is the responsibility of the user to assure that the device is operated in a location which will control the radiated energy such that it will not cause injury and will not violate regulatory levels of electromagnetic interference.

HAZARDOUS RF VOLTAGES

The RF voltages on the center pin of the RF output connector can be hazardous. The RF output connector should be connected to a load before AC power is applied to the amplifier. Do not come into contact with the center pin of the RF output connector or accessories connected to it. Place the equipment in a non-operating condition before disconnecting or connecting the load to the RF output connector.

SAFETY GROUND

This equipment is provided with a protective earth terminal. The main power source to the equipment must supply an uninterrupted safety ground of sufficient size to the input wiring terminals, power cord, or supplied power cord set. The equipment **MUST NOT BE USED** if this protection is impaired.

PHYSICAL DAMAGE

The RF amplifier should not be operated if there is physical damage, missing hardware, or missing panels.

MAINTENANCE CAUTION

Adjustment, maintenance, or repair of the equipment must be performed only by qualified personnel. Hazardous energy may be present while protective covers are removed from the equipment even if disconnected from the power source. Contact may result in personal injury. Replacement fuses are required to be of specific type and current rating.

SAFETY SYMBOLS

This symbol is marked on the equipment when it is necessary for the user to refer to the manual for important safety information.

Dangerous voltages are present. Use extreme care.

CAUTION: The caution symbol denotes a potential hazard. Attention must be given to the statement to prevent damage, destruction, or harm.

Indicates protective earth terminal.

RANGE OF ENVIRONMENTAL CONDITIONS

This equipment is designed to be safe under the following environmental conditions:

- Indoor use
- Altitude up to 2000M
- Temperature of 5°C to 40°C
- Maximum relative humidity 80% for temperatures up to 31°C. Decreasing linearly to 50% at 40°C.
- Main supply voltage fluctuations not to exceed ± 10% of the nominal voltage or minimum and maximum autoranging values.
- Pollution degree 2: Normally non-conductive with occasional condensation. While the equipment will not cause hazardous condition over this environmental range, its performance may vary.

COOLING AIR

Care should be exercised not to block the cooling air inlets or outlets. Cooling air blockage can result in damage to the RF amplifier or intermittent shut-downs.

ADDITIONAL WARNINGS & NOTES

WARNING:

This equipment operates at potentially lethal voltages. Only trained, qualified personnel should operate, maintain, or service it.

Hazardous energy may be present while protective covers are removed from the equipment even if disconnected from the power source. Contact may result in personal injury.

CAUTION:

Adjustment, maintenance, or repair of the equipment must be performed only by qualified personnel.

CAUTION:

Replacement fuses are required to be of specific type and current rating.

CAUTION:

The information in this document was obtained from reliable sources and was believed to be accurate at the time of publication. Since subsequent modifications to the machine may have been made, use this information only as a guide. Carefully compare the unit's actual configuration and operation to the descriptions in this manual before you undertake to operate, service, or modify this machine. Any variance or modification should be noted, dated, and initialed in the discrepant part of all manuals on hand for future reference. If you have technical or editorial comments you wish to make to the manufacturer, please write them on photocopies of the relevant sheets.

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FIGURES

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1. DESCRIPTION AND SPECIFICATIONS

This manual provides operating, interfacing and selected service information pertinent to AR RF/Microwave Instrumentation Model 2000TP2G8B Broadband Microwave Amplifier. The Model 2000TP2G8B is a 2,000 watt pulse only SC band traveling-wave tube amplifier (TWTA).

1.1 TWTA DESCRIPTION

The amplifier uses a broadband traveling-wave tube to provide a minimum of 2,000 watts peak pulsed output power over the amplifier's full bandwidth. The amplifier is well suited for pulse susceptibility and general laboratory testing where instantaneous bandwidth and high gain are required.

For bench top use the amplifier is supplied in an enclosure with integral carrying handles.

The amplifier is completely self-contained and packaged for standard 19-inch rack mounting or bench top use. The front panel of the rack mountable amplifier is 8.75 inches high, and the overall unit is 25 inches deep, excluding the rear-panel connectors.

Primary power is 190-260VAC, 50/60 Hz, single phase. An efficient switching power supply design provides minimum power consumption. A fast regulation control loop and a high degree of filtering ensure performance within specifications over a wide range of operating conditions. The amplifier is fully enclosed, and the upper and lower panels of the enclosure are interlocked to reduce the likelihood of accidental contact with high voltage.

1.2 SUGGESTED APPLICATIONS

- Pulse RF Susceptibility testing
- Antenna and component testing
- Equipment calibration
- General laboratory pulse RF instrumentation

1.3 SPECIFICATIONS

Refer to the AR RF/Microwave Instrumentation Data Sheet on the following pages for detailed specifications.

1.4 ACCESSORIES

AR RF/Microwave Instrumentation offers a number of accessories for use with this amplifier including:

- Directional coupler
- Antenna
- Flexible transmission line

Refer to a current AR catalog for Microwave Accessories.

1.5 TEST DATA SHEET

A Test Data Sheet for a specific unit is prepared at the time of manufacture and is included with the unit's copy of this manual.

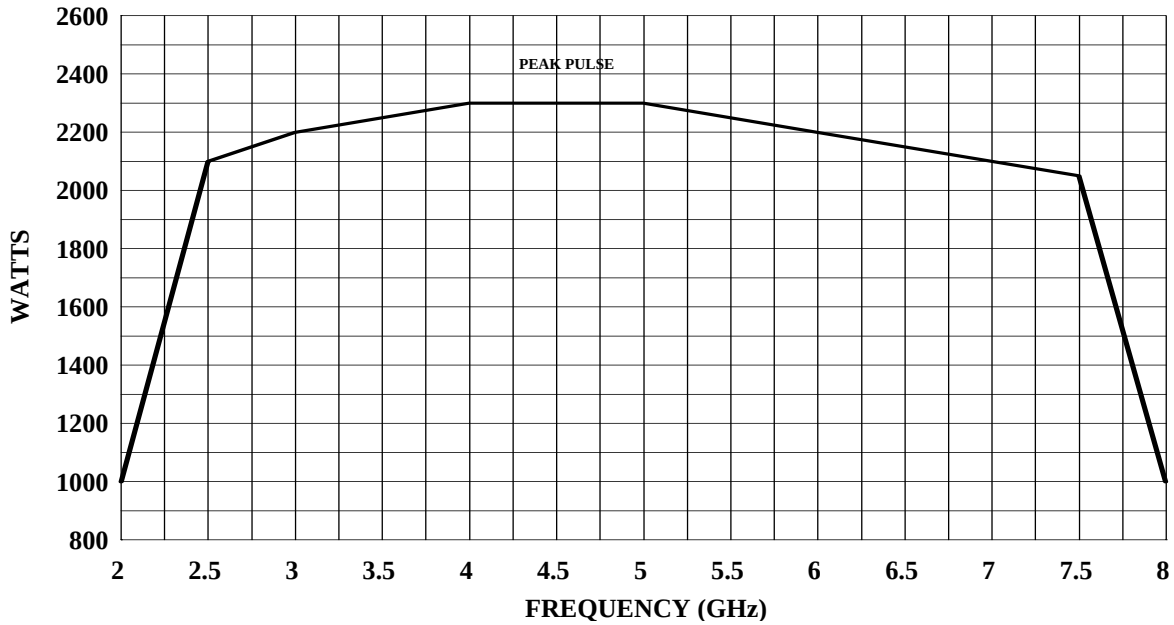
2000TP2G8ß,
M1 through M5
2000 Watts Pulse
2.5-7.5GHz

The Model 2000TP2G8B is a self contained, forced air cooled, broadband traveling wave tube (TWT) microwave amplifier designed for pulse applications at low to moderate duty factors where instantaneous bandwidth and high gain are required. A reliable TWT provides a conservative 2000 watts minimum peak RF pulse power at the amplifier output connector. Stated power specifications are at fundamental frequency.

The amplifier's front panel digital display shows forward and reflected average power output or forward and reflected peak power, plus extensive system status information accessed through a series of menus via soft keys. Status indicators include power on, warm-up, standby, operate, faults, excess average or peak reflected power warning and remote. Standard features include a built-in IEEE-488 (GPIB) interface, 0dBm input, TTL Gating, VSWR protection, gain control, RF output sample port, auto sleep, plus monitoring of TWT helix current, cathode voltage, collector voltage, heater current, heater voltage, baseplate temperature and cabinet temperature. Modular design of the power supply and RF components allow for easy access and repair. Use of a switching mode power supply results in significant weight reduction.

Housed in a stylish contemporary cabinet, the Model 2000TP2G8B provides readily available pulsed RF power for a variety of applications in Test and Measurement, (including EMC RF pulse susceptibility testing), Industrial and University Research and Development, and Service applications. AR also offers a broad range of amplifiers for CW (Continuous Wave) applications. See Model Configurations for alternative packaging and external harmonic filters.

2000T2G8B TYPICAL POWER OUTPUT



SPECIFICATIONS

POWER (fundamental), PEAK PULSE, @ OUTPUT CONNECTOR	
Nominal	2200 watts
Minimum	2000 watts
FLATNESS	±13 dB maximum, equalized for ±4 dB maximum at rated power
FREQUENCY RESPONSE	2.5–7.5 GHz instantaneously
INPUT FOR RATED OUTPUT	1.0 milliwatt maximum
GAIN (at maximum setting)	63 dB minimum
GAIN ADJUSTMENT (continuous range)	35 dB minimum
INPUT IMPEDANCE	50 ohms, VSWR 2.5:1 maximum
OUTPUT IMPEDANCE	50 ohms, VSWR 2.5:1 typical
MISMATCH TOLERANCE	Output pulse width foldback protection at peak reflected power exceeding 1000 watts. Will operate without damage or oscillation with any magnitude and phase of source and load impedance. May oscillate with unshielded open due to coupling to input. Should not be tested with connector off.
PULSE CAPABILITY	
Pulse Width	0.07–30 microseconds.
Pulse Rate (PRF)	100 kHz maximum
Duty Cycle	4% maximum.
RF Rise and Fall	30 ns max (10% to 90%).
Delay	300 ns maximum from pulse input to RF 90%
Pulse Width Distortion	±30 ns maximum (50% point of output pulse width compared to 50% points of input pulse width)
Pulse Off Isolation	80 dB minimum, 90 dB typical
Pulse Input	TTL Level, 50 Ohm nominal termination
NOISE POWER DENSITY	
(pulse on)	Minus 70 dBm/Hz (maximum), minus 72 dBm/Hz (typical)
(pulse off)	Minus 140 dBm/Hz (typical)
HARMONIC DISTORTION	Minus 0 dBc maximum, Minus 1.5 dBc typical
PRIMARY POWER	190-260 VAC, single phase 50/60 Hz 1.2 KVA maximum
CONNECTORS	
RF input	Type N female on rear panel
RF output	Type N female on rear panel
RF output sample port	Type N female on rear panel
Pulse input	Type BNC female on rear panel
GPIB	IEEE-488 female on rear panel
Interlock	DB-15 female on rear panel
COOLING	Forced air (self-contained fans), air entry and exit in rear.
EXPORT CLASSIFICATION	ITAR. This document contains specifications for a commodity whose export is governed by the U.S. International Traffic in Arms Regulations (ITAR). This commodity must not be transferred to a foreign person/entity without proper authorization of the U.S. Government. Violations may result in administrative, civil or criminal penalties.

MODEL CONFIGURATIONS

E Must select one enclosure type from the following [E1 or E2 or E2S]:

E1 Removable outer enclosure, size 50.3 x 25.4 x 82 cm (19.8 x 10 x 32 in). Add approximately 14 kg (30 lbs) to weight of E2.

E2 Without outer enclosure, size 48.3 x 22.2 x 69 cm (19 x 8.75 x 27 in). Weight approximately 39 kg (85 lbs).

E2S Enclosure removed for rack mounting; slides and front handles installed, size same as E2. Add approximately 2 kg (5 lbs) to weight of E2.

S May select a special feature (extra cost) from the following [S2K]:

S2K Supplied with two TF-type externally-mountable harmonic filters and a switch kit that allows the user to select an appropriate filter band, high or low, via this TWTA. Insertion loss when used with filters is maximum 1.5 dB. See **TF Type Filter Specifications** table below. Add filter weights, plus add 1 kg (2 lbs) for switch kit.

Model Number	Features	
2000TP2G8B	**E**	**S**
2000TP2G8B	E1	-
2000TP2G8B M1	E2	-
2000TP2G8BM2	E2S	-
2000TP2G8BM3	E1	S2K
2000TP2G8BM4	E2	S2K
2000TP2G8BM5	E2S	S2K

S2K – TF FILTER TYPE SPECIFICATIONS

Microwave Filter Model	For Use with AR TWTA Model	Pass Band (GHz)	Insertion Loss(dB max)	Reject Band (GHz)	Rejection (dB min)	Power (fundamental & harmonic, watts, max)	Input Connector	Output connector	Size L x W x D (cm, in max)	Weight (kg, lbs typical)	Input VSWR in Pass band (typical)	Input VSWR in Reject band (typical)
TF type filter 1	2000TP2G8B with N connector, requires two filters	2.5-4.2	0.5	5.0 - 8.4	25	150 & 100 average, 3000 & 2000 peak	N male (or N female plus supplied adapter or short cable)	N female	19 x 8 x 13 7.5 x 3 x 5	1, 2	1.3:1	2.5:1
filter 2		4.2-7.5	0.5	8.4 - 15	25	150 & 100 average, 3000 & 2000 peak			13 x 8 x 9 5 x 3 x 3.5	0.5, 1	1.3:1	2.5:1

2. THEORY OF OPERATION

2.1 DESIGN OF THE AMPLIFIER

The Model 2000TP2G8B TWT amplifier consists of three main parts, the microwave power assembly, the power supply, and the control. These will be described in greater detail below.

The heart of the microprocessor control system is the control head assembly (A27509-301), which consists of the CPU board (A25450-000) and the data link board (A22488-013). The microprocessor control system supervises the power supply, provides metering display, processes operator front panel inputs, and enables communication with a host computer over the IEEE-488 interface. Communication from the front panel is through the HPA display board (A25425-001).

The control head is provided with its own power supply and, other than through the IEEE-488 interface bus, is electrically isolated from the amplifier. Communication with the amplifier is via fiberoptic links to the HPA interface board (A25444-001).

2.2 DESCRIPTION OF THE RF CIRCUIT (A27502-318)

The TWTA consists of two stages of RF amplification: a solid state preamp assembly with adjustable gain (E01136-000) and the traveling-wave tube assembly (E01037-000).

The type N RF input connector is located on the rear panel. The RF input is fed to the input connector on the solid state pre-amp. The solid state pre-amp's output drives the RF input of the TWT. The RF output of the TWT is a type SC connector. The output is directed through a coax cable assembly to a dual (-30 dB/-40 dB) directional coupler. The RF Output connector on the rear panel is Type-N female.

An optional external harmonic filter / switch assembly may be used to further reduce harmonic power in a sub-band. The TWTA output connects to the input of a two-position switch via a coax cable. Switching is controlled locally, through the TWTA front panel, or remotely over the TWTA’s GPIB interface. The switch routes the RF to the appropriate band depending upon the sub-band selected:

- LOW band selection: routes to a low pass filter for operation from 2.5 – 4.6 GHz.
- HIGH band selection: routes to a low pass filter for operation from 4.6 – 7.5 GHz.

The reflected signal from the directional coupler is connected to a detector diode, whose output is used for VSWR protection by the power supply logic board, for VSWR measurement in the leveling loop, and for reflected power measurement on the HPA interface board.

The VSWR detection and reflected power Foldback circuit is provided to protect the tube from high reflected peak power that may result from progressive failure or mismatch of the output load. The Foldback circuit reduces the maximum pulse width of the output signal when the reflected power exceeds the factory set value. FOLDBACK ACTIVE appears on Menu 1 of the front panel display when the Foldback activates. When the reflected power is below the Foldback setting, the Foldback circuit de-activates.

The forward port output is split by a -10 dB coupler. The direct output is connected to a detector diode. The output of the detector diode is used on the HPA interface board to measure forward power. The side port of the coupler is connected to the forward type N RF sample port on the rear panel.

Forward and reflected power monitoring, both peak reading and average reading, are designed for use when a CW RF input is present during the entire period of the pulses applied to the external pulse input.

Amplifier gain is determined by the solid state pre-amp (SSPA), which has a voltage-controlled attenuator. The control head determines the output of a digital-to-analog converter (DAC) on the HPA interface board. The output of the DAC controls the SSPA attenuator. The emergency bypass board mounted behind the front panel is provided with a circuit for control head bypass in the event of a failure. In emergency bypass operation the attenuator signal is provided locally by means of a potentiometer on the emergency bypass board.

RF pulsing characteristics are protected by the Pulse Monitor Board (A30750-000). This board protects the HPA from over duty and over pulse width operation. The settings of these faults are factory set prior to shipment. This board also allows for user settable warnings for over peak forward or reflected power. These warnings can be set locally or remotely.

2.3 DESCRIPTION OF THE POWER SUPPLY (A22826-018)

The TWT power supply assembly is of modular construction. Low voltage power for logic and for control of the entire power supply assembly is provided by the low voltage power supply module (A23687-001). Control logic and TWT protection circuits are contained in the HPA Logic and Control Assembly (A16485-000).

The Heater Power Supply Module (A10010-000) powers the TWT DC heater. Bias and pulse top voltage for the TWT grid are provided by the Modulator Assembly (A23684-101).

The high voltage power supply consists of the following: the Power Factor Correction module (A23683-100) converts line voltage to DC for the high voltage switching supply. Switching transistors are on the Power Board Assembly (A16487-382), and switching is controlled by the Regulation Board. The high voltage transformer and rectifiers are contained in the HV Diode/Cap Assembly (A21425-020). The high voltage DC is filtered in the HV Filter Assembly (A21458-004).

Interconnects between the power supply modules are either through a motherboard or interconnected wiring harnesses. The motherboard is installed in the power supply base plate so that the entire area of the finned heat sink is available for heat transfer. The cooling air is provided by a 400 Hz fan. Air enters through the air intake filter on the rear panel. The Motherboard assembly is A23280-000.

The HPA interface board permits the control module to control the power supply and monitor analog values and fault status. Control is through the F/O to RS-485 board, which converts the electrical data from the control module back to fibers to the HPA interface board.

3. OPERATION

Throughout this manual, the symbol:

WARNING:

indicates that a hazard exists that may result in personal injury or loss of life.

CAUTION:

indicates that failure to follow procedures may result in damage to the equipment.

WARNING: DANGER - High Voltage Present:

Electrical equipment in this TWTA generates and stores high-voltage energy that can result in fatal electrocution. Do not operate the TWTA with covers or the front panel removed.

Service work must be performed only by technicians thoroughly familiar with the high-voltages present in microwave tube amplifiers in general, and with this equipment in particular.

Never handle the TWT leads or the high-voltage connectors unless the unit has been unplugged and it has been positively established that the high-voltage filter capacitors have been discharged to a *known* safe level.

WARNING: Safety Ground

Improper grounding of this equipment can result in electric shock. The TWTA must be operated only with a line cord with a safety ground wire. It is the user's responsibility to ascertain that the power connector is properly wired and that the power outlet is grounded.

WARNING: Explosive Atmosphere

To avoid explosion, never operate this TWTA in an explosive atmosphere. This equipment is not certified for operation in an explosive atmosphere.

3.2 INSTALLATION

3.2.1 Unpacking

Upon receiving the TWTA, inspect the shipping container for obvious signs of external damage. If damage is observed, notify the carrier and contact an authorized service representative.

Save and store the shipping container in case the unit needs to be returned to the manufacturer for repair.

3.2.2 Mounting and removing

The TWTA may be operated as a standalone benchtop unit, or it may be installed in a 19" rack.

If rack mounting is desired, first remove the module from the cabinet, then install the module in the rack.

NOTE: Due to the weight of the unit, the installation or removal of the amplifier is a two person operation.

Before removing the amplifier, disconnect power, RF, and any other external interface connectors. On the rear of the unit, remove any screws used to connect support brackets to the amplifier. On the front of the unit, remove all of the screws holding the front panel to the cabinet. Carefully slide the entire amplifier out of the front of the cabinet.

CAUTION:

Never rack mount the TWTA using the front panel alone. The chassis is likely to be damaged unless its weight is supported. Bottom support rails or side slide rails must be used in a rack mount configuration.

See Figure 3-1 (below) for the locations of threaded holes which may be used for supplementary support of the rear of the TWTA.

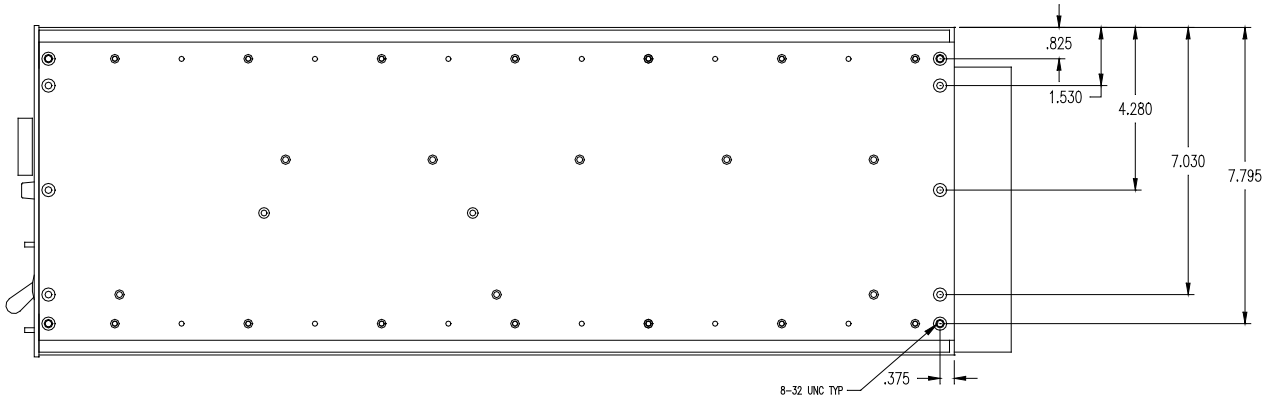


Figure 3-1. Mounting Support Holes

If bottom supports are used for rack mount installation of multiple units, the amplifiers should be separated vertically by at least 1 3/4 inches. This will allow room for necessary support rails and facilitate installation and removal of the units.

3.2.3 Cooling Requirements

The TWTA is provided with a cooling fan. It is important that air movement around the rear of the unit be unobstructed.

CAUTION:

For either bench or rack mounting, do not position the TWTA in such a way that the air intakes or outlets are blocked, or that the exhaust flow is directed into the intakes. See paragraph 3.5 for location of air intake and air outlet. If the unit is rack mounted, make sure that the intake air is 45°C or below. If necessary, fabricate a short duct to direct the hot exhaust air out of the rack enclosure. Great care must be taken to minimize any flow restrictions. Avoid mounting heat-producing equipment in the same rack, especially below the TWTA. Failure to provide adequate cooling can result in the unit's shutting down from overtemperature conditions.

The TWTA dissipates approximately 1,200 watts when in the operate mode at full RF power and maximum duty cycle. Operation at lower duty cycles result in much lower total power dissipation.

3.2.4 AC Line Power Connections

AC line power connection to the amplifier is made at the Power Supply AC inlet J1, which is a female IEC-320 connector. A line cord suitable for the type of AC outlet used, and consistent with local electrical codes, must be obtained to mate with J1. Minimum wire size for the line cord is 14 gauge.

The amplifier will operate from any line voltage between 190 and 260 VAC.

3.2.5 RF Connections

The RF output connector is Type N.

CAUTION:

Never operate the TWTA without a matched output load rated for at least 5000 watts peak, and 200 watts continuous duty. The TWTA is not provided with an output isolator. While the TWTA is protected from excessive reflected power by Foldback and VSWR circuits, it is poor practice to power the unit up without a load or an antenna. Even with no drive, "looping" oscillation can result in RF output if the TWTA is operated without a load. The VSWR detection and Foldback circuit is provided to protect the tube from *progressive* failure or mismatch of the output load; it should not be relied on for protection from the *absence* of a load.

CAUTION:

Never operate the TWTA without a matched input termination or drive source. When operating the unit with an antenna and without adequate isolation to the input, use caution in selecting well-shielded input cables and signal source. Use a 6 dB or larger pad (RF attenuator) directly at the TWTA input connector to reduce risk of "looping" oscillation.

3.2.6 External Interlock Connector

The TWTA is provided with an external interlock capability via a 15-pin female D-sub connector on the power supply/control module. To enable the high-voltage power supply, it is necessary to provide continuity between pins 3 and 4. If the amplifier shuts down because the interlock was opened, it will be necessary to reset the system to return to standby (see "*System Shutdown Screen"* in subsection 3.4). There is an internal jumper between J2 pins 1 and 2; a continuity check through these pins can be used to verify the presence of the amplifier in the instrumentation system. Users may adopt this interlock feature to disable the RF output for either equipment protection or as a backup for personnel protection.

CAUTION:

Do not rely on the external interlock for personnel protection. The intent of the external interlock feature is to disable the RF output for equipment protection. Use proper operating and safety procedures to ensure that power is removed for personnel safety.

When an optional external harmonic filter / switch assembly is installed, the switch control is via the same external interlock connector. The interlock function operates as described above, with access via the plug P1 on the switch control cable.

3.2.7 Video Input (Pulse Gate) Connection

This amplifier is provided with a rear panel BNC connector that is used for pulsing the beam of the TWT and hence the RF output. There will be RF output only when there is RF input and a simultaneous High Level video pulse input. A TTL Level video pulse must be provided at the Pulse Gate input connector. High level (+2 to +5 V pulse) enables the TWTA. Low level (0 to 0.4 V baseline level) disables the TWTA. An open input is considered a Low level. The Pulse Gate input impedance is 50 ohms nominal.

CAUTION:

Always maintain the Video Pulse parameters at the Pulse Gate input within the specified TTL levels, Pulse Width, Pulse Rate (PRF) and Duty Cycle called out on the specification sheet for this amplifier or in this manual. Failure to comply with the specified TTL levels may result in modulator failure.

Refer to AR RF/Microwave Instrumentation Application Note No.35 for additional information on use of pulse only TWT amplifiers. A copy of this application note is included as an appendix to this manual.

3.2.8 Optional External Filter/Switch Connection

When supplied with this TWTA, the optional external harmonic filter / switch assembly may be used to further reduce harmonic power in a sub-band. The TWTA output connects to the input of a two-position switch via a coax cable. The switch routes the RF to the appropriate band depending upon the sub-band selected:

- LOW band selection: routes to a low pass filter for operation from 2.5 – 4.6 GHz.
- HIGH band selection: routes to a low pass filter or coax cable for operation from 4.6 – 7.5 GHz.

Switching is controlled locally, through the TWTA front panel, or remotely over the TWTA's GPIB interface. Switch(es) should not be manually operated.

CAUTION:
The operating frequency must be within the pass band for the filter.

Band	Frequency range
Low	2.5 to 4.6 GHz
High	4.6 to 7.5 GHz

3.2.8.1 Assembly Instructions for Harmonic Filter Switching Kit (2 Filters)

The Harmonic Filter Switching Kit can be used connected to the TWTA or either filter can be removed from the kit and used individually. To assemble the kit to the TWTA connect the coax cable E01036-000 to the RF output connector of the TWTA. Connect the Bandswitch Control Cable to the Interlock connector on the TWTA, removing any existing plug present. Check that both round connectors of the Bandswitch Control Cable are connected to the switches, P2 to S1 and P3 to S2. See Section 3.2.6 for additional information describing use of the external interlock.

Individual filters can be connected directly to the TWTA rf output. If filters have been removed from the assembly for individual use, re-assemble the kit according to the schematic 10-30528-000, using Parts List A30528-000 as a reference.

3.3 FRONT PANEL FEATURES

Refer to Figure 3-2 below.

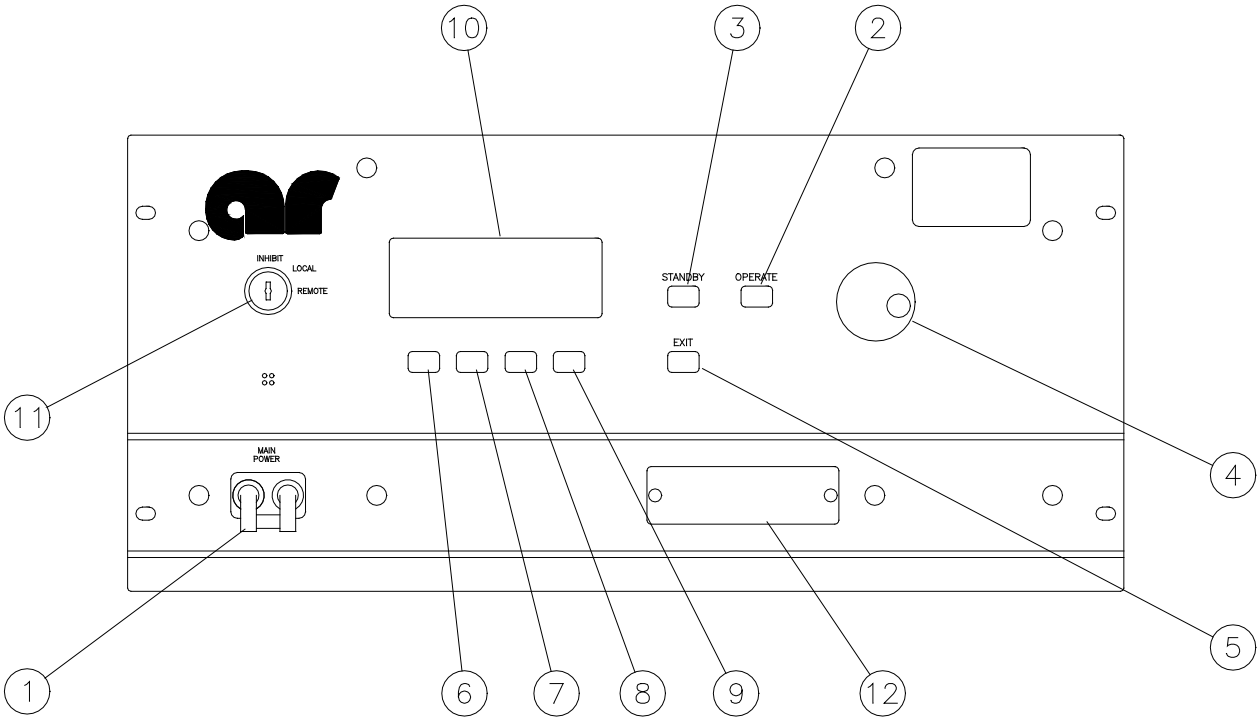


Figure 3-2. Front Panel Features

Table 3-1. Front Panel Features

Label	Title	Function
1	MAIN POWER	Switchable 7.5 A. circuit breaker; turns on control module, closes contactor providing AC to the power supply assemblies.
2	OPERATE	Push-button; turns on high voltage when all faults and heater delay are cleared.
3	STANDBY	Push-button; biases grid off and turns off high voltage.
4	ADJUST	Rotary knob used as an input device to change values of a variety of parameters.
5	EXIT	Push-button; terminates various menu selection routines and returns to the previous menu level.
6-9	S1...S4	"Soft Key" push-buttons; various menu selection functions.
10	Display	Displays numerous parameter values and fault messages.
11	Keylock Switch	Allows operator to inhibit the TWTA, to enable front panel control, or to enable computer control.
12	Emergency bypass switch cover	Provides access to emergency bypass switches, which permit manual control of the amplifier.

3.4 FRONT PANEL DISPLAY AND SOFT KEYS

The purpose of the front panel display is to permit the operator to access extensive information about the condition and operation of the TWTA. To accomplish this, a number of informational screens are programmed. It is important for the operator to be able to select the screen with the required information. Screen selection is accomplished by pressing an appropriate soft key or by pressing the EXIT key. When a soft key is active, its function is displayed on the bottom line of the display. Figure 3-3 provides a "roadmap" for navigating between the screens.

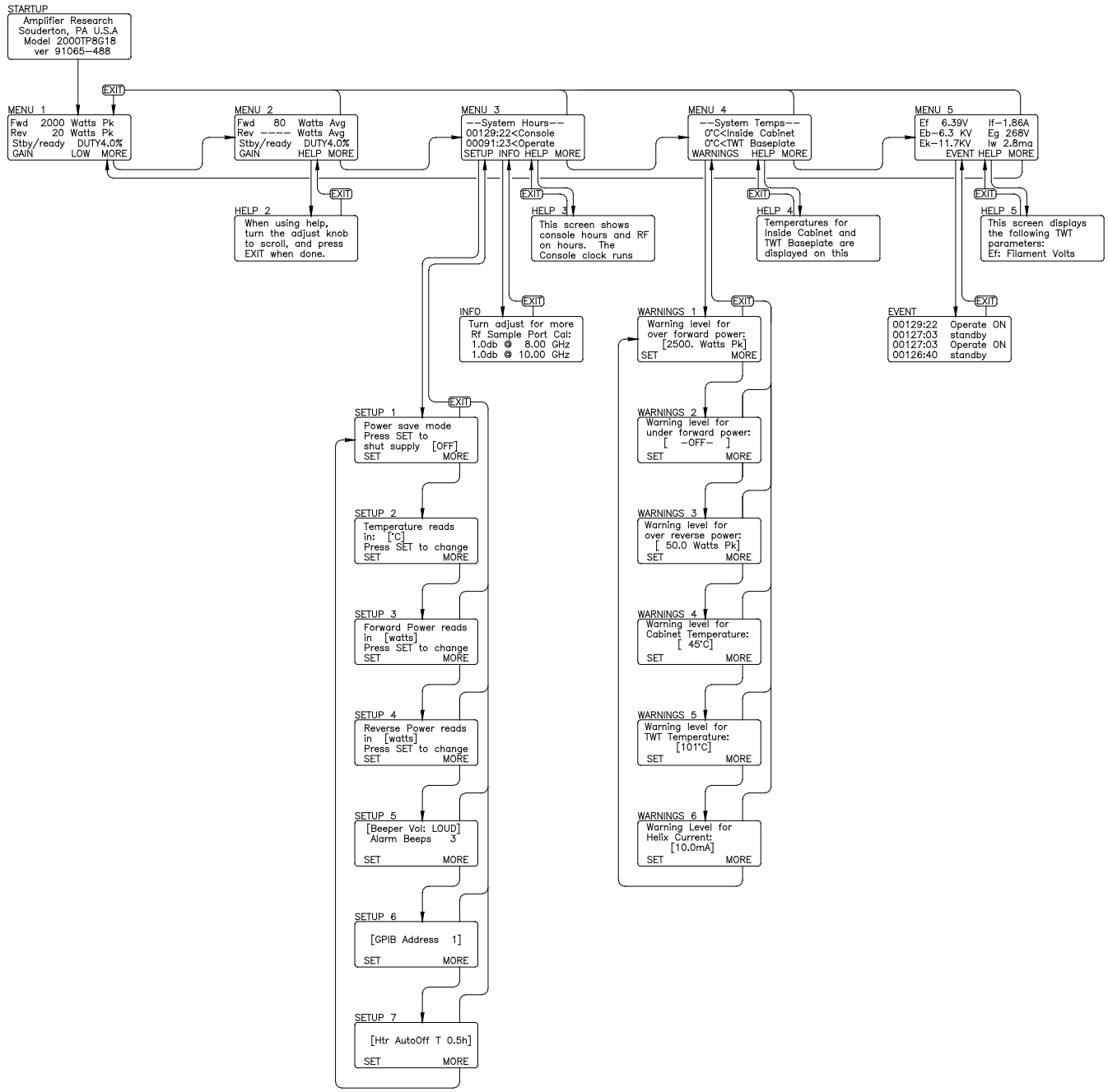


Figure 3-3. Front Panel Display Screens

Menu screens - The screens at the highest level are called menu screens. There are five menu screens. At power on, the MENU 1 screen is displayed. Each of the menu screens has the soft key S4 labeled MORE. The MORE key (S4) causes the next menu screen to appear. From MENU 5, MORE causes MENU 1 to reappear. In short, MORE permits scrolling through the menu screens. The EXIT key returns display to MENU 1 from any other menu screen.

The menu screens display system status and parameter levels. They are configured as follows:

Menu	Setting
MENU 1	Forward power Peak (watts or dBm)
	Reverse power Peak (watts, dBm, or % of fwd power)
	Duty
	System status (if a latched fault exists, MENU 1 is displayed with the system shutdown message)
	Band Switching (LOW/HIGH) (Visible in Standby mode only, this enables the user to manually switch to LOW band or HIGH band when using external harmonic filters and switches - only on models with optional external harmonic filter / switch assembly.)
MENU 2	Forward power Average (watts or dBm)
	Reverse power Average (watts, dBm, or % of fwd power)
	Duty
	System status
MENU 3	Console hours (active when AC power is on)
	Operate hours (active when HV is on)
MENU 4	Inside cabinet temperature (°C or °F)
	TWT baseplate temperature (°C or °F)
MENU 5	Heater voltage (Ef)
	Heater current (If)
	Collector voltage (Eb)
	Grid voltage (Eg)
	Cathode voltage (Ek)
	Helix current (Iw)

Help Screens - On each of the menu screens, soft key S3 is labeled HELP. If S3 is selected, a message describing the functions of that screen will be displayed. Use the ADJUST knob to scroll through the message. The EXIT key will return you to the screen from which the help screen was called.

Setup Screens - From MENU 2, S1 (labeled SETUP) selects the first of several setup screens, SETUP 1. This allows the user to manually shut off the heater power supply and put the HPA into “Sleep Mode”. Pressing S1 (SET) toggles between On and OFF. Pressing MORE brings up the SETUP 2 screen. This toggles display of temperature parameters between Fahrenheit and Celsius degrees. Pressing S1 (SET) changes the selection. The setting displayed when the screen is exited will be retained. Pressing MORE again brings up the SETUP 3 screen, which allows a choice of displaying forward power in dBm or watts. Pressing MORE again brings up SETUP 4, which allows a choice of dBm, watts, or % of forward power for displaying reflected power. Pressing MORE again brings up SETUP 5, which allows entering the desired number of alarm beeps and the desired beep volume. S1 (SET) toggles between parameters, and the adjust knob is used to enter the data. Pressing MORE again brings up SETUP 6, which allows the IEEE-488 address to be set. Pressing MORE again brings up SETUP 7, which allows setting the auto heater off time delay in 30 minutes intervals up to 3 hours. S1 (SET) changes the settings. Pressing MORE returns you to SETUP 1. EXIT returns you from any of the setup screens to MENU 2.

The Sleep Mode feature allows the *user* to selectively shut off the heater module of the power supplies. This can be done manually through the front panel or remotely via the computer interface. This is typically used during extended periods of *remote* operation to improve tube life, by turning off the filaments (Sleep Mode activated). This eliminates excessive STANDBY hours on the TWTs while still permitting remote capability to turn on the amplifier.

After activating the Sleep Mode:

Screen will display "Cooling On" while heaters cool down. "System Off" notifies user that the amplifier is in Sleep Mode

To deactivate Sleep Mode:

Press the ON soft key to de-activate Sleep Mode. Amplifier will return to MENU 1. When de-activating the Sleep Mode the heaters will require approximately a 5 minute heater time delay. Wait the full 5 minutes prior to selecting OPERATE.

Warnings Screens - From MENU 3, S1 (labeled WARNINGS) selects WARNINGS 1 which allows the operator to enter the maximum forward peak power. The existing value is between brackets[ ]; pressing SET puts arrows >< around the value, indicating that the adjust knob is active. The effect of the warning setpoint is as follows: if the forward peak power exceeds the setpoint, the audible alarm will sound (if configured in SETUP 5).

This warning will be repeated every thirty seconds until the over forward power condition is cleared. In addition, a warning message will appear on line 3 (the status line) of MENU 1. In the event that the alarm is heard, the operator should go to MENU 1 to determine the cause.

Pressing MORE brings up WARNINGS 2, which allows the under forward peak power setpoint to be entered. Adjusting this to the minimum value causes -OFF- to be selected, disabling this alarm.

In WARNINGS 3, the maximum reverse peak power level is set. Note that these are warning levels at which the beep sounds; the actual maximum reverse power level that generates a system fault is set in hardware in the TWT power supply HPA Logic and Control module.

MORE brings up WARNINGS 4, which allows input of the maximum cabinet temperature. Entering this parameter is performed as above.

MORE brings up WARNINGS 5, identical to the previous screen except that it deals with the maximum TWT collector block temperature. If either parameter exceeds the setpoint, the audible alarm will sound every 30 seconds (if configured), and a warning message will appear on line 3 of MENU 1.

MORE brings up WARNINGS 6, which permits setting the maximum helix current. Any helix current above this setpoint will result in an audible alarm (if configured), repeated every 30 seconds; and a warning message is displayed on the status line of MENU 1.

Pressing MORE again returns display to WARNINGS 1. As before, pressing EXIT from any of the warnings screens returns display to MENU 3.

Info Screen - From MENU 3, S2 (labeled INFO) selects a screen that displays the RF sample port calibration factors at various frequencies across the band. In addition, this screen displays the model number, serial number and firmware revision information that may be required by a service representative when providing technical assistance. The EXIT key returns the display to MENU 2.

Event Screen - From MENU 5, S2 (labeled EVENT) provides a display of events logged by the control system. These events include AC power-up, heater warm-up, change from standby to operate, faults, and resets. The events are stored in a first-in-first-out (FIFO) software buffer that has room for 100 events; as new events are logged, the older ones are discarded.

System Shutdown Screen - In the event of a system shutdown due to a fault (refer to Table 3-5) the MENU screen is replaced by a screen indicating the nature of the fault. Softkey S4 (labeled OK) is implemented as a reset key; pressing S4 brings back the MENU screens. Line 3 of MENU 1, which normally displays the operational state of the TWTA, is used as a fault display line until the fault is cleared. Most faults will turn HV off, unless otherwise specified in Table 3-5. When these faults are cleared the system will automatically resume the standby state and operate on will be enabled once again.

Some faults (O/PLS WIDTH, OVER DUTY, and EXTERNAL INHIBIT) will turn off RF while the fault is being displayed on the screen. HV will remain on during these faults. Once the fault is corrected the fault will clear and the system will turn RF back on automatically.

Factory Service Screens - A number of screens intended for factory service and calibration are behind passwords and are not accessible to the user.

System Malfunction Screens - A number of screens are reserved to display error messages. These messages are not normally seen and indicate a malfunction of the TWTA. System malfunction messages include the following:

- Database corrupt
- Communication failure
- Cannot restore
- CU line voltage too low to operate. System shutdown

In the event that one of these appears, shut off the TWTA and contact an authorized service representative before proceeding.

CAUTION:

Attempts to operate the TWTA despite control unit problems may result in loss of the static RAM database and calibration information.

3.5 REAR PANEL FEATURES

See Figure 3-4 below.

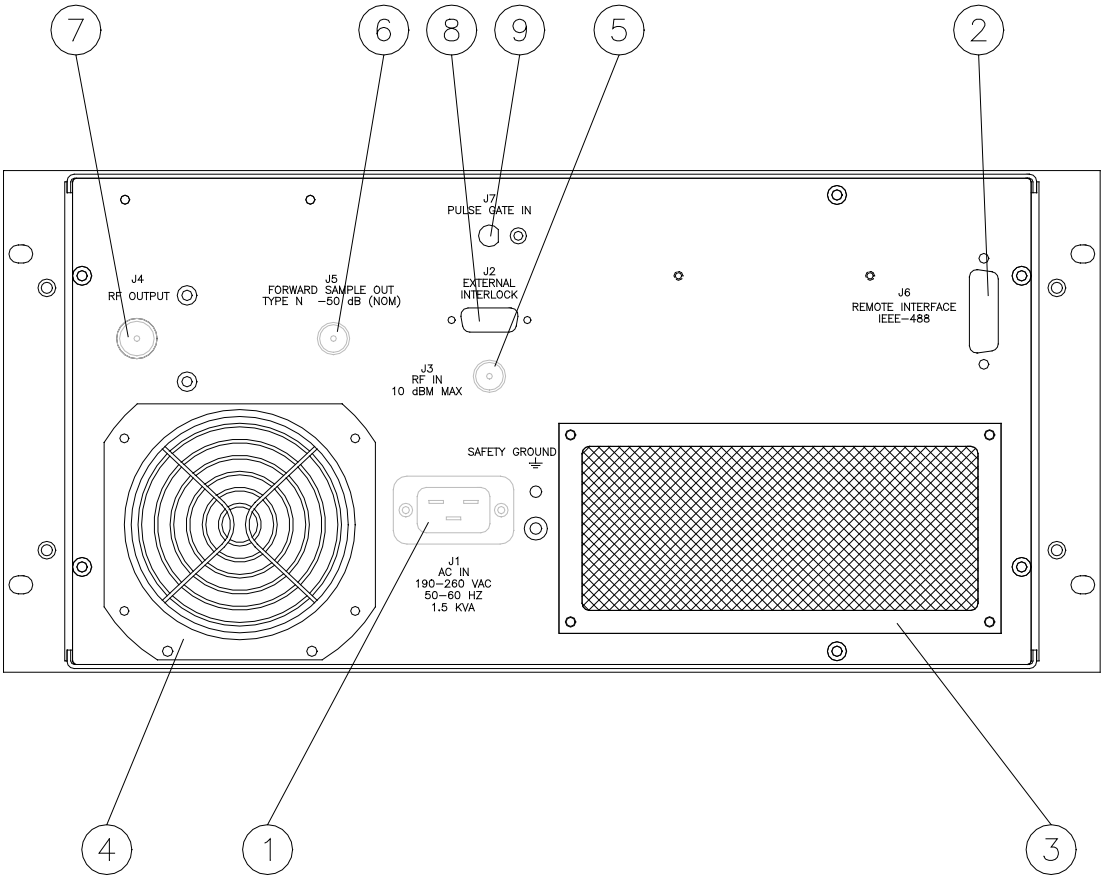


Figure 3-4. Rear Panel Features

Table 3-2. TWTA Rear Panel Features

Label	Title	Function
1	208 VAC IN	AC power input cable
2	IEEE-488	Remote control connector: 24-pin hermaphrodite
3		Cooling air intake.
4		Cooling air outlet.
5	RF INPUT	Type N female connector
6	RF SAMPLE OUT	Type N female connector
7	RF OUT	Type N female connector
8	EXTERNAL INTERLOCK/ SWITCH CONTROL	Connector to remote temperature switch protecting the isolator or load; Connector for optional RF switch control cable; D-sub 15-pin female
9	PULSE GATE	External pulse input; BNC connector

3.6 INITIAL TURN ON AND WARM-UP PROCEDURE

Operation is described without the external filter/switch assembly attached. Operation with the external filter/switch assembly attached is the same, except that the band selection must first be set to match the input RF frequency range, and the load is connected to the filter / switch assembly RF output connector. Sub-band selection changes can only be made when in the Standby mode, not the Operate mode. Remote commands to band switch while in the Operate mode will not be processed to switch bands.

Band	Frequency Range
Low	2.5 to 4.6 GHz
High	4.6 to 7.5 GHz

CAUTION:
Do *not* position the switch using manual controls on the switch.

Install the TWTA as discussed in section 3.2. Provide an RF generator to the RF input Type N connector. Set RF generator level below -50dBm and set desired frequency in specified range. Connect a load suitable for 200 watts continuous operation to the RF output. The load VSWR should be less than 2.0:1 A power meter and suitable attenuators may be connected to the RF reverse power sample port. The RF sample port calibration factors on the rear of the unit or on the *Info* screen in MENU 2 show the relation between the amplifier output power and the RF sample port power as a function of frequency.

Connect a TTL level video pulse signal within the specification sheet parameters to the Pulse Gate input (Video). For test purposes, the following parameters may be set:

- Pulse Width: 10 Microseconds
- Pulse Rate: 1 kHz
- Baseline: 0V
- Peak level: +4V
- Video source impedance: 50 ohms or less.

This results in a Duty Cycle (also called duty factor) of 1%. This is within the specified range.

Set keylock to LOCAL.

Switch on the MAIN POWER circuit breaker. The fans will operate. The front panel display will show several identification messages and then the MENU 1 screen. The third line will indicate that the heater time delay is active.

Allow the heater warm-up delay to expire. Line three will indicate OFF/READY.

CAUTION:

Do not allow the TWTA to remain in STANDBY for extended periods of time. If the TWTA will not be used in the OPERATE mode within an hour, shut the TWTA off. The reason for this precaution is that in the STANDBY mode, the TWT's cathode runs very hot since it is not cooled by electrons boiling off the surface, and small amounts of out-gassing are not cleaned up by the electron beam. *Extended operation in Standby can result in irreparable damage to TWT!*

Push S4 (MORE) three times to go to MENU 4. Verify that the heater voltage and current for TWT #1 are near their nominal levels. The values of these parameters at the time the TWTA left the factory are logged on the test data sheet.

Push the OPERATE push-button. You will now see the cathode and the collector voltages rise. Verify that the grid, collector, and cathode voltages are near nominal. The helix current should be near the nominal value for no RF drive. Then push MORE or EXIT to go back to MENU 1.

Set the TWTA gain to maximum. Adjust the RF generator to slowly increase the RF drive toward 0 dBm to reach the desired FWD peak power on the display and power meter (connected to sample port). The forward power reading will become active and reach a maximum reading when peak power output is achieved. Best performance is obtained when the input RF drive is set at or just below the level that causes the highest level of peak power output. Do not set input drive above 0 dBm (Input drive above +13 dBm may damage the unit). The reverse power level should remain below 10% of the forward power, assuming that the load is properly matched.

An alternate procedure is to pre-set the TWTA gain to minimum, set the RF generator to 0 dBm and then slowly increase the TWTA gain to set the desired RF output level.

Observe that the helix current is sensitive to the RF drive level of the TWT. It is at a minimum with no RF drive. The helix current with no drive and with rated RF power output mid-band are logged on the test data sheet for a specific set of pulse input drive conditions. The value of the helix current under these drive conditions is a good qualitative indicator of RF and video pulse drive input present.

To shut the system down, turn down the RF generator level below -50 dBm and press STANDBY. Allow the TWTA to cool down until the TWT temperatures drops below 70°C, and then turn off main power.

3.7 REMOTE IEEE-488 OPERATION

The TWTA is provided with an IEEE-488 interface that permits remote emulation of OPERATE, STANDBY, and RESET push-buttons as well as access to parameter measurements, system faults, gain adjustment and control unit status. The Power Save mode (Sleep Mode) provides *remote capability* to control the TWT heater (filament) and to lower the amplifier standby power consumption during non-operational intervals.

The following tables summarize the commands and the return codes.

Table 3-3. Catalog of IEEE-488 Commands

Command	Function	Units	Response format
RDSTAT	Returns status code of processing of previous command (see Table 3-4)		STATUS=[ ]
RDFLT	Returns system fault code (see Table 3-5)		flt=[ ]
SYSTEM:ON;	Emulates pressing the System ON button from System OFF (Exit Sleep Mode)		
SYSTEM:OFF;	Emulates pressing the Power Save button. (Enter Sleep Mode)		
OPERATE;	Emulates OPERATE push-button		
STANDBY;	Emulate STANDBY push-button		
POWER:OFF;	Emulate STANDBY push-button		
RESET;	Emulates RESET softkey		
RDS/N	Returns serial number		s/n=[ ]
RDCONHR	Returns console hours		ConHr=[ ]
RDRFHR	Returns RF hours		RfHr=[ ]
RDEK	Returns cathode voltage	KV	Ek=[ ]
RDEB	Returns collector voltage	KV	Eb=[ ]
RDEG	Return grid voltage	V	Eg=[ ]
RDEF	Returns heater voltage	V	Ef=[ ]
RDIF	Returns heater current	A	If=[ ]
RDIW	Returns helix current	mA	Iw=[ ]
RDTMPTWTF	Returns TWT temp (°F)	°F	TWTF=[ ]F
RDTMPTWTC	Returns TWT temp (°C)	°C	TWTC=[ ]C
RDTMPPSF	Returns power supply temp (°F)	°F	PSF=[ ]F
RDTMPPSC	Returns power supply temp (°C)	°C	PSC=[ ]C
RDTWTOTF	Returns TWT overtemp warning setpoint (°F)	°F	TWTOTF=[ ]F
STWTOTF	Sets TWT overtemp warning setpoint (°F)	°F	
RDTWTOTC	Returns TWT overtemp warning setpoint (°C)	°C	TWTOTC=[ ]C
STWTOTC	Sets TWT overtemp warning setpoint (°C)	°C	
RDPSOTF	Returns power supply overtemp warning setpoint (°F)	°F	PSOTF=[ ]F
SPSOTF	Sets p. s. overtemp warning setpoint (°F)	°F	
RDPSOTC	Returns p. s. overtemp warning setpoint (°C)	°C	PSOTC=[ ]C
SPSOTC	Sets p. s. overtemp warning setpoint (°C)	°C	
RDIWOC	Returns helix overcurrent warning setpoint	mA	IwOC=[ ]
SIWOC	Sets helix overcurrent warning setpoint	mA	
RDLOGIC	Returns logic state code (see Table 3-6)		Sys=[ ]
RDA	Returns gain	%	A=[ ]
SA	Sets gain	%	
RDHTDREM	Returns remaining heater time delay	sec.	HTD=[ ]s
RDPODP	Returns forward power out (dBm) Peak	dBm	Po=[ ]dBm Pk
RDPOWP	Returns forward power out (W) Peak	watts	Po=[ ]W Pk
RDPOD	Returns forward power out (dBm) Average	dBm	Po=[ ]dBm Avg
RDPOW	Returns forward power out (W) Average	watts	Po=[ ]W Avg

Command	Function	Units	Response format
RDPRDP	Returns reverse power out (dBm) Peak	dBm	Pr=[ ]dBm Pk
RDPRWP	Returns reverse power out (W) Peak	watts	Pr=[ ]W Pk
RDPRD	Returns reverse power out (dBm) Average	dBm	Pr=[ ]dBm Avg
RDPRW	Returns reverse power out (W) Average	watts	Pr=[ ]W Avg
RDDUTY	Returns Duty	%	DTY=[ ]%
RDPOHIDP	Returns over forward power warning setpoint (dBm) Peak	dBm	Pohi=[ ]dBm Pk
SPOHIDP	Sets over forward power warning setpoint (dBm) Peak	dBm	
RDPOLODP	Returns under forward power warning setpoint (dBm) Peak	dBm	Polo=[ ]dBm Pk
SPOLODP	Sets under forward power warning setpoint (dBm) Peak	dBm	
RDPOHIWP	Returns over forward power warning setpoint (W) Peak	watts	Pohi=[ ]W Pk
SPOHIWP	Sets over forward power warning setpoint (W) Peak	watts	
RDPOLOWP	Returns under forward power warning setpoint (W) Peak	watts	Polo=[ ]W Pk
SPOLOWP	Sets under forward power warning setpoint (W) Peak	watts	
RDPRHIDP	Returns over reverse power warning setpoint (dB) Peak	dBm	Prhi=[ ]dBm Pk
SPPRHIDP	Sets over reverse power warning setpoint (dBm) Peak	dBm	
RDPRHIWP	Returns over reverse power warning setpoint (W) Peak	watts	Prhi=[ ]W Pk
SPRHIWP	Sets over reverse power warning setpoint (W) Peak	watts	
RDHTRAUTOOFF	Returns heater to auto off delay	hours	
SHTRAUTOOFF	Sets heater auto off delay (see Table 3-9)		
*IDN?;	Returns the product model number		[ ]
*STA?;	Returns status string (see Table 3-7)		[ ]
*STB?;	Returns status string (see Table 3-8)		[ ]

With Optional External Harmonic Filter / Switch Assembly

Command	Function	Units	Response format
STBAND	Sets sub-band switch position		0 = low 1 = high
RDBAND	Returns sub-band switch position		Band = [ ] 0 = low, 1 = high

Table 3-4. Catalog of Status Codes

(The RDSTAT command causes the TWTA to return a string in the form STATUS=[*code*], where [*code*] is an ASCII number whose meaning is given below)

Status Code	Meaning
0	No command was given
1	Last command was successful
2	Last command is in process.
3	Last command failed to complete. Time-out.
10	Last command failed. Invalid command.
11	Last command failed. Data was unparseable.
20	Last set command failed. Data was beyond high limit.
21	Last set command failed. Data was beyond low limit.
22	Last set command failed. Data was out of range
23	Last set command failed. Data was wrong polarity
50	Last command failed. Local system does not have remote enabled.
51	Remote system is not ready to accept commands.
901	Assert error: invalid table argument*.
902	Assert error: invalid calibration*.

* Please call a service representative if you observe this error.

Table 3-5. Catalog of Fault Codes

(The RDFLT command causes the TWTA to return a string in the form flt=[*code*], where [*code*] is an ASCII number whose meaning is given below)

Fault Code	Meaning
0	No fault
7	SYSTEM FAULT
8	FIL NOT READY
9	LOW LINE
10	CATH O/VOLTAGE
11	BODY O/CURRENT
12	CATH U/VOLTAGE
13	O/PLS WIDTH (turns RF off only)
14	OVER DUTY(turns RF off only)
15	COLL U/VOLTAGE
16	INVERTER FAULT
17	INTERLK OPEN
18	TUBE ARC
19	TWT OVER TEMP(h)
20	CABINET O/TEMP(h)
22	EXTERNAL INHIBIT(turns RF off only)
23	OVER REV POWER
26	Panel Open
30	GRID O/VOLTAGE

Table 3-6. Catalog of System State Codes

(The RDLOGIC command causes the TWTA to send a string containing an operational state code consisting of 4 ASCII characters representing hex digits. The response is in the form "Sys:*[w][x][y][z][eol]*" where the hex values of *[w],[x],[y] and [z]*are formed as shown below)

z bit	Meaning
0 (LSB)	High voltage on
1	Transmit on
2	Remote mode
3 (MSB)	Fault

y bit	Meaning
4 (LSB)	Heater time delay expired
5	Under forward power warning
6	Foldback active
7 (MSB)	Inhibit mode

x bit	Meaning
8 (LSB)	External inhibit
9	Interlock open
10	(not used)
11 (MSB)	(not used)

w bit	Meaning
12 (LSB)	(not used)
13	Sleep Mode Active
14	(not used)
15 (MSB)	(not used)

Table 3-7. *STA?; Response Codes

(The command *STA?; causes the TWTA to send a string indicative of the current system state)

*STA?; response	Meaning
SLEEP	Sleep Mode active (heater off)
WARM-UP	System is in heater time delay.
STANDBY	System is ready to allow high voltage on
OPERATE	High voltage is on and beam is on
FAULT	High voltage is off and system requires reset

Table 3-8. *STB?; Response Codes

(The command *STB?; causes the TWTA to send a string containing an operational state code consisting of 2 ASCII characters representing hex digits. The response is in the form "STATUS:*[x][y][eol]*" where the hex values of *[x]* and *[y]* are formed as shown below)

y bit	Meaning
0 (LSB)	Power status; always 1(power on)
1	Standby status; 0 if not in standby, 1 if in standby
2	Operate status; 0 if not in operate, 1 if in operate
3 (MSB)	Fault status; 0 if no fault, 1 if fault exists

x bit	Meaning
4 (LSB)	Mode switch; always 1 (reset)
5	Blank switch; always 1 (off)
6	Blank status; always 0 (off)
7 (MSB)	Not used; always 0

Table 3-9. Catalog of Heater Auto Off Time Delay Codes

Argument	Meaning
0	0.5 hour heater auto off time delay
1	1.0 hour heater auto off time delay
2	1.5 hour heater auto off time delay
3	2.0 hour heater auto off time delay
4	2.5 hour heater auto off time delay
5	3.0 hour heater auto off time delay

Command syntax is in this form:

<command mnemonic> <parameter> <carriage return>

where:

<command mnemonic> consists of one of any valid command found in Table 3-3.

<parameter> (as applicable) consists of one ASCII "space" character followed by a number.

<carriage return> consists of an ASCII carriage return.

All commands are case sensitive.

The system will return parameter values, fault codes, and status codes regardless of whether remote is enabled. The parameter value is returned as a string of 20 characters or less, consisting of a label,"=", and a value. For example, outputting the command RDEF to the TWTA would result in the TWTA sending back the string "Ef=6.03" (assuming the heater voltage is 6.03 volts). Units are usually not returned; see table 3-3 for the units.

If remote is not enabled, set commands and commands to the system logic (e.g., OPERATE;, STANDBY;, or RESET;) will not be accepted.

It is recommended that the RDSTAT command be used to provide the host program with a report on how a command was processed.

A small sample program that can send commands and receive the strings returned by the TWTA is included in section 5.5. It is written in Hewlett-Packard's "Rocky Mountain" BASIC. The program assumes that the IEEE-488 bus is at address 7 and that the address of the TWTA is 01.

Remote operation is determined by the application (software) program in the system controller. This application program will aid the user in generating the Command Codes and displaying/monitoring the Status Codes. Consult the application program users instructions for Remote operation procedure.

The application program should issue only one string at a time. After each functional command is issued the status should be checked to ensure that the command has been properly executed. The application program should allow sufficient time for the function to be completed before checking the status.

The application program should facilitate checking the status just prior to issuing a command - since the status could have been changed by a fault condition of the amplifier or by operator activation of the amplifier. Periodic checking of the status is also recommended.

3.8 TWTA GENERAL CONSIDERATIONS

This section is intended to offer some guidelines regarding operation, storage and use of AR RF/Microwave Instrumentation TWTAs.

Storage: TWTAs, as with other electronic equipment, are best stored in a benign environment at reasonably constant temperature. Service life is not improved by periodic operation.

Availability: For critical missions, and after long periods of storage, it is recommended that TWTA operation be checked sufficiently in advance of the mission to permit repair if required. Though service life is not improved by periodic operation, users experiencing amplifier trip due to body over current may benefit by periodically operating a unit with high voltage and grid on, but no rf drive. Such operation for about one hour on a weekly basis should effectively reduce nuisance tripping. Since the cathode structure has finite life, extended periods of non-functional operation of TWTAs is not recommended. An alternate approach, if periodic trip off has been observed, is to operate the unit without rf input for 1-2 hours before planned functional operation, resetting the unit after occasional trip off.

Cooling during Operate Mode: AR TWTAs have their air outlets and inlets on the rear panels. It is important to prevent the heated air, which is expelled from the TWTA's air outlets, from being recycled into the air inlets. Applications should have a clearance behind the TWTA of at least two feet for single bench top units and at least three feet for the higher power units, or the heated air should be ducted away.

Operation in Standby Mode: Standby mode for TWTAs readies the unit for operation. In this mode the filaments are on but the high voltage is off. TWTAs should not be left in this Standby mode for extended periods. Where practical, operational procedures should limit the time on Standby mode to less than approximately one hour. (See *Explanation of…*., below)

Operate Turn on: When selecting the Operate mode, when high voltage is first turned on, there may be some internal TWT arcing which can cause protective circuits to deselect the Operate mode, thereby returning the unit to the Standby mode. There may be a report of body over-current fault. In either case, if there is no other contraindication, the Operate mode may be selected again. This procedure may be repeated, if needed up to 25 times, until the Operate mode is actually set. If this condition persists, contact AR RF/Microwave Instrumentation Service for additional assistance. (See *Explanation of…*, below)

Noise Power Density (NPD): TWTAs produce rf noise over their operating frequency range, as specified by the Noise Power Density (NPD). This noise is significantly higher than the noise produced by typical solid state amplifiers, and is inherent in present TWTAs. The noise may surprise users new to TWTAs when it accumulates and results in a significant indication in a broadband measurement device – such as a power meter or field probe. The error produced by this indication is not significant when operating near rated TWTA power levels, but may cause difficulty when trying to operate high power TWTAs at low output power levels.

For example, consider a hypothetical typical NPD of –76 dBm/Hz, from a 4 GHz bandwidth amplifier. A broadband detector might see the NPD as [-76 dBm/Hz + 10 (log 4 x 10^9) BW factor = -76 + 96=] +20 dBm, or 0.1 watts. This power is insignificant for a user operating at 200 watts (+53 dBm), but may be very noticeable to a user trying to operate below 1 watt (+30 dBm). [One watt is 0.5% of (23 dB below) rated power for a 200-watt amplifier.] A field probe user who obtains a 200 V/M field with 200 watts, may see a field as high as [53 dBm – 20 dBm = 33 dB below 200 V/M=] 4.5 V/M due to this hypothetical NPD.

For these applications the use of a lower power amplifier is highly recommended, especially when considering safety issues. Alternatively, additional power loss in the form of an added high power microwave attenuator, or preferably an increased space loss for radiated fields, may be used to lower the noise received by the broadband measurement device.

Explanation of Limiting the Time in Standby mode and of Repeated Operate Selection.

Traveling wave tubes tend to get "gassy" if they are left in a "Standby" mode for extended periods of time. In this "Standby" mode, the heater (filament) is on but there is no high voltage applied to the collector (or high voltage is applied to the collector but the grid is off). This is the normal state after a tube's warm up time, just prior to entering the "Operate" mode.

In this state the cathode end of the TWT is heating up but the electron "Beam" is off. In other words, there is no cathode current. As the cathode heats up, gas trapped in the structure of the tube can be released, thus corrupting the vacuum of the tube. If the tube become too "gassy", arcing may occur when the high voltage is fully applied in the "Operate" mode. Another possible failure mode is a body over-current fault when the beam is turned on and the tube is "gassy".

Occasional arcing is normal for a TWT. The support components are designed to handle this, protecting both the TWT and its support circuitry. However, if the tube arcs two or three times in rapid succession, or worse yet repeatedly, a fault will be sensed that will shut the high voltage off, thus removing the unit from "Operate" status. The remedy usually recommended is to repeat the selection of the "Operate" mode until the unit remains in "Operate". It as been found that most of the faults that can be cleared by this method will be cleared within 25 attempts to enter the Operate mode.

Once the tube is operating normally, gas will continue to evolve at a slow enough rate that the TWTA will not fault. This happens because the gas in the tube will interact with the beam and become ionized. As the electrons in the beam hit the gas molecules they ionize the gas, at which point it is accelerated into the collector structure and "buried" deep enough so that it ceases to be a problem.

To preclude this gassing problem, and thus reduce the need for repeating the "Operate" selection, it is recommended that the time in "Standby" be limited – to about one hour. Extended periods in "Standby" may result in an inability to clear the fault by this method. In this case, service measures may be needed to correct the unit. Thus, users should reduce the likelihood of occurrence of this problem by limiting the amount of time in the "Standby" mode.

4. MAINTENANCE

The TWTA requires a minimum of routine maintenance**.** The only moving parts are the elements of switches, relays and blowers. Preventive maintenance is recommended in Paragraph 4.3.

In the event that the TWTA needs repairs, it is recommended that the unit be returned to the factory. However, some user service organizations may choose to perform their own corrective maintenance, and under some circumstances returning the unit to the factory may be impractical. The highly modular construction of the TWTA facilitates troubleshooting to the level of readily replaced subassemblies. Section 5 provides partial technical documentation to support field repairs. Nevertheless, the factory or its service representative should be contacted before undertaking repair work on these TWTAs. **Warnings and Cautions must be observed.**

4.1 SAFETY WARNING

WARNING:

Service work must be performed only by technicians thoroughly familiar with the high voltages present in microwave tube amplifiers in general, and with this equipment in particular.

Never handle the TWT leads or the high-voltage connectors unless it has been positively established that the high-voltage filter capacitors have been discharged to a *known* safe level.

CAUTION:

A malfunctioning power supply can cause damage to the TWT. If you are troubleshooting the TWTA, remove the TWT and substitute suitable loads to prevent damage to the TWT.

4.2 UNAUTHORIZED REPAIRS

CAUTION:

Unauthorized repairs or modification of this product during the warranty period may void the warranty. In the event that the TWTA malfunctions while it is still under warranty, always contact an authorized service representative.

4.3 PREVENTIVE MAINTENANCE

The RF characteristics and power supply voltages and currents of the amplifier should be logged on a regular basis. Maintenance should be performed if significant deviations from the logged values appear. If the unit is under warranty, contact an authorized service representative if impaired performance is suspected.

If there is accumulated dust on the air intake grill clean it with dry compressed air.

If significant dust has been noted on the air intake grill it may be desirable to vacuum the dust and debris from inside the enclosure. To open the enclosure:

1. Remove the amplifier from the cabinet or rack as follows:

   NOTE: Due to the weight of the unit, the removal of the amplifier from the cabinet or rack is a two-person operation

   Disconnect power, RF, and any other interface connectors. On the rear of the unit, remove any screws used to connect brackets to the amplifier. On the front of the unit, remove all of the screws holding the front panel to the cabinet. Carefully slide the entire amplifier out of the front of the cabinet.

2. Remove the screws that secure the lower cover and the screws that secure the upper cover. Remove the covers to gain access to the interior of the amplifier.

Vacuum dust and debris from inside the enclosure. Clean dust from the amplifier and its flying leads. Remove any dirt from around the high voltage connectors. While the cover is off, check for loose wires, components or fasteners. Reassemble in the reverse order.

4.4 TROUBLESHOOTING

Symptom	Possible cause
TWT or power supply overtemperature	Air inlet filter(s) dirty Collector heat sink dirty Inadequate clearance behind TWTA High air inlet temperature Defective fan or fan driver
No response when main power turned on	Disconnected power cable Defective circuit breaker Panel open interlock switch open
Control module display does not come up; unit does not beep when powered up	Shorted or defective control module power supply Control module failure
Control module does not boot	EPROM(s) missing Control head PC board defective
Control module "datalink failure" error appears	HPA interface failure. Data steering board failure Fiberoptic link failure ±15 VDC supply failure
Heater power supply does not come up	Defective low voltage power supply module Defective heater power supply module
No high voltage	Keylock switch on "INHIBIT" or "REMOTE" Defective high voltage power supply. Open external interlock
Voltages normal, but no RF output, helix current low	No RF input Defective SSA Gain turned down

After reviewing the symptoms of the failure, the user may want to check for a loose connector or component especially after rough handling of the unit. Look externally for physical damage or loose connectors and internally for unmated or loose parts**.**

The service technician should become familiar with the internal mechanical construction to permit correct re-assembly. Limited troubleshooting may be conducted, with caution, based on the failure symptom and an understanding of the logic/schematic diagrams**.**

4.5 NON-REPAIRABLE MODULES

The Heater power supply (A10010-000), the Grid modulator (A23684-101), the HV filter (A21458-004), the Diode/Cap assembly (A21425-020), and the Capacitor bank (A21458-005) are encapsulated modules and are not repairable. Contact an authorized service representative if replacement modules are needed.

5. TECHNICAL DOCUMENTATION

NOTE: The purpose of this technical documentation section is to provide a guide to the TWTA for technician-level servicing. It is intended for use by qualified technical personnel who must troubleshoot and repair the TWTA in the field. Such repairs are typically limited to replacement of modules or major components. For this reason, only documentation pertaining to the highest levels of the system and to system control logic is included.

5.1 TOP LEVEL BUILD TREE

	A27500-913	HPA ASSY 23PSC, 2 KW PULSED 2.5-7.5 GHZ, IEEE-488 (AR)
1A1	A22826-018	PULSED TWT P. SUPPLY (PFC) FOR TWT 3041B
1A1A1	A23280-000	HEAT SINK/MOTHER BOARD
1A1A2	A23687-001	LOW VOLTAGE POWER SUPPLY MODULE
1A1A3	A16485-000	HPA LOGIC AND CONTROL MODULE
1A1A4	A23683-100	POWER FACTOR MODULE (500W)
1A1A4L4	A09006-000	PFC INDUCTOR FOR 100VAC-255VAC
1A1A5	A16487-382	POWER BOARD ASSEMBLY,PULSED TWTA
1A1A5L1	A09025-000	PULSED BUCK INDUCTOR
1A1A5T1 (E42)	A09402-000	XFMR,GATE DRIVE (HAND WOUND)
1A1A5T2 (E41)	A09403-000	XFMR,GATE DRIVE (HAND WOUND)
1A1A6	A21425-020	HV DIODE/CAP MODULE FOR TWT 3041B
1A1A6T1	A09483-001	HV XFMR FOR TWT 3041B-REV B
1A1A7	A21458-004	HV FILTER
1A1A8	A23684-101	PIJ/PSC GRID MODULATOR MODULE, REGULATED
1A1A8A1	A23686-101	PIJ/PSC HV MODULATOR WITH REGULATED
1A1A8A1T1(NOTE 7)	A09227-000	PULSE TOP XFMR,HAND WOUND
1A1A8A1T2(NOTE 7)	A09228-000	FEEDBACK XFMR,HAND WOUND
1A1A8A1T3(NOTE 7)	A09229-000	BIAS XFMR,HAND WOUND
1A1A8A1T4, T5(NOTE 7)	A09230-000	XFMR,GATE DRIVE (HAND WOUND)
1A1A8A1T6(NOTE 7)	A18478-000	PULSE TOP SUPPLY TRANSFORMER,
1A1A8A2	A23715-101	PIJ/PSC MODULATOR CONTROL BOARD
1A1A9	A10010-000	HEATER POWER SUPPLY MODULE
1A1A9T1	A09409-000	XFMR,HEATER FEEDBACK
1A1A9T2	A09408-000	XFMR,HEATER POWER
1A1A10	A21459-020	PULSED PWM BD (TWT 3041)
1A1A11	A25398-020	FACTORY SELECT FOR 13PSC(REV F LOGIC BD)
1A1A12	A21458-005	CAPACITOR BANK
1A2	A27502-318	MICROWAVE POWER ASSY 2 - 4 GHZ PULSED HPA
1A2J1	A28357-000	UNIVERSAL SMA ADAPTER KIT
1A3	A25444-001	HPA INTERFACE BOARD (200UM GLASS FIBERS)
1A4	A27509-301	HPA CONTROL CHASSIS ASSY, GPIB/LINK
1A4A2	A25450-000	CPU BOARD W/POWERFAIL (20MHZ)
1A4A3	A22488-013	GPIB/LINK TRANSCEIVER BOARD, 5U AND 6U TWT
1A5	A30137-900	FRONT PANEL ASSY, 5U, FRONT PANEL MOUNT,
1A5A1	A22700-900	HPA DISPLAY BOARD
1A5A1	A25425-001	HPA DISPLAY BOARD
1A5A2	A24830-000	EMERGENCY BYPASS BOARD
1A6	A23692-000	INSULATED FAN DRIVER
1A6T1	A09594-000	FAN DRIVER TRANSFORMER
1A8	A30750-000	PULSE MONITOR BOARD
1A9	A27507-913	HPA WIRING KIT, SINGLE PHASE 13PSC, GPIB
1A9XJ1	A30346-000	EMI MODIFICATION KIT FOR 400KU
1A9XJ1A1	A28181-000	POWER ENTRY FILTER BOARD
1A10	A27501-900	CABINET ASSY ETM 13P SC-BAND W/IEEE-488 (AR)
	A30528-000	HARMONIC FILTER SWITCHING ASSY (optional)

5.2 SCHEMATICS

10-16485-000	HPA Logic and Control (A16485-000)
10-16487-000	Power Board Assembly (A16487-382)
10-23683-100	Power Factor Module (A23683-100)
10-23687-001	LV Power Supply Module (A23687-001)
10-24830-000	Remote Control Board, Foldback only (A24830-000)
10-25444-001	HPA Interface (A25444-001)
10-30528-000	Harmonic Filter Switching Kit (Two filters)
10-30681-000	RF Switch Control Cable (Two switches)
10-30750-000	Pulse Monitor Board (A30750-000)
10-27500-913	1000W Pulsed TWT Amplifier, SC Band, AR (A27500-913)

5.3 PARTS LISTS

A16485-000	HPA Logic and Control
A22826-018	Pulsed TWT Power Supply
A24830-000	Remote Control Board, Foldback
A25444-001	HPA interface
A27500-913	TWTA 2kW Pulsed SC Band
A27502-318	Microwave Power Assembly
A27507-913	Wiring Kit, 13PSC, Single Phase
A30528-000	Harmonic Filter Switching Kit (Two filters)

5.3.1 Parts List, HPA Logic and Control Module, A16485-000

REF DESIG	ETM P/N	DESCRIPTION	QUANTITY
	B16485-000	HPA LOGIC AND CONTROL BOARD	1
C11	C16333-000	CAP,33MF,25V,AERL,(NICHICON UVX1E330M)	1
C2, C5, C15, C58	C31028-000	CAP,1000PF,200VDC,10%,CER,1% FAILURE,(KEMET CKR05 SERIES W/"V" OPTION)	4
C3, C9, C10, C13, C14, C17, C19, C21, C22, C27, C28, C30, C31, C33, C36, C46	C31032-000	CAP,0.01MF,200VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	16
C61	C31033-000	CAP,0.022MF,100VDC,10%,CER,1% FAILURE,(KEMET CKR06B223K W/V OPTION)	1
C24, C60	C31036-000	CAP,0.1MF,100VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	2
C1, C4, C6, C7, C16, C18, C25, C26, C32, C34, C37, C38, C39, C40, C41, C43, C44, C45, C48, C49	C31040-000	CAP,1MF,50VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	20
D16, D23, D31	D10965-000	ZENER,15V,(DIODES INC 1N965B)	3
D1, D3, D4, D5, D7, D8, D9, D10, D11, D12, D13, D17, D18, D19, D21, D22, D25, D26, D28, D30, D35, D37, D36	D14454-000	DIODE,AXIAL,(MOTOROLA 1N4454)	24
	D14733-000	ZENER,5.1V,1W,10%,AXIAL,(MOTOROLA 1N4733)	1
	F00010-000	WASHER,#2,LOCK,SST	3
	F10086-000	PHP,2-56 X 3/16SST	3
J2	J10370-000	CONN,37 PIN,MALE,D-SUB,PCB RIGHT ANGLE, (AMP 747252-4)	1
	J18075-000	MALE SCREW LOCK,FOR D SUBMIN CONN,(AMP 205817-1)	1
J4, J5	J18086-000	CONN,,SMA,JACK RECEPTACLE,RIGHT ANGLE,0-18GHZ,PC MOUNT [JOHNSON COMPONENTS 142-0701-301]	2
J1	N25003-000	HYPERTRONICS CONN,29 PIN MALE RIGHT ANGLE,(CUT ENDS)	1
Q2	Q22907-000	TRANSISTOR,PNP,2N2907A,TO-18	1
R1, R9, R19, R37, R44, R50	R00100-000	RES,10 OHM,1/4W,5%,CC,(A/B RC07GF100J)	6
R4, R20, R27, R29	R01100-000	RES,100 OHM,1/4W,5%,CC,(A/B RC07GF101J)	4
R5, R17, R18, R28, R34, R45, R49, R53, R54, R59, R71, R88	R02100-000	RES,1K,1/4W,5%,CC,(A/B RC07GF102J)	12
R6	R02270-000	RES,2.7K,1/4W,5%,CC,(A/B RC07GF272J)	1
R30, R31, R36	R02470-000	RES,4.7K,1/4W,5%,CC,(A/B RC07GF472J)	3
R86, R87	R02510-000	RES,5.1K,1/4W,5%,CC,(A/B RC07GF512J)	2
R75	R02560-000	RES,5.6K,1/4W,5%,CC,(A/B RC07GF562J)	1
R38, R77, R90	R03100-000	RES,10K,1/4W,5%,CC,(A/B RC07GF103J)	3
R32	R03470-000	RES,47K,1/4W,5%,CC,(A/B RC07GF473J)	1
R35	R05820-000	RES,8.2M,1/4W,5%,CC,(A/B RC07GF825J)	1
R13, R14	R10002-000	TRIMPOT,5K,1/2W,10%,CERMET,20T,SIDE ADJ,(BOURNS 3296X-1-502)	2
R76	R21499-000	RES,4.99K,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R10	R21523-000	RES,5.23K,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R16	R21866-000	RES,8.66K,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R52, R73	R21887-000	RES,8.87K,1/2W,1%,MF,100PPM,(DALE RN55D)	2

REF DESIG	ETM P/N	DESCRIPTION	QUANTITY
R67	R21953-000	RES,9.53K,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R47, R48	R22200-000	RES,20K,1/2W,1%,MF,100PPM,(DALE RN55D)	2
R79, R80	R22470-000	RES,47K,1/2W,1%,MF,100PPM,(DALE RN55D)	2
R42, R60, R61, R89	R23100-000	RES,100K,1/2W,1%,MF,100PPM,(DALE RN55D)	4
R33, R55	R23698-000	RES,698K,1/2W,1%,MF,100PPM,(DALE RN55D)	2
R41	R23750-000	RES,750K,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R21	R23845-000	RES,845K,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R66	R23953-000	RES,953K,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R12, R15	R32020-000	TRIMPOT,10K,1/2W,10%,CERMET,20T,SIDE ADJ,(BECKMAN 67X)	2
U4, U5, U6	U02390-000	IC,QUAD COMPARATOR,(NAT LM139J)	3
U7	U03240-000	IC,LOW POWER OP AMP,(NAT LM324)	1
U9	U10070-000	REFERENCE,PRECISION 10V [LINEAR TECH LT1031DCH]	1
U8	U17805-000	IC,5V REGULATOR,TO-220,(NAT LM340T-5.0)	1
U1, U2, U3	U20148-000	IC,HEX INVERTER,SCHMIDTT TRIGGER,(74HC14) (SSD)	3
RP8	U30106-000	IC,10K,RES NETWORK,6 PIN,SIP (DALE MSP06A-01-103G)	1
RP1-2, RP5-7, RP9	U30410-000	IC,10K,2%,0.40A,10 PIN,ISOLATED RESISTORS (DALE MSP10C-03-103G OR BOURNS 4610H-102-103)	6
RP4	U31020-000	IC,1K RES NETWORK,SIP,(BECKMAN L061C102G)	1
W3-W8	W12200-000	WIRE, 22 AWG, BLU, 600V, TEFLON, (BELDEN 83006)	6

5.3.2 Parts List, Pulsed TWT Power Supply (PFC), A22826-018

REF DESIG.	ETM P/N	DESCRIPTION	QUANTITY
A9	A10010-000	HEATER POWER SUPPLY MODULE	1
A3	A16485-000	HPA LOGIC AND CONTROL MODULE	1
A5	A16487-382	POWER BOARD ASSEMBLY,PULSED TWTA	1
A6	A21425-020	HV DIODE/CAP MODULE FOR TWT 3041B	1
A7	A21458-004	HV FILTER	1
A12	A21458-005	CAPACITOR BANK	1
A10	A21459-020	PULSED PWM BD (TWT 3041)	1
A1	A23280-000	HEAT SINK/MOTHER BOARD	1
A4	A23683-100	POWER FACTOR MODULE (500W)	1
A8	A23684-101	PIJ/PSC GRID MODULATOR MODULE, REGULATED REFERENCE	1
A2	A23687-001	LOW VOLTAGE POWER SUPPLY MODULE	1
A11	A25398-020	FACTORY SELECT FOR 13PSC(REV F LOGIC BD)	1

5.3.3 Parts List, Emergency Bypass Board, A24830-000

REF. DESIG	ETM P/N	DESCRIPTION	QUANTITY
	B24830-000	EMERGENCY BYPASS BOARD	1
C6	C30010-000	CAP,10MF,35V,TANT,RADIAL,(NEMCO TB10-35K1)	1
C7	C31040-000	CAP,1MF,50VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	1
I2, I3	I10066-000	LED,RED,HIGH EFFICIENCY,HIGH BRIGHTNESS	2
I1	I10096-000	LED,GREEN,DIFFUSED,T1-3/4 (XC55G)	1
J1	J18180-000	CONN,D-SUB,15 PIN,MALE,STRAIGHT,PCB MOUNT (POSITRONIC MD15M3000)	1
	J31014-000	SPRING LATCH KIT,D-SUB,(AMPHENOL 17-529)	2
Q1-Q3	Q22222-000	TRANSISTOR,NPN,2N2222A,TO-18	3
R3, R5, R7	R02220-000	RES,2.2K,1/4W,5%,CC,(A/B RC07GF222J)	3
R4, R6, R8	R03100-000	RES,10K,1/4W,5%,CC,(A/B RC07GF103J)	3
R1	R12107-000	TRIMPOT,1K,1/2W,10%,CERMET,1T,SIDE ADJ,(BECKMAN 72XL)	1
S2, S3	S22004-000	SWITCH,TOGGLE,DPDT,PC MNT,(AUGAT MTA-206N-PC)	2
S1	S22010-000	SWITCH,TOGGLE,4PDT,ON-NONE-ON,125V @ 6A,(AUGAT MTA-406N-PC)	1
U1	U17805-000	IC,5V REGULATOR,TO-220,(NAT LM340T-5.0)	1

5.3.4 Parts List, HPA Interface Board 200UM Glass, A25444-001

REF DESIG.	ETM P/N	DESCRIPTION	QUANTITY
	B25444-000	HPA INTERFACE BOARD	1
C161	C03105-000	CAP,0.01MF,100V,CER,10%,RADIAL,(AVX SR201C103KAA)	1
C171	C04223-000	CAP,0.22MF,35V,TANT,RADIAL, [JAMCO 33507]	1
C20, C32, C100	C05153-000	CAP,1.5MF,35V,TANT,RADIAL,(AVAX, TAP155K035SCS)	4
C129, C163	C05223-000	CAP,2.2MF,35V,10%,SOLID SEALED TANT,RADIAL,(SPRAGUE 199D225X9035BA1)	2
C80, C81, C164	C06103-000	CAP,10MF,25V,20%,SOLID TANT,RADIAL,(KEMET, T356E106K025AS)	3
C15	C06220-000	CAP,22MF,16V,SOLID TANT,RADIAL,(AVX TAP226K016SCS)	1
C99	C16103-000	CAP,10MF,35V,AERL,(NICHICON UVR1V100MDA)	1
C101	C17472-000	CAP,470MF,16V,AERL,(NICHICON UVX1C471M)	1
C47, C67	C17474-000	CAP,470UF,50V,AERL,[PANASONIC P5279]	2
C44, C168, C169	C30066-000	CAP 47 MF, 35V, SOLID TANT. RADIAL, (KEMET T356M476K035AS)	3
C6, C7, C9, C13, C16, C39, C43, C69, C165, C166	C31016-000	CAP,100PF,200VDC,10%,CER,1% FAILURE,(KEMET CKR05 SERIES W/"V" OPTION)	10
1, 2, 3, 4, 5, 10, 11, 22, 23, 24, 25, 26, 28, 30, 33, 35, 40, 41, 42, 48, 49, 50, 51, 53, 62, 63, 64, 65, 70, 71, 73, 77, 79, 83, 85, 87, 88, 89, 91, 94, 96, 97, 98, 102, 103, 105, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 121, 125, 132, 167	C31036-000	CAP,0.1MF,100VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	61
C12, C14, C17, C18, C19, C21, C27, C29, C31, C34, C36, C38, C45, C46, C52, C54, C55, C56, C57, C58, C59, C60, C61, C66, C68, C72, C75, C82, C84, C86, C90, C92, C93, C95, C104, C106, C118, C119, C120, C122, C123, C124, C133	C31040-000	CAP,1MF,50VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	43
D8, D10, D12, D14, D15, D16, D18, D19	D14007-000	DIODE,1000V,1A,AXIAL,(MOTOROLA 1N4007)	8
D1-D7	D14454-000	DIODE,AXIAL,(MOTOROLA 1N4454)	7
D9, D17	D14733-000	ZENER,5.1V,1W,10%,AXIAL,(MOTOROLA 1N4733)	2
I1	I10074-000	LED,GREEN,ALGAAS,NON-DIFFUSED,(HEWLETT PACKARD HLMP-1540)	1
J5	J10021-000	HEADER,2 PIN,MALE,RIGHT ANGLE,SERIES 7478 (MOLEX 22-05-3021)	1
J1	J10371-000	D-SUB,37 PIN MALE,PCB MOUNT,STRAIGHT (POSITRONICS MD37M3S000)	1
XU17	J14161-000	SKT,DIP,16 PIN,MACH SLEEVES,(AUGAT 516-AG11D)	1
XU26	J14202-000	SKT,DIP,20 PIN,MACH SLEEVES,(SAMTEC ICA-320-SGT)	1
XU15	J14281-000	SKT,DIP,28 PIN,MACH SLEEVES,(SAMTEC ICA-628-SGT)	1
TP0	J16210-000	TEST JACK,BLACK,VERTICAL,(EF JOHNSON 105-0853-001)	1
TP1	J16211-000	TEST JACK,BROWN,VERTICAL,(EF JOHNSON 105-0858-001)	1
TP2	J16212-000	TEST JACK,RED,VERTICAL,(EF JOHNSON 105-0852-001)	1

REF DESIG.	ETM P/N	DESCRIPTION	QUANTITY
TP3	J16213-000	TEST JACK,ORANGE,VERTICAL,(EF JOHNSON 105-0856-001)	1
TP4	J16214-000	TEST JACK,YELLOW,VERTICAL,(EF JOHNSON 105-0857-001)	1
TP5	J16215-000	TEST JACK,GREEN,VERTICAL,(EF JOHNSON 105-0854-001)	1
J4	J18167-000	D-SUB,37 PIN,FEMALE,PCB MOUNT,RIGHT ANGLE (AMP 745784-4)	1
J3	J18180-000	CONN,D-SUB,15 PIN,MALE,STRAIGHT,PCB MOUNT (POSITRONIC MD15M3000)	1
J2	J31013-000	CONN,D-SUB,25 PIN,MALE,RIGHT ANGLE,PCB MOUNT,[AMP 747238-4]	1
XJ1-XJ4	J31014-000	SPRING LATCH KIT,D-SUB,(AMPHENOL 17-529)	4
K1-K6	K02009-000	RELAY,DPDT,5VDC,125V @ 0.5A / 30VDC @ 1A CONTACTS,PCB TERMINALS,SEALED (OMRON G6H-2-DC5)	6
L1-L4	L00200-000	WIDE BAND CHOKE,(VK200 10/3B FERROXCUBE)	4
Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8	Q22222-000	TRANSISTOR,NPN,2N2222A,TO-18	8
R41	R00680-000	RES,68 OHM,1/4W,5%,CC,(A/B RC07GF680J)	1
R2	R01220-000	RES,220 OHM,1/4W,5%,CC,(A/B RC07GF221J)	1
R1	R04200-000	RES,200K,1/4W,5%,CC,(A/B RC07GF204J)	1
R4, R7	R05820-000	RES,8.2M,1/4W,5%,CC,(A/B RC07GF825J)	2
R6, R8, R58	R20100-000	RES,100 OHM,1/2W,1%,MF,100PPM,(DALE RN55D)	3
R57	R20200-000	RES,200 OHM,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R59	R22332-000	RES,33.2K,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R3, R5	R30071-000	TRIMPOT,10K,1/2W,10%,CERMET,100PPM,20T,TOP ADJ,(BECKMAN 67W)	2
R9, R12, R15, R22, R35, R40, R44	R30103-000	RES,10K,1/8W,1%,MF,AXIAL,100PPM,(DALE CMF-50 / RN50C1002F)	7
R17, R18, R19, R20, R21, R23, R25, R28, R31, R42, R43, R46	R30140-000	RES,1K,1/8W,1%,MF,50PPM,(DALE RN50C)	12
R13, R14, R24, R26, R27, R29, R32, R37, R38, R39, R47, R100	R31164-000	RES,100K,1/20W,1%,FILM,AXIAL,100PPM,MIL,(DALE RN50C1003F)	12
U7, U8	U00027-000	IC,ULTRA LOW NOISE PRECISION OP AMP,(ANALOG DEVICES OP27GP)	2
U26	U00029-000	CONVERTER,NO OIL,16BIT,A TO D,SERIAL OUT,[BURR-BROWN ADS7809PB,PB],[ANALOG DEVICES AD977CN]	1
U17	U00524-000	IC,INSTRUMENTATION AMP,(ANALOG DEVICES AD524A) (SSD)	1
U15	U00725-000	IC,DUAL 16 BIT DIGITAL TO ANALOG CONVERTER,(BURR-BROWN DAC-725) (SSD)	1
U9, U10, U18	U04090-000	IC,4CH ANALOG MULTIPLEXER,(DATEL MXD-409)	3
DP2, DP4, DP5, DP8, DP9	U08010-000	IC,8 COMMON CATHODE CLAMPIMG DIODES,9 PIN SIP,(ROHM DAN801)	5
DP1, DP3, DP6, DP7, DP10	U08011-000	IC,8 COMMON ANODE CLAMPING DIODES,9PIN SIP,(ROHM DAP801)	5
U27	U11165-000	IC,6.5536MHZ CLOCK OSCILLATOR,1/2 SIZE,(ECLIPTEK EC1100HS-6.5536MHZ) (SSD)	1
U40	U11528-000	IC,VERSALINK TRANSMITTER,HORIZONTAL, (200UM FIBER) (HEWLETT PACKARD HFBR-1528)	1
U54	U12521-000	IC,FIBER OPTIC RECEIVER,HORIZONTAL,(HP HFBR-2521) (SSD)	1
U36	U17545-000	DRIVER,OIL,DS75451N,DUAL AND,[NATIONAL SEMICONDUCTOR DS75451N]	1
U6, U19, U34, U39, U60	U20148-000	IC,HEX INVERTER,SCHMIDTT TRIGGER,(74HC14) (SSD)	5
U42	U20730-000	IC,DUAL J-K FLIP FLOP W/RESET,(7473) (SSD)	1

REF DESIG.	ETM P/N	DESCRIPTION	QUANTITY
U51	U21328-000	IC,QUAD 2 INPUT NAND,SCHMIDTT TRIGGER,(74HC132) (SSD)	1
U52	U21388-000	IC,3 TO 8 DECODER/DEMULTIPLEXER,INVERTING,(74HC138) (SSD)	1
U32	U21536-000	IC,DUAL 4 INPUT DIGTAL MULTIPLEXER,(74F153) (SSD)	1
U35	U22598-000	IC,8 BIT ADDRESSABLE LATCH W/RESET,(74HC259) (SSD)	1
U47	U23909-000	IC,DUAL 4 BIT BINARY/BIQUINARY COUNTER (74HCT390) (SSD)	1
U41, U48	U24018-000	IC,JOHNSON DECADE COUNTER W/10 DECODED OUTPUTS,(74HC4017) (SSD)	2
U45	U24138-000	IC,8 BIT BINARY DOWN COUNTER,(74HC40103) (SSD)	1
U43	U26889-000	IC,8 BIT MAGNITUDE COMPARATOR,(74HCT688) (SSD)	1
U22, U24, U57	U28008-000	IC,QUAD 2 INPUT AND,(74HC08) (SSD)	3
U4, U49, U58	U28032-000	IC,QUAD 2 INPUT OR,(74HC32) (SSD)	3
U44, U46	U28040-000	IC,12 BIT DECADE COUNTER,(74HCT4040) (SSD)	2
U5, U13, U14, U23, U25, U33, U50	U28074-000	IC,DUAL D FLIP FLOP W/RESET,(74HC74) (SSD)	7
U2	U28123-000	IC,DUAL RETRIGGERABLE 1-SHOT,(74HC123) (SSD)	1
U31, U53	U28164-000	IC,8 BIT SERIAL IN PARALLEL OUT SHIFT REGISTER,(74HC164) (SSD)	2
U3, U12, U28, U37, U38	U28165-000	IC,8 BIT PARALLEL IN SERIAL OUT SHIFT REGISTER,(74HC165) (SSD)	5
RP6	U32001-000	IC,1K FEED-THROUGH RES NETWORK,16 PIN DIP,(A/B 316B102)	1
RP1-RP5	U32103-000	IC,10K FEED-THROUGH RES NETWORK,16 PIN DIP,(A/B 316B103)	5
U56	U40008-000	REGULATOR,OIL,5V,100MA,TO-92,[MOTOROLA MC78L05ABP]	1
U55	U40012-000	FLIP-FLOP,OCTAL D-TYPE LATCH WITH RESET,[NATIONAL MM74HC273N]	1

5.3.5 Parts List, HPA Assy 13PSC, 1 KW Pulsed 2-4 GHZ, A27500-913

REF DESIG	ETM P/N	DESCRIPTION	QUANTITY
A1	A22826-018	PULSED TWT P. SUPPLY (PFC) FOR TWT 3041B	1
A6	A23692-000	INSULATED FAN DRIVER	1
A3	A25444-001	HPA INTERFACE BOARD (200UM GLASS FIBERS)	1
A10	A27501-900	CABINET ASSY ETM 13P SC-BAND W/IEEE-488 (AR)	1
A2	A27502-318	MICROWAVE POWER ASSY 2 - 4 GHZ PULSED HPA	1
A9	A27507-913	HPA WIRING KIT, SINGLE PHASE 13PSC, GPIB	1
A4	A27509-301	HPA CONTROL CHASSIS ASSY, GPIB/LINK TRANSCEIVER BOARD, 200UM HCS FIBERS	1
A5	A30137-900	FRONT PANEL ASSY, 5U, FRONT PANEL MOUNT, GPIB (AR)	1
A8	A30750-000	PULSE MONITOR BOARD	1

5.3.6 Parts List, Microwave Power Assy 2 - 4 GHZ, A27502-318

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
J1	A28357-000	UNIVERSAL SMA ADAPTER KIT	1
	E00888-009	CABLE,RF FLEX, 9,SMA,MALE TO MALE,20 GHZ,50 OHM,0.141 CABLE,INSULATED JACKET,[SRC 150-150-150090]	1
	E00888-012	CABLE,RF FLEX,12,SMA,MALE TO MALE,20 GHZ,50 OHM,0.141 CABLE,INSULATED JACKET,[SRC 150-150-150120]	1
	E00888-015	CABLE,RF FLEX,15,SMA,MALE TO MALE,20 GHZ,50 OHM,0.141 CABLE, INSULATED JACKET, [SRC 150-150-150150]	1
	E00888-020	CABLE,RF FLEX,20,SMA,MALE TO MALE,20 GHZ,50 OHM,0.141 CABLE, INSULATED JACKET,[SRC 150-150-150200]	1
	E00888-024	CABLE,RF FLEX,24,SMA,MALE TO MALE,20 GHZ,50 OHM,BLUE FEP TEFLON (DICAR EZ402-2121-24)	1
	E00944-000	ISOLATOR, 2.0 - 8.0 GHZ, SMAF-SMAF, [DITOM D3I2080]	1
V1	E01037-000	TWT, 2.0-8.0 GHZ, 1KW PULSED, 6%, +/-4 DB EQ [TELEDYNE MTG-3041L, 6%, +/-4 DB EQ]	1
A1	E01136-000	SSPA, 2.5 - 8 GHZ, 30DBM, 33 DB GAIN, VGA , CPI CMA2580B(XX)	1
	E20012-000	ATTENUATOR 6DB SMA 2W,SUB-MINIATURE,[INMET, 18A-6]	1
	E20130-000	ADAPTER,SMA MALE TO SMA FEMALE,RIGHT ANGLE (CDI 5490CCSF / PASTERNACK PE9262)	4
A2	E20174-000	COUPLER, DUAL DIRECTIONAL, 2-8 GHZ	1
	E20180-000	COAX CABLE ASSY,.41 DIA X 14.7 LONG,N X SC STRAIGHT CONN,(STORM 90-466-014.7)	1
A3	E20245-000	DIRECTIONAL COUPLER,10DB,2-8 GH8,(MAC TECH C2045-10)	1
D1, D2	E20284-000	ZERO-BIAS SCHOTTKY DETECTOR,10MHZ-18.5GHZ,POSITIVE OUT PUT POLARITY,(RLC, M-3747)	2
J2, J3	J17264-000	ADAPTER,TYPE N FEMALE TO SMA FEMALE,PANEL MOUNT,(ASTROLAB 29047)	2
	N31571-000	BRACKET	1
	N31573-000	SUPPORT ISOLATOR	1

5.3.7 Parts List, HPA Wiring Kit, Single Phase 13PSC, A27507-913

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
XJ1	A30346-000	EMI MODIFICATION KIT FOR 400KU	1
B1	E01120-000	FAN, 11000 RPM, 400HZ, MODEL 1284DH, [AMETEK 010182 MODIFIED PER DRAWING]	1
A11	E20282-000	EMI LINE FILTER,(SAE POWER INC STD-20)	1
	H10066-000	CABLE TIE MOUNT #8 SCREW,(PANDUIT TA1S8-C)	25
	H10067-000	FLAT CABLE MOUNT,2WIDE,(PRO-STAINLESS, 859365)	2
	H11072-000	STRAIN RELIEF FOR LINE CORD,(PANEL COMPONENTS 85910051)	1
	H14012-000	FUSE HOLDER,(BUSSMAN HTB-44I)	1
P30	J00010-000	CONN,1 PIN,FEMALE,(MOLEX 03-09-1011)	1
P14, P15	J00020-000	CONN,PIN & SOCKET,2 PIN,FEM,(MOLEX 03-09-1027)	2
P10	J00021-000	CONN,FEMALE 2 PIN .063,(MOLEX 03-06-1023)	1
P27	J00023-000	CONN,HOUSING,FEMALE,02 PIN,(MOLEX 5197-N 10-01-3026)	1
P12, P16	J00025-000	HOUSING,2 PIN,FEMALE,0.1 SPACING,7880 SERIES,(MOLEX 10-11-2023)	2
P25	J00033-000	CONN,FEMALE 3 PIN,.063,(MOLEX 03-06-1032)	1
P28	J00034-000	CONN,HOUSING,FEMALE,03 PIN,(MOLEX 5197-N 10-01-3036)	1
	J00040-000	CONN,PIN & SOCKET,4 PIN,FEM,STR,(MOLEX 03-09-1041)	1
P29	J01010-000	CONN,1 PIN,MALE,250V (MOLEX 03-09-2011)	1
XP15, 28880	J01020-000	CONN,PIN & SOCKET,2 PIN,MALE,(MOLEX 03-09-2021)	1
P11	J01021-000	CONN,MALE 2 PIN .063,(MOLEX 03-06-2023)	1
	J01040-000	CONN,PIN & SOCKET,4 PIN,MALE,STR,(MOLEX 03-09-2041)	1
XP11	J03013-000	CONN,PIN MALE,.063,(MOLEX 002-06-2103)	3
XP10	J04013-000	CONN,PIN FEMALE .063,(MOLEX 002-06-1103)	3
XP12, XP16, XP17, XP18	J04014-000	TERMINAL PIN HIGH PRESSURE MOLEX 7879 SERIES [MOLEX 08-50-0005] (FOR SERIES 7880 HOUSING 10-11-XXXX)	18
XP27, XP28	J04015-000	PIN,TERMINAL FOR HOUSING CONNECTOR 5.08MM,(MOLEX 5194 SERIES 08-70-1030)	5
P31	J10264-000	CONN,FEM SOCKET,26 PIN,IDC MASS TERMINATION,(THOMAS & BETTS 609-2601M)	1
J3	J11240-000	CONN,RIBBON,24 PIN,FEMALE,1A CONTACTS,BLUE,[3M 3549-1000-SR-3448-61]	1
P5, P6	J11370-000	CONN,D-SUB,37 PIN,FEMALE,RIBBON (THOMAS & BETTS 609-375-M)	2
P1	J12031-000	CONN,D-SUB,FEMALE,3 PIN,#8 AWG,PLUG,HI POWER [ITT CANNON DAM-3W3S]	1
P9, P13	J12091-000	CONN,D-SUB,9 PIN,FEMALE,CRIMP (ITT CANNON DEU-9S)	2
P2	J12250-000	CONN,D-SUB,25 PIN,FEMALE,CRIMP	2

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
J4	J17102-000	BNC,BULKHEAD RECEPTACLE,GROUNDED,(AMPHENOL 31-221)	1
A1J1, A1J2	J17250-000	BULKHEAD MT N-JACK TO SMA JACK ADAPTOR,[MIDISC0 XBNF-SF]	2
	J18012-000	CONN,FIBER OPTIC,GRAY,W/CRIMP RING,(HP HFBR-4501)	2
	J18013-000	CONN,FIBER OPTIC,BLUE,W/CRIMP RING,(HP HFBR-4511)	2
XP1	J18054-000	CONTACT,FEMALE,HI PWR,20 AMP,UP TO 12AWG WIRE,[ITT CANNON DM53744-6]	3
	J18073-000	MALE SCREW LOCK,D SUB CONN,(AMP 205980-1)	1
	J18075-000	MALE SCREW LOCK,FOR D SUBMIN CONN,(AMP 205817-1)	2
P20-P24	J18124-000	CONN,SMA MALE SOLDER ATTACHMENT FOR RG188,(PASTERNACK PE4036)	5
J1	J18162-000	POWER INLET,MALE,16A,250VAC, IEC-320 (PANEL COMPONENTS CORP 83011340)	1
P3, J2	J18176-000	CONN,D-SUB,15 PIN,FEMALE,CRIMP,(ITT CANNON DAU-15S)	2
XJ2	J18184-000	D-SUB,15 PIN MALE,CRIMP (ITT CANNON DAU-15P)	1
P4	J31011-000	D-SUB,37 PIN,MALE,CRIMP,5A,20 AWG (ITT CANNON DCU-37P)	1
P7, P8	J31012-000	CONN,D-SUB,15 PIN,FEMALE,RIBBON CABLE,W/STRAIN RELIEF,PLASTIC,[AMPHENOL 841-17-DAFR-B15S]	2
	J31014-000	SPRING LATCH KIT,D-SUB,(AMPHENOL 17-529)	8
L1	L50503-000	EMI SUPPRESSION CORE,0.25HOLE,WITH CASE,(FAIR-RITE 0443164251)	1
	N24373-000	CONNECTOR COVER	1
XA11	N27418-000	COVER TERMINAL EMI FILTER	2
	N27728-000	HPA INTERFACE SHIELD	1
	R01166-000	RES,160 OHM,2W,5%,FILM	2
S2, S3	S25002-000	SWITCH,PUSHBUTTON,SPDT,SAFETY DOOR INTERLOCK,DEFEATABLE,(MICRO SWITCH 3AC6)	2
	S26016-000	C/B,2 POLE,30A,250V,50HZ,(AIRPAX IEGH-66-1-61-30.0-21)	1
U1, U2	U00052-000	PRECISION CELSIUS TEMP SENSOR, TO-220 [NATIONAL LM35DT]	2
	W01880-000	WIRE,26 AWG,COAXIAL,RG-188A/U,900V (BELDEN 83269)	4
	W11400-000	WIRE,14 AWG,600V,BLUE,(ALPHA 5859)	4
	W11600-000	WIRE,16 AWG,BLUE,TFE,(BELDEN 83010-6)	2
	W11800-000	WIRE,18 AWG,BLUE,(BELDEN 83009)	3
	W12000-000	WIRE,20 AWG,BLUE,(BELDEN 83007)	4
	W12200-000	WIRE, 22 AWG, BLU, 600V, TEFLON, (BELDEN 83006)	5
W3	W12209-000	CABLE,25 COND,AWG 22,STRANDED,W/FOIL SHIELD,(ALPHA WIRE 1299/25C)	1
	W21201-000	POWER CORD,12 AWG,5 COND,NEOPRENE COVERED,(ROYAL ELECTRIC 4A-1205)	10
	W22210-000	WIRE,22AWG,3 COND SHIELD,(BELDEN 8771)	3

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
W1, W2	W30020-000	CABLE,FIBER OPTIC,1000UM POF, [NISSHO|WAI AMERICAN CORP GH-4001]	2
F1	Z20020-000	FUSE,2A,250V,3AG,SB,(LITTELFUSE 313.002)	1
Z1	Z31022-000	SURGE ARRESTOR,(CPCLARE AC240L)	1
Z2	Z31024-000	TRANZORB, 440V, 1.5KE440CA (GI 1.5KE440CA)	1

5.3.8 Parts List, 200W SC External Filters, A30528-000

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
A2	A30681-000	CABLE, COAXIAL BANDSWITCH CONTROL	1
F1	E00999-000	SC BAND ABS. COAX HARM. FILTER, BP= 2.8-4.8GHZ, BS=5.6-9.6 GHZ,250 WATTS CW MIN,[MDC 102000-152]	1
F2	E01022-000	SC BAND ABS. COAX HARM. FILTER, BP= 4.8-8.0GHZ, BS=9.6-16.0 GHZ,250 WATTS CW MIN,[MDC 102000-153]	1
S1, S2	E01035-000	SWITCH, COAX, HIGH POWER 300W, DC - 7.5 GHZ15VDC,WITH ONE SET IND,[LOGUS LMC224ANL9X181],	2
W1, W2, W3, W4	E01036-000	0.410 DIA X 12.0 COAXIAL CABLE,N-SP/N-SP,(STORM PRODUCTS 90-078-012)	4
L1, L2	E20069-000	TERMINATION,COAXIAL,5W,N,DC-12.4 GHZ,(MICROLAB/FXR TA-5MN)	2

5.4 RECOMMENDED SPARE PARTS

A10010-000	Heater Module
A16487-382	Power Board Assembly
A21425-020	Diode / Cap Assembly
A21458-004	HV Filter
A21458-005	Capacitor Bank
A21459-020	PWM Board
A23683-100	Power Factor Module
A23684-101	Grid Modulator, Regulated Reference
A23687-001	Low Voltage Power Supply Module
A23692-000	Insulated Fan Driver
E01035-000	External RF Switch (if optional harmonic filter switching assy is purchased)
N26677-000	Fan, Modification (Y10038)

5.5 SAMPLE PROGRAM FOR IEEE-488 COMMUNICATION

```
1000  ! ********************************************
1010  ! *     IEEE-488 COMMUNICATIONS SOFTWARE       *
1030  ! *     7/24/92  AARON D. McCLURE              *
1040  ! ********************************************
1041 DIM F$[80]
1042  DIM A$[80]
1050  CLEAR SCREEN
1060  INPUT "INPUT COMMAND TO SEND TO POWER SUPPLY.  EXIT TO QUIT.",A$
1070  IF A$="EXIT" THEN 1130
1080 OUTPUT 701;A$
1090  IF A$[1,2]<>"RD" THEN GOTO 1060
1095 IF A$[1,1]="*" THEN GOTO 1100
1100  ENTER 701;F$
1110  PRINT "OUTPUT FROM COMMAND ",A$," IS ",F$
1120  GOTO 1060
1130  CLEAR SCREEN
1140  END
```

Application Note #35
Pulse Traveling Wave Tube Amplifiers

AR RF/Microwave Instrumentation's pulse traveling wave tube amplifiers (TWTAs) offer a cost-effective source of high RF power for applications in which only a low to moderate RF duty cycle is required, i.e., where the RF power is on for only a small percentage of the time. A typical application is electromagnetic compatibility (EMC) RF pulse susceptibility testing. This Application Note discusses the unique specifications and characteristics applicable to pulse TWTAs.

Pulse-rated TWTAs use a traveling wave tube (TWT) incorporating a control grid that can be used to turn on and off the TWT's beam current. The TWT acts as an RF amplifier only when the beam is turned on. Turning the beam off when no RF output is needed results in a significant reduction in power consumption, and hence reduces the amount of heat to be dissipated.

When compared to a continuous wave (CW)-rated amplifier with similar power specifications, a low to moderate duty cycle PULSE TWTA typically: uses less AC input power, produces less heat, is smaller and lighter, costs less, has lower noise power output during the pulse off time, and allows use of peripheral components (connectors, cables or waveguide, directional couplers, loads, and so forth) with lower CW power ratings. AR's pulse TWTAs are designed specifically for pulsed applications. They cannot be used to produce CW output. AR's TP series of pulse TWTAs do incorporate many of the excellent features of AR's T series of CW TWTAs such as: foldback protection, bright 4 line by 20 character alphanumeric display and extensive remote status and control via a GPIB (IEEE-488) interface. For CW applications, contact AR RF/Microwave Instrumentation for information on its extensive line of CW-rated amplifiers.

Unique Specification for Pulse TWTAs

Some unique specification characteristics (those not commonly specified for CW rated amplifiers) of AR RF/Microwave Instrumentation's pulse TWTAs are listed below, along with a set of typical parameter values. An explanation of their significance follows.

PULSE CAPABILITY

Pulse Width	0.07-30 microseconds
Pulse Rate (PRF)	100 kHz maximum
Duty Cycle	4% maximum
RF Rise and Fall	30ns maximum (10% to 90%)
Delay	300ns maximum from pulse input to RF 90%
Pulse Width Distortion	±30ns max (50% point of output pulse width
	compared to 50% points of input pulse width)
Pulse Off Isolation	80 dB minimum, 90 dB typical
NOISE POWER DENSITY	(Pulse on) xxxx
	(Pulse off) Minus 140dBm/Hz (typical)

CONNECTORS

Pulse Input	Type BNC female on rear panel

Delay, RF Rise and Fall time and the Pulse Input

The beam is turned on and off in response to a TTL-level input (typically from an external Pulse Generator) applied to the Pulse Input Connector. A positive level (logical 1) turns on the beam. If RF had been applied to the TWTA input prior to the positive (logical 1) TTL input, the RF output would reach 90% of its final value within 300ns (Delay) with an observed RF Rise time of up to 30ns (10% to 90%). (See Figure 1.)

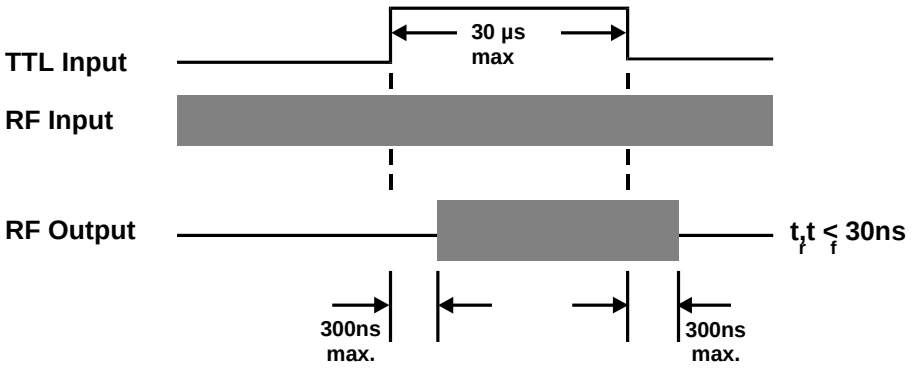


Figure1: CW RF Input

After this initial delay in enabling the RF output, the RF output level will respond to the level of the RF input. As with a CW amplifier, the subsequent RF rise and fall times are inversely related to the RF bandwidth of the specific TWTA, with typical rise and fall times in the low- or sub-nanosecond range.

If the RF input remains and the TTL level goes low (logical 0), then the RF output would reach 10% of its prior "on" value within 300ns (Delay). The observed RF Fall time would be less than 30ns (10 to 90%). (See Figure 1.) Using the TTL input to modulate the RF output may result in some small distortion of the output pulse width (usually shrinkage), as compared to the TTL-level input pulse width, and therefore is not recommended for producing pulses lasting less than 0.2 microseconds, or for applications where the pulse width must be accurately preserved. Alternately, the RF input can be turned off prior to the end of the TTL pulse to obtain a fast and well-defined RF fall time.

To obtain well-defined RF timing while minimizing power consumption, the RF and TTL-level inputs should be timed as shown in Figure 2:

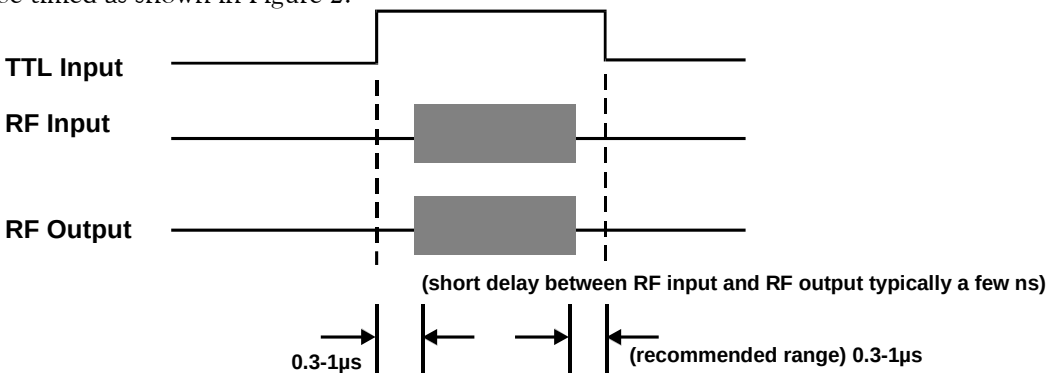


Figure 2: Pulse RF Input

Pulse Width
The Pulse Width specification (0.07-30 microseconds) defines the range of acceptable pulse widths that must be presented at the TTL input to operate the TWTA. The maximum value (30 microseconds) describes the greatest RF pulse width available from the TWTA. RF output pulse widths less than 0.2 microseconds can best be produced by providing a correspondingly short RF pulse at the RF input, with timing as shown in Figure 2.
The Pulse Width Distortion specification further defines the maximum pulse width distortion at the 50% points of the output pulse width compared to 50% points of the input pulse width when using the pulse input. Lower distortion can be obtained with timing as shown in Figure 2.

Pulse Rate
The Pulse Rate (PRF) specification (100 kHz max.) defines the rate of the maximum continuous pulse stream that may be fed to the TTL-level input. In other words, each succeeding TTL-level input pulse (of a continuous stream of pulses) must begin no sooner than 100 microseconds (1/10,000 sec.) following the beginning of the previous pulse. There is no minimum rate specification. Users should contact AR RF/Microwave Instrumentation regarding any specific requirements they may have for non-continuous pulse-stream applications with higher burst rates.

Duty Cycle
The Duty Cycle specification (4% max.) is an additional limitation on the TTL-level input that must be observed by the user. This specification defines the maximum percentage of the time that the TTL-level input can be allowed to remain positive (logical 1). For example, if the chosen PRF is 5 kHz, then the maximum allowable TTL input pulse width is reduced to 8 microseconds (1/5,000 x .04 sec.).

Pulse Off Isolation
Pulse off isolation specifies the reduction of signal level, input to output, when the Pulse Input is not high (i.e. in the pulse-off condition), causing the beam to be off.

Noise Power Density
Noise Power Density describes the noise level at the TWTA's output. TWTs typically produce considerable broadband RF noise when they are operating (TTL high). When the TTL-level input is not high, (i.e. in the pulse-off condition) the TWT noise is significantly reduced. A typical Noise Power Density level is thus indicated.

Forward and Reflected Peak Power
AR RF/Microwave Instrumentation Pulse TWTAs feature a display for peak RF power output to supplement the usual display for average RF power output. This display is developed from a measurement of the peak RF and is especially convenient for setting the peak power level when using a varying duty cycle. This feature operates when the pulse width is greater than 1 microseconds and the RF input is present before the start of the TTL pulse.

Peak power measurements using laboratory power meters are typically accomplished by measuring the average power and then calculating the peak power using the known duty cycle:

$$\text{Peak Power} = \text{Average Power} \div \text{Duty Cycle}.$$

For accurate indirect measurements of peak power, it may be desirable to measure the actual RF output pulse width to determine the duty cycle.

Summary

This Application Note has discussed some features of AR RF/Microwave Instrumentation's Pulse high power TWTAs and their unique specifications, those not commonly specified for CW rated amplifiers. A number of conditions have been defined which must be observed to obtain proper operation of these Pulse TWTAs (though TWTA design prevents damage when these conditions are exceeded). Be sure to refer to the appropriate AR Data Sheet for detailed amplifier specifications.

Users should contact AR RF/Microwave Instrumentation at 215-723-8181 to discuss any specific application requirements for high burst rates, low off-level noise and special off-level timing (such as in NMR spectroscopy applications), Peak Power measurement of narrow pulses or other characteristics.

WARRANTIES: LIMITATION OF LIABILITY

Seller warrants (i) that seller has title to the goods sold and (ii) that Amplifiers (all parts excluding traveling wave and vacuum tubes), Antennas, Transient Generators, Power Meters, Directional Couplers, Field Monitoring Equipment, Conducted Immunity Generators, Signal Generators and Tripods will be free from defects in material and workmanship for a period of three (3) years from date of shipment shown on AR RF/Microwave Instrumentation invoice. Traveling Wave Tubes in the 200T2G8A, 250T1G3 and 250T8G18 will be free from defects in material and workmanship for a period of two (2) years from date of shipment. Vacuum tubes in the 'L' series amplifiers, other traveling-wave tubes in models not previously listed and power heads will be free from defects in material and workmanship for a period of one (1) year. Contact AR RF/Microwave Instrumentation for warranty information regarding items not listed. Seller's sole responsibility in fulfilling these warranties shall be to repair or replace any goods which do not conform to the foregoing warranties or, at seller's option, to give buyer credit for defective goods. The warranty is valid only when used in the country specified at time of order. Warranty service must be obtained from the repair facility designated at that time. If warranty service is not available in the country where the equipment is to be used, it must be returned to AR RF/Microwave Instrumentation. Warranty service will be provided only for defective goods which are returned within the warranty period, freight costs prepaid to AR RF/Microwave Instrumentation or its designated repair facility.

There are no other warranties, express or implied, including any warranty of merchantability or fitness. Seller shall not be responsible for any incidental or consequential damages arising from any breach of warranty.

No person other than an officer of Amplifier Research Corporation, has any authority to bind seller to any affirmation, representation or warranty except as specifically included in the preceding terms and conditions.

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