Operating and Service Manual

2000TP8G18M1

Model

1013824-502

Part Number

Serial Number

ar worldwide • rf/microwave instrumentation

160 School House Road Souderton, PA 18964-9990 • 215-723-8181 • Fax 215-723-5688 • www.ar-worldwide.com

EC Declaration of Conformity

We; Amplifier Research
160 School House Road
Souderton, PA 18964

declare that our product;

the Model 2000TP8G18 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.

TABLE OF CONTENTS

FIGURES

TABLES

1. DESCRIPTION AND SPECIFICATIONS

This manual provides operating, interfacing and selected service information pertinent to Amplifier Research Model 2000TP8G18 Broadband Microwave Amplifier. The Model 2000TP8G18 is a 2,000 watt pulse only IJ band traveling-wave tube amplifier (TWTA).

1.1 TWTA DESCRIPTION

The amplifier uses a broadband traveling-wave "supertube" assembly that consists of two traveling wave tubes (TWTs) that are power combined 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 in a single unit housed in a standard 19 inch rack cabinet 14 inches high and approximately 26 inches deep. It is packaged in two sub-enclosures: a power supply/control module that is 8.75" high, and an RF power unit (the "supertube") that is 5.25" high. The sub-enclosure packages are connected together with side plates to form the amplifier. They are interconnected by a low voltage cable. The two sub-enclosures are completely open to one another on the inside of the unit to allow for HV interconnects.

Primary power is 190-260VAC, 50/60 Hz, single phase. An efficient switching power supply design provides minimum power consumption. In addition, the TWTs in the supertube module are provided with dual collectors to minimize prime 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 Amplifier Research Data Sheet on the following pages for detailed specifications.

1.4 ACCESSORIES

Amplifier Research offers a number of accessories for use with this amplifier including:

- Directional coupler
- Antenna
- Flexible transmission line

Refer to a current Amplifier Research catalogue 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.

AMPLIFIER RESEARCH
160 School House Road, Souderton, PA 18964-9990 USA
Phone 215-723-8181•FAX 215-723-5688

MODEL 2000TP8G18,
M1
2000 WATTS PULSE
7.5 – 18 GHz

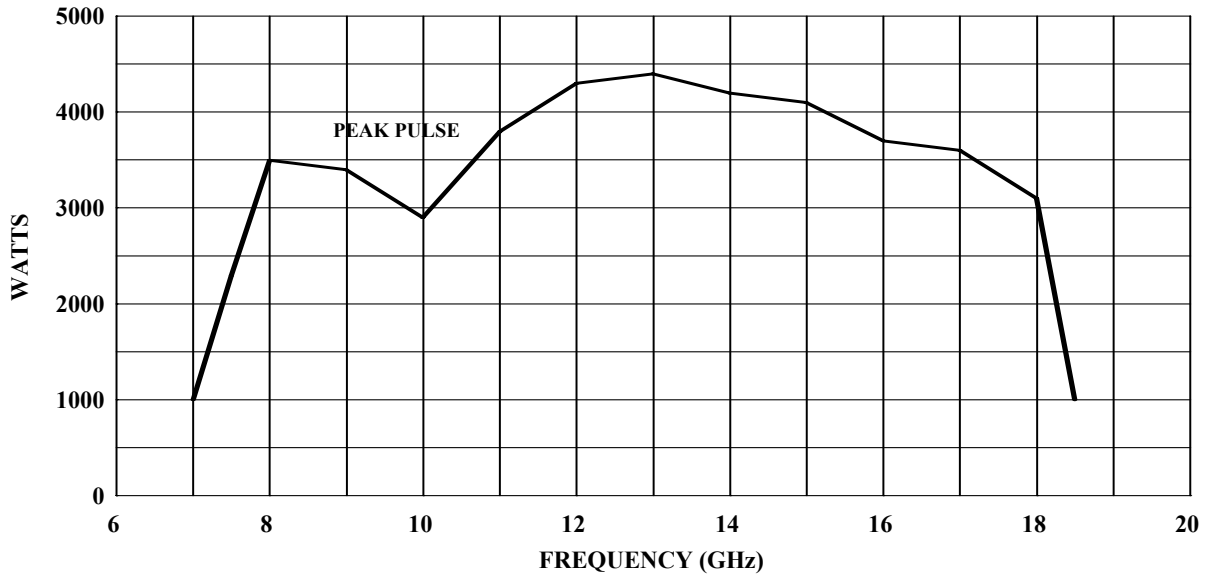
The Model 2000TP8G18 is a self contained, forced air cooled, broadband traveling wave tube (TWT) microwave amplifier designed for pulse applications at low to moderate duty factors where instantaneous bandwidth, reduced harmonics and high gain are required. A reliable TWT subsystem provides a conservative 2000 watts minimum peak RF pulse power at the amplifier output connector. Stated power specifications are at the 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, 0 dBm 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 2000TP8G18 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 external harmonic filters.

2000TP8G18 TYPICAL POWER OUTPUT



REV121304

SPECIFICATIONS
Model 2000TP8G18

POWER (fundamental), PEAK PULSE, @ OUTPUT CONNECTOR

Nominal	*2500 watts*
Minimum	*2000 watts*

FLATNESS	***±8 dB maximum, equalized for ±3 dB maximum at rated power***
FREQUENCY RESPONSE	***7.5 – 18 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))	*100kHz 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 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)	***Minus 55 dBm/Hz (maximum) , minus 58 dBm/Hz(typical)***
(pulse off)	***Minus 140 dBm/Hz (typical)***
HARMONIC DISTORTION	***Minus 18 dBc maximum, Minus 20 dBc typical***
PRIMARY POWER	***190-260 VAC, single phase 50/60 Hz 3 KVA maximum***

CONNECTORS

RF input	*Type N female on rear panel*
RF output	*Type WRD 750D24 waveguide flange 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.***
WEIGHT	***See Model Configuration.***
SIZE (W x H x D).	***See Model Configuration. See Note 1.***

2000TP8G18 Model Configurations

Model Number	*Description*	*Weight*	*Size (W x H x D) (Note 1)*
2000TP8G18		*72 kg (170 lb)*	*50.3. x 39.37 x 77.5 cm 19.8 x 15.5 x 30.5 in.*
2000TP8G18M1	*Supplied with one TF type filter and switch kit to offer harmonics minus 25dBc maximum at the output of the kit. (See Note 2)*	*91 kg (200 lb)*	*50.3. x 39.37 x 77.5 cm 19.8 x 15.5 x 30.5 in.*

NOTE 1: *Dimensions shown are for TWTA only, without kits and filters.*

NOTE 2: *TF type filters are externally mountable harmonic filters. Refer to filter TF type specification below. Also supplied with a switch kit that allows user to select an appropriate band, high (which bypasses filter) or low (which applies filter), via this TWTA. Insertion loss when used with filter is maximum 1.5 dB.*

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, typical)**	**Weight (kg, lbs typical)**	**Input VSWR in Pass band (typical)**	**Input VSWR in Reject band (typical)**
TF type filter 1	2000TP8G18 with WRD750D24 waveguide flange, requires one filter	7.5 - 12.4	0.5	15 - 36	25	200 & 10 average, 5000 & 150 peak	WRD750D24 waveguide flange	WRD750D24 waveguide flange	30 x 18 x 15 12 x 3 x 6	4.5, 10	1.3:1	2.5:1

2. THEORY OF OPERATION

2.1 DESIGN OF THE AMPLIFIER

The Model 2000TP8G18 TWT amplifier consists of three main parts, the supertube, 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 (A22933-300), which consists of the CPU board (A18450-006) and the data link board (A22488-001). 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 (A22700-900).

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 (A25444-000).

2.2 DESCRIPTION OF THE RF CIRCUIT (A30986-000)

The TWTA consists of two stages of RF amplification: a solid-state preamp assembly with adjustable gain (E01415-000) and the dual traveling-wave tube "Supertube" assembly (A30983-000).

The "Supertube" consists of a pair of 1,500-watt pulse only TWTs (E01449-000). Each tube is mounted on its own heat sink and cooled with its own 400 Hz fan powered by its own fan driver (A23692-000). The single Type N precision RF input connector is located on the rear panel. The RF input is fed to the input connector on the solid state preamplifier. The solid state preamp's output drives the RF input of the TWT module via the external low voltage cable that connects the power supply chassis to the RF chassis. The solid state preamp includes a voltage controlled variable gain feature that permits control of the preamp's output power from the control module. The preamp's output is then split by a 180° hybrid. The hybrid's sum port is terminated, and the secondary ports are run to the RF inputs of each TWT via line stretchers. The line stretchers have been adjusted to make the electrical length of the two TWTs identical for instantaneous phase combining across the band. This phase matching is done at the factory and is transparent to the user.

Each TWT's type WRD-750D24 output flange is connected by waveguide to the side port of a magic tee (waveguide 180° hybrid) (E20399-000). The sum port is terminated with a 500-watt load. The difference port is connected to a dual directional coupler, whose output flange forms the RF output of the TWTA. Because the two TWTs in the RF chassis share a common power supply, protective circuits, and RF input and output, the two TWTs serve in the system like a single TWT ("supertube"). The major differences between a conventional power supply and a supertube power supply is the dual grid modulators used in a supertube supply (to allow the two tubes to use the same cathode and collector supply, sometimes different grid voltages must be used), and an additional temperature reading.

Since the fundamental frequencies are amplified 180° out of phase, the second harmonic products, which represent significant power in the lower part of the band, are largely in phase, and are dumped in the sum port. The residual harmonics are generally lower than –20 dBc, low enough in power that they can be blocked by a reflective filter without harm to the TWTs.

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 straight piece of waveguide.

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 7.5 – 12.4 GHz.
- HIGH band selection: routes to a low pass filter or straight piece of waveguide for operation from 12.4–18.0 GHz.

The reflected signal from the directional coupler is connected through a -10 dB coupler 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 via a pad. 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 precision 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 (A30984-000)

The TWT power supply provides cathode, heater, grid, and collector power for both tubes in the Supertube assembly. The power supply chassis contains the TWT power supply assembly (A22826-344), an HPA interface board (A25444-000), a pulse monitor board (A30750-000), the HPA control head and a front panel circuit breaker. In addition, the chassis has a 400 Hz cooling fan and a fan inverter (A23692-000). The 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 (A23687-150). Control logic and TWT protection circuits are contained in the HPA logic and Control Assembly (A16485-000).

The Heater Power Supply Module (A23724-000) powers the DC heaters of both TWTs. Bias and pulse top voltage for the TWT grid are provided by the Modulator Assembly (A23684-100 and A23684-101), one modulator per tube.

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 Rectifier (A21425-021). 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

3.1 WARNINGS AND CAUTIONS

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.

CAUTION:

The Model 2000TP8G18 combines two separate sub-enclosures (power supply chassis and RF chassis) attached together with side plates. These two chassis should never be separated except by authorized service personnel. Separating the two packages will expose the user to HV without the protection of safety interlocks.

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. Do not remove the cable connecting the two sub-enclosures. 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 on the power supply/control module which may be used for supplementary support of the rear of the TWTA.

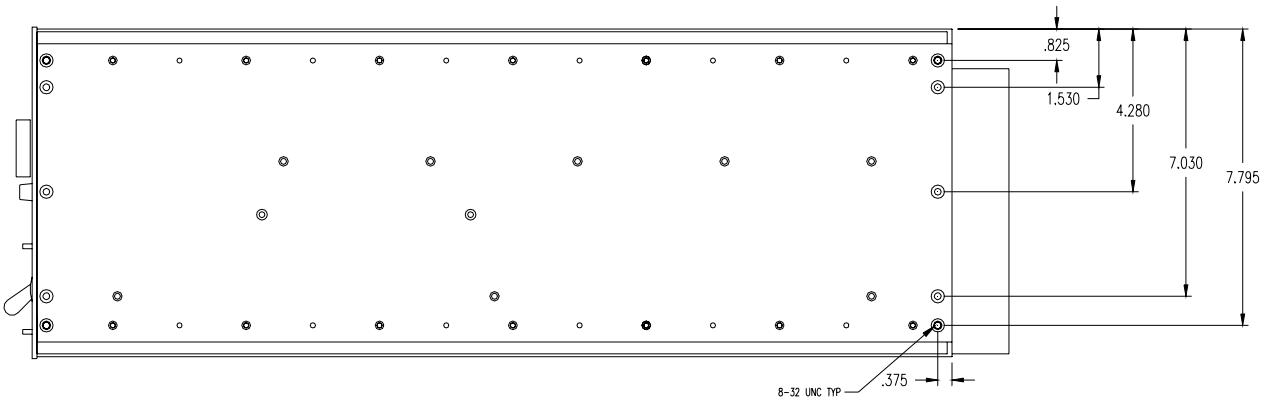


Figure 3-1. Mounting Support Holes

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 power supply/control module is provided with a cooling fan, and the supertube assembly has two high-speed blowers. 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 short ducts 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 3,000 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 a WRD-750D24 waveguide flange.

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, J4. 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 Amplifier Research 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 straight piece of waveguide. 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 7.5 – 12.4 GHz.
- HIGH band selection: routes to a low pass filter or straight piece of waveguide for operation from 12.4 – 18.0 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.

The filter(s) provided in the assembly may alternatively be installed for use without the switch(es). This allows for harmonic reduction, but eliminates the additional power loss that accompanies the use of switch(es). The filter(s) can be removed from the assembly. The input is then connected directly to the output of the TWTA and the output connected to the load. The filter must be manually removed for operation outside of its pass band.

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

Band	Frequency range
Low	7.5 to 12.4 GHz
High	12.4 to 18.0 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, attach the straight waveguide piece E01155-000 to the output flange of the HPA. During assembly verify that all waveguide flanges align with each other in the proper direction.

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. Refer back to 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 schematic 10-30529-000, using Parts List A30529-000 as a reference.

3.2.8.2 Assembly instructions for Harmonic Filter Switching Kit (1 Filter):

The Harmonic Filter Switching Kit can be used connected to the TWTA or the filter can be removed from the kit and used individually. To assemble the kit to the TWTA, attach the straight waveguide piece E01155-000 to the output flange of the HPA. During assembly verify that all waveguide flanges align with each other in the proper direction.

Connect the Bandswitch Control Cable to the Interlock connector on the TWTA, removing any existing plug present. Check that the round connector of the Bandswitch Control Cable is connected to the switch, P2 to S1. See Section 3.2.6 for additional information describing use of the external interlock.

An individual filter can be connected directly to the TWTA RF output. If the filter has been removed from the assembly for individual use, re-assemble the kit according to the schematic 25-30529-001, using Parts List A30529-001 as a reference.

3.3 FRONT PANEL FEATURES

Refer to Figure 3-2 and Table 3-1 below

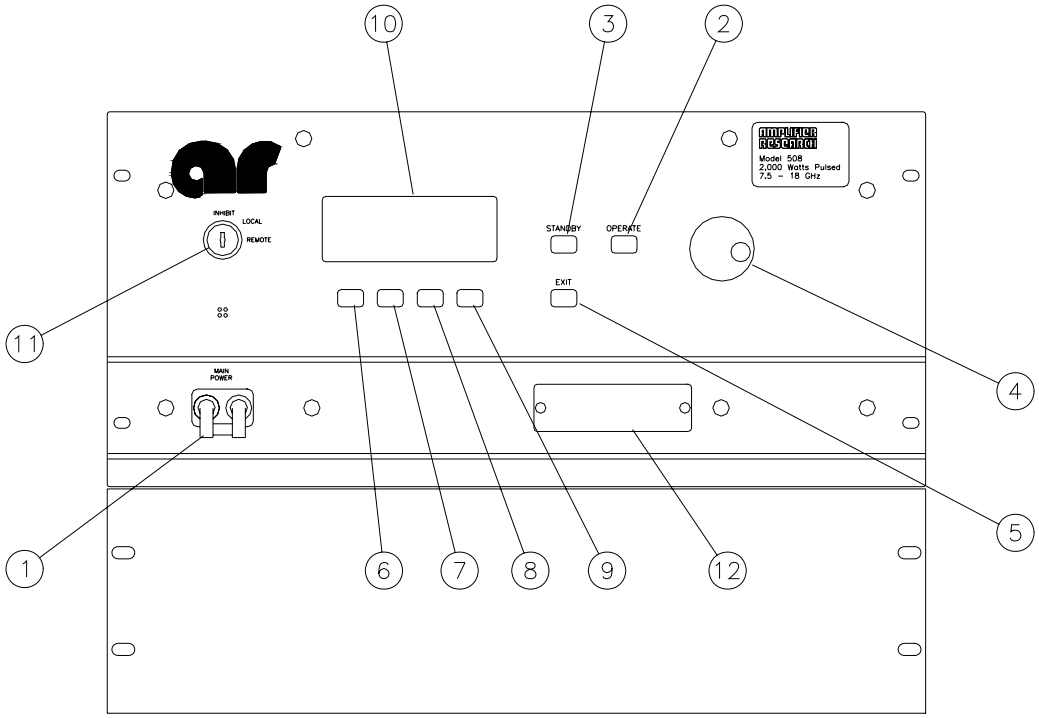


Figure 3-2. Front Panel Features

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.

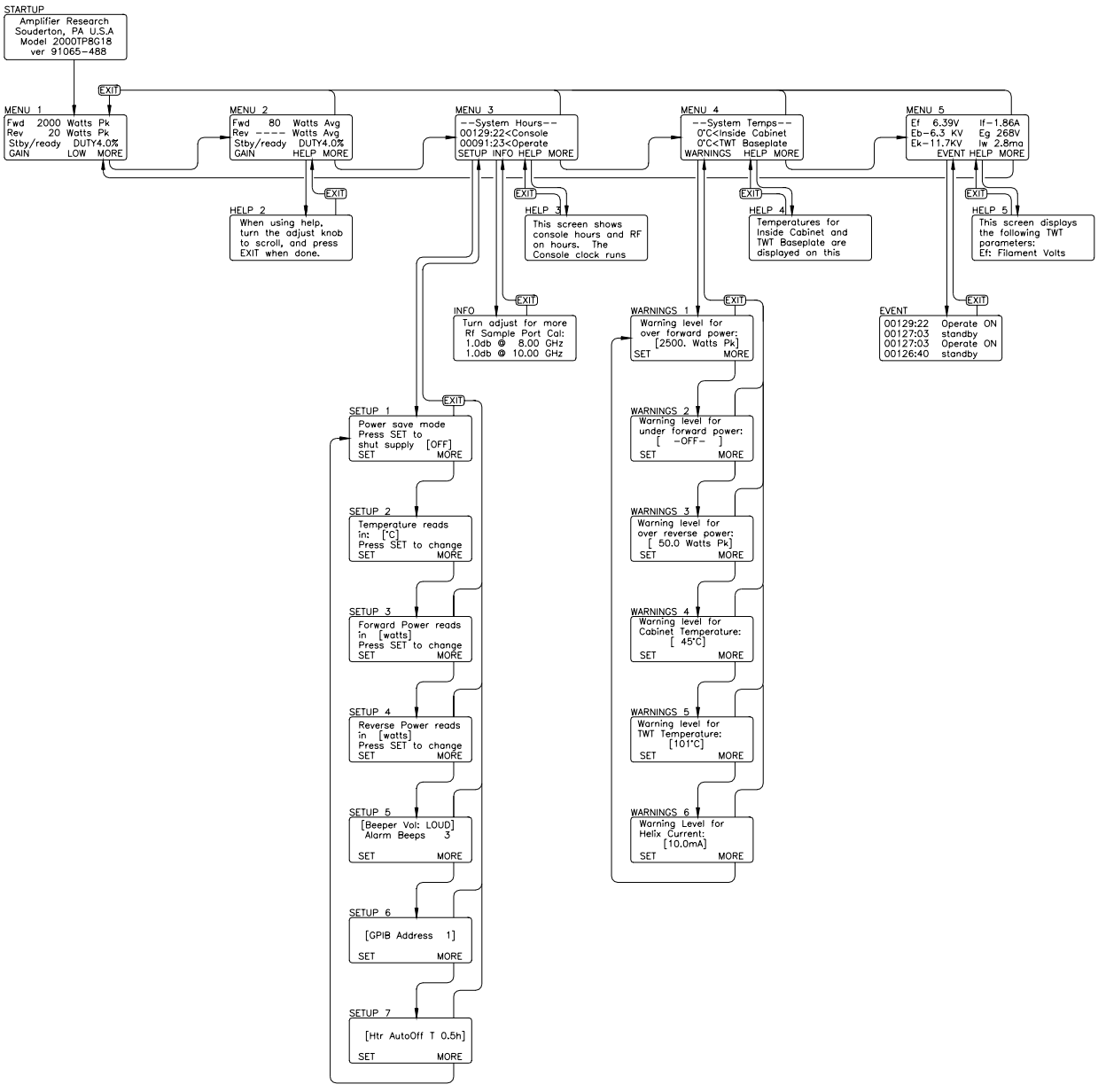


Figure 3-3. Front Panel Display Screens

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 filter(s) and switch(es) - 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 de-Activate 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 and Table 3-2 below.

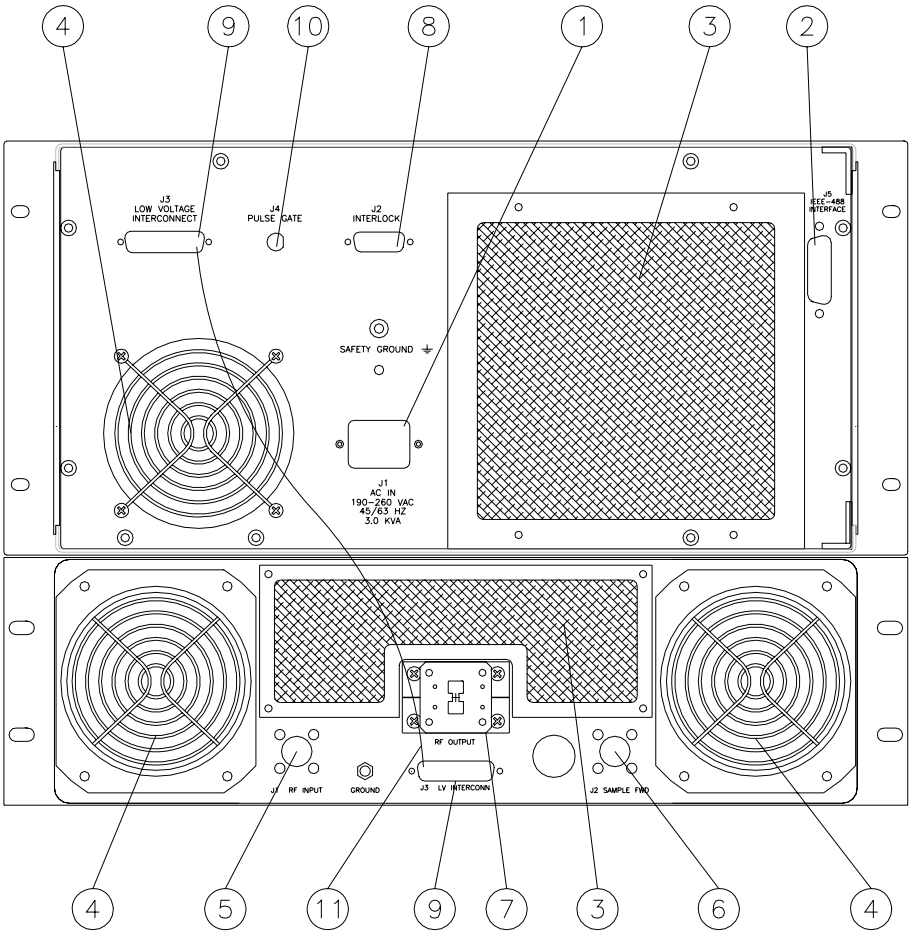


Figure 3-4. Rear Panel Features

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 precision female connector
6	RF SAMPLE OUT	Type N precision female connector
7	RF OUT	Type WRD-750D24 flange
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	LV INTERCONNECT	Connector for LV between RF and power supply modules (Do not remove mating cable)
10	PULSE GATE	External pulse input; BNC connector
11	LV CABLE	Low voltage cable connection between power supply and RF chassis (This cable is part of unit. Do not remove this cable)

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	7.5 to 12.4 GHz
High	12.4 to 18.0 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 connector J1 on the supertube module. 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 flange. The load VSWR should be less than 2.0:1 A power meter and suitable attenuators may be connected to the RF sample port J2 on the supertube module. 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), J4 on the Power Supply module. 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 TWTs' cathodes run very hot since they are 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 TWTs!

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. Press MORE again to view MENU5 and verify the values for TWT #2. 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
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

Command	Function	Units	Response format
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			
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 Amplifier Research 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 Amplifier Research 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 109) 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 (A23724-000), the Grid modulators (A23684-100 and A23684-101), the HV filter (A21458-004), the Diode/Cap assembly (A21425-021), and the Capacitor bank (A21458-008) 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

1	A30985-000	TWTA 2KW PULSED IJ BAND (AR)
1A1	A30984-000	POWER SUPPLY, 2KW PULSED IJ BAND (AR)
1A1A1	A22826-344	PULSED TWT PS (PFC) FOR TWT MTI-3444L
1A1A1A1	A23280-000	HEAT SINK/MOTHER BOARD
1A1A1A2	A23687-150	LV POWER SUPPLY MODULE, AC INPUT
1A1A1A3	A16485-000	HPA LOGIC AND CONTROL MODULE
1A1A1A4	A23683-100	POWER FACTOR MODULE (500W)
1A1A1A4L4	A09006-000	PFC INDUCTOR FOR 100VAC-255VAC
1A1A1A5	A16487-382	POWER BOARD ASSEMBLY,PULSED TWTA
1A1A1A5L1	A09025-000	PULSED BUCK INDUCTOR
1A1A1A5T1 (E42)	A09402-000	XFMR,GATE DRIVE (HAND WOUND)
1A1A1A5T2 (E41)	A09403-000	XFMR,GATE DRIVE (HAND WOUND)
1A1A1A6	A21425-021	DIODED/CAP ASSY FOR TWT 3444L
1A1A1A6T1	A09487-000	HV XFMR FOR TWT MTI-3444L
1A1A1A7	A21458-004	HV FILTER
1A1A1A8	A23684-101	PIJ/PSC GRID MODULATOR, REGULATED
1A1A1A8A1	A23686-101	PIJ/PSC HV MODULATOR WITH REGULATED
1A1A1A8A1T1	A09227-000	PULSE TOP XFMR,HAND WOUND
1A1A1A8A1T2	A09228-000	FEEDBACK XFMR,HAND WOUND
1A1A1A8A1T3	A09229-000	BIAS XFMR,HAND WOUND
1A1A1A8A1T4, T5	A09230-000	XFMR,GATE DRIVE (HAND WOUND)
1A1A1A8A1T6	A18478-000	PULSE TOP SUPPLY TRANSFORMER, PIJ/PSC
1A1A1A8A2	A23715-101	PIJ/PSC MODULATOR CONTROL BOARD
1A1A1A9	A23724-000	HEATER MODULE, 6.3V 4A/8A
1A1A1A9L1	A09594-900	MODIFIED INDUCTOR
1A1A1A9L2	A09595-900	MODIFIED INDUCTOR
1A1A1A9T2	A20957-000	XFMR, HEATER POWER SUPPLY, 6.3V 4A
1A1A1A9T1	A09553-000	XFMR,HEATER FEEDBACK
1A1A1A10	A21459-021	PWM BOARD FOR TWT 3444
1A1A1A11	A25398-021	FACTORY SELECT, 13PIJ
1A1A1A12	A21458-008	CAP BANK AND SPURIOUS REDUCTION FILTER
1A1A1A13	A23684-100	PSC GRID MODULATOR, REG REF,(SLAVE)
1A1A1A13A1	A23686-101	PIJ/PSC HV MODULATOR WITH REGULATED
1A1A1A13A1T1	A09227-000	PULSE TOP XFMR,HAND WOUND
1A1A1A13A1T2	A09228-000	FEEDBACK XFMR,HAND WOUND
1A1A1A13A1T3	A09229-000	BIAS XFMR,HAND WOUND
1A1A1A13A1T4, T5	A09230-000	XFMR,GATE DRIVE (HAND WOUND)
1A1A1A13A1T6	A18478-000	PULSE TOP SUPPLY TRANSFORMER, PIJ/PSC
1A1A1A13A2	A23715-102	MODULATOR CONTROL BD FOR PARALLEL
1A1A2	A25444-000	HPA INTERFACE BOARD (PLASTIC FIBERS)
1A1A3	A30750-000	PULSE MONITOR BOARD
1A1A4	A22933-300	CONTROL HEAD ENCLOSURE, IEEE-488
1A1A4A2	A18450-006	MAIN CPU BOARD

1A1A4A3	A22488-001	GPIB/LINK TRANSCEIVER BOARD, 5U AND 6U TWT
1A1A5	A26856-001	FRONT PANEL ASSY, AR 500T SINGLE PHASE
1A1A5A1	A22700-900	HPA DISPLAY BOARD
1A1A5A2	A24830-001	EMERGENCY BYPASS BOARD
1A1A6	A24830-000	EMERGENCY BYPASS BOARD
1A1A7	A26721-000	SNUBBER ASSY.,300MHZ
1A1A8	A26874-000	DUAL MODULATOR LV HARNESS
1A1A9	A31049-000	WIRING KIT, 23PIJ, SINGLE PHASE
1A1A9XJ1	A30346-000	EMI MODIFICATION KIT FOR 400KU
1A1A9XJ1A1	A28181-000	POWER ENTRY FILTER BOARD
1A1A10	A31044-000	CABINET KIT 23 PIJ
1A1A11	A30537-000	HIGH VOLTAGE BREAKOUT BOX ASSY
1A2	A30986-000	SUPERTUBE, PULSED 7.5 - 18 GHZ, WRD-750 (AR)
1A2A1	A30983-000	RF COMPONENTS, 23PIJ SUPERTUBE
1A2A2-A3	A23692-000	INSULATED FAN DRIVER
1A2A2-A3T1	A09594-000	FAN DRIVER TRANSFORMER
1A2A9	A31094-000	WIRING KIT
1A2A10	A31015-000	CHASSIS ASSY, IJ SUPERTUBE W/ SSA, PULSED
1A3	A30846-000	LOW VOLTAGE CABLE ASSY, 25 COND, 2500X
	A30529-000	HARMONIC FILTER (2) SWITCHING ASSY (optional)
	A30529-001	HARMONIC FILTER (1) 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 (A23687-150)
10-24830-000	Remote Control Board, Foldback only (A24830-000)
10-25444-000	HPA Interface (A25444-000) (4 pages)
10-26874-000	Dual Modulator LV Harness (A26874-000)
10-30529-000	Harmonic Filter Switching Kit (Two filters) (A30529-000)
25-30529-001	Harmonic Filter Switching Kit (One filter) (A30529-001)
10-30750-000	Pulse Monitor Board (A30750-000) (2 pages)
10-30530-000	RF Switch Control Cable (Two switches) (A30530-000)
10-30530-001	RF Switch Control Cable (One switch) (A30530-001)
10-30984-000	Power Supply, 23PIJ
10-30986-000	Supertube, 23PIJ

5.3 PARTS LISTS

A16485-000	HPA Logic and Control
A22826-344	Pulsed TWT Power Supply
A24830-000	Remote Control Board, Foldback only (Emergency Bypass Board)
A24830-001	Remote Control Board (Emergency Bypass Board)
A25444-000	HPA interface
A30529-000	Harmonic Filter Switching Kit, Two Filters (200W IJ External Filters)
A30529-001	Harmonic Filter Switching Kit, One Filter (200W IJ External Filter Switching)
A30983-000	RF Components 23PIJ Supertube
A30984-000	Power Supply, 2kW Pulsed IJ-Band
A30985-000	TWTA 2kW Pulsed IJ Band
A31049-000	Wiring Kit, 23PIJ, Single Phase

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,	D14454-000	DIODE,AXIAL,(MOTOROLA 1N4454)	24
D36	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
R67	R21953-000	RES,9.53K,1/2W,1%,MF,100PPM,(DALE RN55D)	1

REF DESIG	ETM P/N	DESCRIPTION	QUANTITY
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, A22826-344

REF DESIG	ETM P/N	DESCRIPTION	QUANTITY
A3	A16485-000	HPA LOGIC AND CONTROL MODULE	1
A5	A16487-382	POWER BOARD ASSEMBLY,PULSED TWTA	1
A6	A21425-021	DIODED/CAP ASSY FOR TWT 3444L	1
A7	A21458-004	HV FILTER	1
A12	A21458-008	CAPACITOR BANK AND SPURIOUS REDUCTION FILTER	1
A10	A21459-021	PWM BOARD FOR TWT 3444	1
A1	A23280-000	HEAT SINK/MOTHER BOARD	1
A4	A23683-100	POWER FACTOR MODULE (500W)	1
A13	A23684-100	PSC GRID MODULATOR, REG REF,(SLAVE)	1
A8	A23684-101	PIJ/PSC GRID MODULATOR MODULE, REGULATED REFERENCE	1
A2	A23687-150	LOW VOLTAGE POWER SUPPLY MODULE, AC INPUT 230VAC, 50/60HZ, 200W	1
A9	A23724-000	HEATER MODULE, 6.3V 4A/8A	1
A11	A25398-021	FACTORY SELECT, 13PIJ	1

5.3.3 Parts List, Remote Control Board, Foldback Only (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, Remote Control Board (Emergency Bypass Board), A24830-001

REF DESIG	ETM P/N	DESCRIPTION	QUANTITY
	B24830-000	EMERGENCY BYPASS BOARD	1
C3-C5	C04105-000	CAP,0.1MF,100V,20%,MON,(KEMET C331C104M1R5CA)	3
C6	C30010-000	CAP,10MF,35V,TANT,RADIAL,(NEMCO TB10-35K1)	1
C2	C31028-000	CAP,1000PF,200VDC,10%,CER,1% FAILURE,(KEMET CKR05 SERIES W/"V" OPTION)	1
C1	C31032-000	CAP,0.01MF,200VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	1
C7	C31040-000	CAP,1MF,50VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	1
D1, D2	D14454-000	DIODE,AXIAL,(MOTOROLA 1N4454)	2
D3, D4	D14733-000	ZENER,5.1V,1W,10%,AXIAL,(MOTOROLA 1N4733)	2
I2, I3	I10066-000	LED,RED,HIGH EFFICIENCY,HIGH BRIGHTNESS	2
I1, I4	I10096-000	LED,GREEN,DIFFUSED,T1-3/4 (XC55G)	2
TP2	J16212-000	TEST JACK,RED,VERTICAL,(EF JOHNSON 105-0852-001)	1
TP3	J16213-000	TEST JACK,ORANGE,VERTICAL,(EF JOHNSON 105-0856-001)	1
J2	J18086-000	CONN,,SMA,JACK RECEPTACLE,RIGHT ANGLE,0-18GHZ,PC MOUNT [JOHNSON COMPONENTS 142-0701-301]	1
J1	J18180-000	CONN,D-SUB,15 PIN,MALE,STRAIGHT,PCB MOUNT (POSITRONIC MD15M3000)	1
Q1-Q3	Q22222-000	TRANSISTOR,NPN,2N2222A,TO-18	3
Q4, Q5	Q22907-000	TRANSISTOR,PNP,2N2907A,TO-18	2
R18, R23	R01100-000	RES,100 OHM,1/4W,5%,CC,(A/B RC07GF101J)	2
R21	R01150-000	RES,150 OHM,1/4W,5%,CC,(A/B RC07GF151J)	1
R19	R02100-000	RES,1K,1/4W,5%,CC,(A/B RC07GF102J)	1
R3, R5, R7	R02220-000	RES,2.2K,1/4W,5%,CC,(A/B RC07GF222J)	3
R22	R02330-000	RES,3.3K,1/4W,5%,CC,(A/B RC07GF332J)	1
R16, R17	R02470-000	RES,4.7K,1/4W,5%,CC,(A/B RC07GF472J)	2
R24	R02510-000	RES,5.1K,1/4W,5%,CC,(A/B RC07GF512J)	1
R4, R6, R8, R9, R13, R15	R03100-000	RES,10K,1/4W,5%,CC,(A/B RC07GF103J)	6
R1	R12107-000	TRIMPOT,1K,1/2W,10%,CERMET,1T,SIDE ADJ,(BECKMAN 72XL)	1
R20	R20267-000	RES,267 OHM,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R10, R11, R12	R23100-000	RES,100K,1/2W,1%,MF,100PPM,(DALE RN55D)	3
R2	R30074-000	TRIMPOT,1K,1/2W,10%,CERMET,100PPM,20T,TOP ADJ,(BECKMAN 67W)	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
U2	U11458-000	IC,DUAL OP AMP,(NAT LM1458CN)	1
U1	U17805-000	IC,5V REGULATOR,TO-220,(NAT LM340T-5.0)	1

5.3.5 PARTS LIST, HPA INTERFACE BOARD, PLASTIC, A25444-000

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,(JAMECO TM1.5/35)	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,(AVX TAP106M025HSB)	3
C15	C06220-000	CAP,22MF,16V,SOLID TANT,RADIAL,(AVX TAP226K016SCS)	1
C99	C16103-000	CAP,10MF,35V,AERL,(NICHICON UVX1V100)	1
C101	C17222-000	CAP,220MF,16V,AERL,(ILL CAP 227RAR016A)	1
C47, C67	C17224-000	CAP,220MF,50V,AERL,(ILL CAP 227RAR050A)	2
C44, C168, C169	C30066-000	CAP 47 MF, 35V, SOLID TANT. RADIAL, (KEMET T356M476K035AS)	3
C165, C166, C6, C7, C9, C13, C16, C39	C31016-000	CAP,100PF,200VDC,10%,CER,1% FAILURE,(KEMET CKR05 SERIES W/"V" OPTION)	10
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, 1, 2, 3, 4, 5	C31036-000	CAP,0.1MF,100VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	61
C12, C14, C21, C27, C29, C31, C34, C36, C38, C17, C18, C19, C37, C54, C55, C56, C57, C58, C59, C60, C61, C118, C119, C120, C122, C123, C124, C133, C46, C52, C66, C68, C72, C75, C82, C84, C86, C90, C92, C93, C95, C104, C106, C45	C31040-000	CAP,1MF,50VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	44
D8, D10-D16, D18-D19	D14007-000	DIODE,1000V,1A,AXIAL,(MOTOROLA 1N4007)	10
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
TP3	J16213-000	TEST JACK,ORANGE,VERTICAL,(EF JOHNSON 105-0856-001)	1

REF DESIG	ETM P/N	DESCRIPTION	QUANTITY
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
TP6	J16216-000	TEST JACK,BLUE,VERTICAL,(EF JOHNSON 105-0860-001)	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
R2	R01220-000	RES,220 OHM,1/4W,5%,CC,(A/B RC07GF221J)	1
R41	R01680-000	RES,680 OHM,1/4W,5%,CC,(A/B RC07GF681J)	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
R11	R20243-000	RES,243 OHM,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R16	R20845-000	RES,845 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, R36, R40, R44,	R30103-000	RES,10K,1/8W,1%,MF,AXIAL,100PPM,(DALE CMF-50 / RN50C1002F)	9
R17, R19, R20, R21, R23, R25, R28, R31, R42, R43, R46, R18	R30140-000	RES,1K,1/8W,1%,MF,50PPM,(DALE RN50C)	12
R13, R14, R24, R26,	R31164-000	RES,100K,1/20W,1%,FILM,AXIAL,100PPM,MIL,(DALE	11
R27, R29, R32, R37, R38, R39, R47	RN50C1003F)		
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
U1	U03171-000	IC,ADJUSTABLE VOLTAGE REGULATOR,15W,1.5A, TO-220,(NAT LM317T)	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

REF DESIG	ETM P/N	DESCRIPTION	QUANTITY
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
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

5.3.6 Parts List, Harmonic Filter Switching Kit, Two Filters, (200W IJ External Filters), A30529-000

REF DESIG	ETM P/N	DESCRIPTION	QUANTITY
A2	A30530-000	CABLE, BANDSWITCH CONTROL	1
F1	E01023-000	IJ BAND ABS. WR-90 HARM. FILTER, BP= 8.0-12.4GHZ, BS=16.0-40. GHZ,250 WATTS CW MIN,[MDC, 57090-602]	1
F2	E01024-000	IJ BAND ABS. WR-62 HARM. FILTER, BP= 12.4-18.0GHZ, BS=24.0-36 GHZ,250 WATTS CW MIN,[MDC 57062-206]	1
	E01028-000	RF GASKET WR-90 GROOVED FLANGE, CONDUCTIVE CONTINENTAL MICROWAVE & TOOL, GSK90-1-C	4
W2, W4	E01043-000	E-BEND, WR-62G 1.5 X 1.5	2
W3, W5	E01044-000	E-BEND, WR-90G 1.5 X 2.0	2
	E01045-000	WG GASKET WRD-750 GROOVED FLANGE, CONTINENTAL GSK750	6
	E01046-000	WG GASKET, WR-62 GROOVED FLANGE, CONTINENTAL GSK62--C	4
	E01153-000	TRANSITION WG, WRD-750- GROOVED TO WR-62,[MDC 23750-455]	2
	E01154-000	TRANSITION WG, WRD-750 GROOVED TO WR-90,[MDC, 23750-456]	2
W1	E01155-000	WAVEGUIDE WRD-750 WITH GROOVED FLANGES 3-3/4 STRAIGHT PIECE (MDC, 25750-332)	1
S1, S2	E20389-000	WAVEGUIDE SWITCH, WRD-750, 15V LATCHING LOGIC,[LOGUS LMR750BSL93]	2
	N26122-000	WAVEGUIDE COVER PLATE WRD-750, WRD-580	2

5.3.7 Parts List, Harmonic Filter Switching Kit, One Filter (200W IJ External Filter Switching), A30529-001

REF DESIG	ETM P/N	DESCRIPTION	QUANTITY
A2	A30530-001	CABLE, SINGLE FILTER SWITCH CONTROL	1
F1	E01023-000	IJ BAND ABS. WR-90 HARM. FILTER, BP= 8.0-12.4GHZ, BS=16.0-40. GHZ,250 WATTS CW MIN,[MDC, 57090-602]	1
	E01028-000	RF GASKET WR-90 GROOVED FLANGE, CONDUCTIVE CONTINENTAL MICROWAVE & TOOL, GSK90-1-C	2
	E01029-000	RF GASKET WR-90 COVER FLANGE, CHOMERICS 20-11-5015-1239	1
W3	E01044-000	E-BEND, WR-90G 1.5 X 2.0	1
	E01045-000	WG GASKET WRD-750 GROOVED FLANGE, CONTINENTAL GSK750	4
W2, W4	E01154-000	TRANSITION WG, WRD-750 GROOVED TO WR-90,[MDC, 23750-456]	2
W1	E01155-000	WAVEGUIDE WRD-750 WITH GROOVED FLANGES 3-3/4 STRAIGHT PIECE (MDC, 25750-332)	1
W5	E01843-000	WAVEGUIDE, J-BEND, WRD-750 IN/OUT [MDC TBD]	1
S1	E20389-000	WAVEGUIDE SWITCH, WRD-750, 15V LATCHING LOGIC,[LOGUS LMR750BSL93]	1
	N26122-000	WAVEGUIDE COVER PLATE WRD-750, WRD-580	2

5.3.8 Parts List, RF Components, 23PIJ Supertube, A30983-000

REF DESIG	ETM P/N	DESCRIPTION	QUANTITY
A7	E00324-000	DUAL BROADWALL COUPLER, WRD-750 -40, -40 DB [PER SPECIFICATION DRAWING]	1
A6	E00325-000	RF LOAD, 500W, WRD-750, AIR COOLED	1
	E00326-000	90 DEG. OFFSET JOGGLE, WRD-750 (PER ETM DWG. E00326)	1
A1	E01415-000	SSPA, 7.5-18 GHZ, 30 DBM @1DB, +30 DB, 0-35DB VAR,[KMIC TECH CMA75180B]	1
A3, A4	E01449-000	TWT 7.5-18GHZ, 1.5KW PULSE, +/-2 DB EQ [MTI-3444L, WRD-750, +/-2 DB EQ, ISOL TEMP, PHASE COMBINED]	2
ATT1	E20066-000	ATTENUATOR,10DB,2W,DC-18GHZ,(OMNI SPECTRA 2082-6193-10)	1
ATT2	E20072-000	ATTENUATOR,20DB,2W,(OMNI SPECTRA 2082-6148-20)	1
A9	E20129-000	COUPLER,10DB,4-18GHZ,SMA,(MAC TECHNOLOGIES C4258-10)	1
LS1, LS2	E20131-000	LINE STRETCHER DC 18GHZ,(ARRA 9428T-MF)	2
D1, D2	E20284-000	ZERO-BIAS SCHOTTKY DETECTOR,10MHZ-18.5GHZ,POSITIVE OUT PUT POLARITY,(KRYTAR 301 AP)	2
	E20376-000	WRD-750,E-BEND,90 DEG,[HNL 98-20376/A]	2
A2	E20385-000	HYBRID COUPLER, 180 DEG, 6 TO 20 GHZ, OPTIMIZED <8 DEG PHASE IMBALANCE,7.5 TO 18 GZ,[KRYTAR 4060200]	1
A5	E20399-000	MAGIC TEE, WRD-750,[MDC 10750-TBD]	1
A10	E20400-000	TERMINATION, 2 WATT, SMA MALE,[INMET 3004M]	1
	H00600-000	WAVEGUIDE FLANGE GASKET, WRD-650, WRD-750	7
J1, J2	J17219-000	ADAPTER,N TO SMA,PNL MT,FEM,(HUBER & SUHNER 37N-SMA-50-1)	2
	N31104-000	BRACE, RF LOAD	1
	N31105-000	CLAMP, RF LOAD	1
	N32506-000	MOUNTING PLATE SSPA	1

5.3.9 Parts List, Power Supply, 2KW Pulsed IJ Band, A30984-000

REF DESIG	ETM P/N	DESCRIPTION	QUANTITY
A1	A22826-344	PULSED TWT P. SUPPLY (PFC) FOR TWT MTI-3444L	1
A4	A22933-300	CONTROL HEAD ENCLOSURE, IEEE-488	1
A6	A24830-000	EMERGENCY BYPASS BOARD	1
A2	A25444-000	HPA INTERFACE BOARD (PLASTIC FIBERS)	1
A7	A26721-000	SNUBBER ASSY.,300MHZ	1
A5	A26856-001	FRONT PANEL ASSY, AR 500T SINGLE PHASE	1
A8	A26874-000	DUAL MODULATOR LV HARNESS	1
A11	A30537-000	HIGH VOLTAGE BREAKOUT BOX ASSY	1
A3	A30750-000	PULSE MONITOR BOARD	1
A10	A31044-000	CABINET KIT 23 PIJ	1
A9	A31049-000	WIRING KIT, 23PIJ, SINGLE PHASE	1

5.3.10 Parts List, TWTA 2KW Pulsed IJ Band (AR), A30985-000

REF DESIG	ETM P/N	DESCRIPTION	QUANTITY
A3	A30846-000	LOW VOLTAGE CABLE ASSY, 25 COND, 2500X	1
A1	A30984-000	POWER SUPPLY, 2KW PULSED IJ BAND (AR)	1
A2	A30986-000	SUPERTUBE, PULSED 7.5 - 18 GHZ, WRD-750 (AR)	1

5.3.11 Parts List, Wiring Kit, 23PIJ, Single Phase, A31049-000

REF DESIG	ETM P/N	DESCRIPTION	QUANTITY
XJ1	A30346-000	EMI MODIFICATION KIT FOR 400KU	1
	E01039-000	AIR FILTER TRIM-TO-FIT EXPANDED ALUMINUM [GRAINGER 5C438]	1
A15	E01479-000	TRANSDUCER,CURRENT,50A RMS,+/-4VDC OUT,1%,(LEM USA HAL 50-S)	1
A12	E20282-000	EMI LINE FILTER,(SAE POWER INC STD-20)	1
A13	E30145-010	RIBBON CABLE,10.5,28 AWG,D-SUB 15 PIN FEMALE TO D-SUB 15 PIN FEMALE,[DICAR / ETM E30145-010]	1
A14	E30147-020	RIBBON CABLE, 28 AWG, D-SUB 37 PIN FEMALE TO D-SUB 37 PIN FEMALE,[DICAR PER ETM 30147]	1
P15, P26, P27	J00020-000	CONN,PIN & SOCKET,2 PIN,FEM,(MOLEX 03-09-1027)	3
P25	J00025-000	HOUSING,2 PIN,FEMALE,0.1 SPACING,7880 SERIES,(MOLEX	1
10-11-2023)			
P8	J00033-000	CONN,FEMALE 3 PIN,.063,(MOLEX 03-06-1032)	1
P29, P30	J00046-000	CONN,HOUSING,FEMALE,4 PIN,0.1SPACING,7880 SERIES,(MOLEX 10-11-2043)	2
P28	J10264-000	CONN,FEM SOCKET,26 PIN,IDC MASS TERMINATION,(THOMAS & BETTS 609-2601M)	1
J5	J11240-000	CONN,RIBBON,24 PIN,FEMALE,1A CONTACTS,BLUE,[3M 3549-1000-SR-3448-61]	1
	J11249-000	CONN,1 PIN,FEMALE,PLUG,10KVDC,10A,0.150 DIA. LEAD (REYNOLDS 167-9219)	10
P1	J12031-000	CONN,D-SUB,FEMALE,3 PIN,#8 AWG,PLUG,HI POWER [ITT CANNON DAM-3W3S]	1
P9	J12091-000	CONN,D-SUB,9 PIN,FEMALE,CRIMP (ITT CANNON DEU-9S)	1
J3	J12250-000	CONN,D-SUB,25 PIN,FEMALE,CRIMP	1
J4	J17102-000	BNC,BULKHEAD RECEPTACLE,GROUNDED,(AMPHENOL 31-221)	1
XP1	J18054-000	CONTACT,FEMALE,HI PWR,20 AMP,UP TO 12AWG WIRE,[ITT CANNON DM53744-6]	2
	J18055-000	CONTACT,MALE,HI PWR,20AMP,UP TP 12AWG WIRE,[ITT CANNON DM53745-7]	2
	J18073-000	MALE SCREW LOCK,D SUB CONN,(AMP 205980-1)	1
	J18075-000	MALE SCREW LOCK,FOR D SUBMIN CONN,(AMP 205817-1)	3
P21, P22, P23, P24, P20, P19	J18124-000	CONN,SMA MALE SOLDER ATTACHMENT FOR RG188,(PASTERNACK PE4036)	6
J1	J18162-000	POWER INLET,MALE,16A,250VAC, IEC-320 (PANEL COMPONENTS CORP 83011340)	1
J2	J18176-000	CONN,D-SUB,15 PIN,FEMALE,CRIMP,(ITT CANNON DAU-15S)	1
XJ2	J18184-000	D-SUB,15 PIN MALE,CRIMP (ITT CANNON DAU-15P)	1
P4, P7	J31011-000	D-SUB,37 PIN,MALE,CRIMP,5A,20 AWG (ITT CANNON DCU-37P)	2
	J31014-000	SPRING LATCH KIT,D-SUB,(AMPHENOL 17-529)	6
L1	L50504-000	EMI SUPPRESSION CORE,0.39HOLE,WITH CASE,(FAIR-RITE 0443167251)	1

REF DESIG	ETM P/N	DESCRIPTION	QUANTITY
	N24366-000	RIBBON CABLE CLAMP	1
	N24366-001	CABLE CLAMP,COVER (KYGAR DEMAND-PULL)	1
	N24373-000	CONNECTOR COVER	1
	N25458-000	RIBBON CABLE CLAMP	4
XA12	N27418-000	COVER TERMINAL EMI FILTER	2
S2	S25002-000	SWITCH,PUSHBUTTON,SPDT,SAFETY DOOR INTERLOCK,DEFEATABLE,(MICRO SWITCH 3AC2)	1
CB1	S26026-000	C/B,2 POLE,15A,(AIRPAX IEGH-66-1-61-15.0-C-21)	1
U1	U00052-000	PRECISION CELSIUS TEMP SENSOR, TO-220 [NATIONAL LM35DT]	1
	W01880-000	WIRE,26 AWG,COAXIAL,RG-188A/U,900V (BELDEN 83269)	8
	W11400-000	WIRE,14 AWG,600V,BLUE,(ALPHA 5859)	8
	W11800-000	WIRE,18 AWG,BLUE,(BELDEN 83009)	4
	W12200-000	WIRE, 22 AWG, BLU, 600V, TEFLON, (BELDEN 83006)	8
W1, W2	W30020-000	CABLE,FIBER OPTIC,1000UM POF, (HP HFBR-3504)	4
	W30054-000	POWER CORD, 250VAC, 20A, 3 CONDUCTOR, FEMALE, STRAIGHT PLUG, 60 DEG C, [PANEL COMPONENTS 8629S240]	1
Z1	Z31022-000	SURGE ARRESTOR,(CPCLARE AC240L)	1
Z2	Z31024-000	TRANZORB, 440V, 1.5KE440CA (GI 1.5KE440CA)	1

5.4 RECOMMENDED SPARE PARTS

A16487-382	Power Board Assembly
A21425-021	Diode / Cap Assembly
A21458-004	HV Filter
A21458-008	Capacitor Bank and Spurious Reduction Filter
A21459-021	PWM Board
A23683-100	Power Factor Module
A23684-100	Grid Modulator, Regulated Reference (Slave)
A23684-101	Grid Modulator, Regulated Reference
A23687-150	Low Voltage Power Supply Module
A23692-000	Insulated Fan Driver
A23724-000	Heater Module
E20389-000	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
```

AMPLIFIER RESEARCH®
160 School House Road, Souderton, PA 18964-9990 USA
telephone (215) 723-8181 • fax (215) 723-5688
e-mail: info@ar-amps.com • website: www.ar-amps.com

Appendix Application Note 35: Pulse TWTAs

1.0 INTRODUCTION

Amplifier Research'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: power 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 Amplifier Research for information on its extensive line of CW-rated amplifiers.

The contents of the remainder of this Application Note are listed below and describe the unique pulse features of AR's TWTA:

2.0 UNIQUE SPECIFICATION FOR PULSE TWTAS

Some unique specification characteristics (those not commonly specified for CW rated amplifiers) of Amplifier Research'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 max 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

2.1 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.)

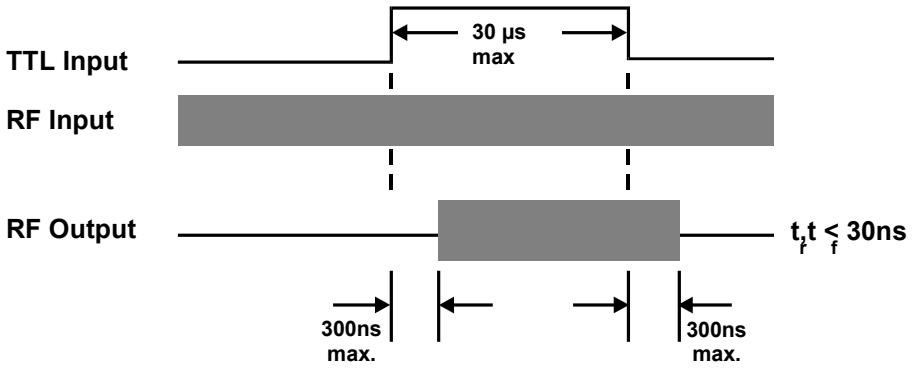


Figure 1. CW RF Input

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:

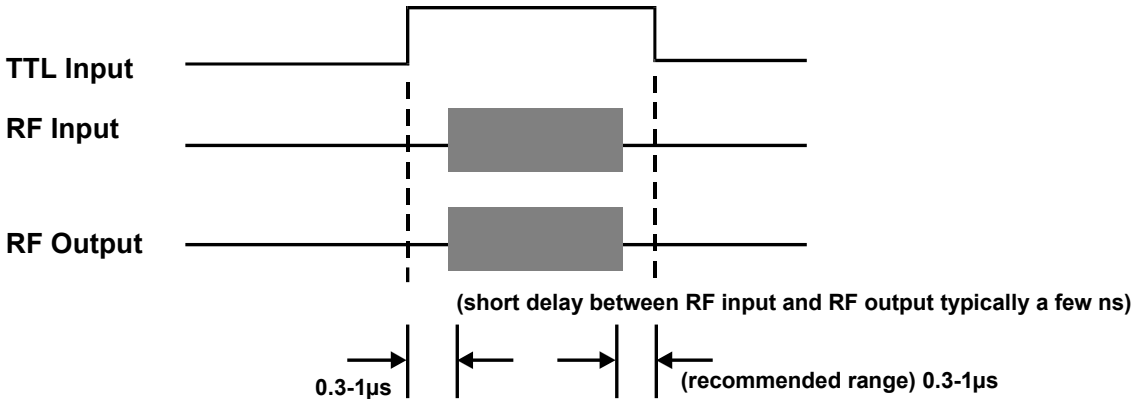


Figure 2. Pulse RF Input

2.2 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.

2.3 PULSE RATE

The Pulse Rate (PRF) specification (100kHz 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 Amplifier Research regarding any specific requirements they may have for non-continuous pulse-stream applications with higher burst rates.

2.4 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 5kHz, then the maximum allowable TTL input pulse width is reduced to 8 microseconds (1/5,000 x .04 sec.).

2.5 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.

2.6 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.

2.7 FORWARD AND REFLECTED PEAK POWER

AR 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: Peak Power = Average Power ÷ 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.

3.0 SUMMARY

This Application Note has discussed some features of AR'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 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, Antennas, Pre-compliance Test Systems, Transient Generators, Power Meters, Directional Couplers and Tripods will be free from defects in material and workmanship for a period of three (3) years from date of shipment shown on Amplifier Research invoice. Field Monitoring Equipment, Teseo Fiberoptic Systems and Traveling Wave Tubes in the 200T1G3A, 200T2G8A and 200T8G18A will be free from defects in material and workmanship for a period of two (2) years from date of shipment. Vacuum tubes, 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 Amplifier Research 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 Amplifier Research. Warranty service will be provided only for defective goods which are returned within the warranty period, freight costs prepaid to Amplifier Research 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.