rf/microwave instrumentation

Operating and Service Manual

1500T2G8A

Model

Part Number

Serial Number

ar worldwide • rf/microwave instrumentation

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rf/microwave instrumentation

EC Declaration of Conformity

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

declare that our product(s);

the Models 1500T1G2 series, 1500T2G8 series and 1500T8G18 series RF amplifiers

to which this declaration relates is in compliance with the requirements of the: EEC EMC Directive (89/336/EEC) in accordance with Article 10 (2) of the directive, with the provision that the user must install the equipment as directed by the "Instructions for European EMC Conformity" in the Operating and Service Manual.

This product(s) is in compliance with the requirements of the Low Voltage Directive (72/23/EEC) in accordance with safety standard IEC EN60950 (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:

Only qualified personnel must perform adjustment, maintenance, or repair of the equipment.

CAUTION:

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

CAUTION:

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

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1. DESCRIPTION AND SPECIFICATIONS

This manual provides operating, interfacing and selected service information pertinent to AR Model 1500T2G8A Broadband Microwave Amplifier. The Model 1500T2G8A is a 1700 watt SC-band traveling-wave tube amplifier (TWTA).

1.1 TWTA DESCRIPTION

The amplifier uses four traveling wave tubes (TWTs) power combined to provide rated power output over the TWT amplifier's full bandwidth. Harmonic power is moderate at the amplifier output flange without filtering by the use of this power combining approach. The amplifier is well suited for susceptibility and general laboratory testing where instantaneous bandwidth, high gain and moderate or low harmonic levels are required.

The amplifier is completely self-contained and packaged in a standard 19-inch rack cabinet provided with lifting eyes and castors. The amplifier cabinet is approximately 63 inches high including castors and lifting eyes, 22 inches wide at the base, and 33 inches deep at the base, excluding projecting rear-panel connectors.

Primary power is 190-255 volts, 50/60 Hz, three-phase with ground (4 wire). Efficient switching power supplies result in minimum power consumption. A fast regulation control loop and a high degree of filtering ensure performance within specifications over a wide range of operating conditions. The amplifier is fully enclosed, and the service panels of the amplifier are interlocked to reduce the likelihood of accidental contact with high voltage.

1.2 SUGGESTED APPLICATIONS

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

1.3 SPECIFICATIONS

Refer to the AR Data Sheet on the following pages for detailed specifications.

1.4 ACCESSORIES

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

- Directional coupler
- Antenna
- Flexible transmission line

Refer to a current AR catalog for Microwave Accessories.

1.5 TEST DATA SHEET

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

1500T2G8A

- M1–M7
- 1700 Watts CW
- 2.5GHz–7.5GHz

Features

The Model 1500T2G8A is a self contained, forced air cooled, broadband traveling wave tube (TWT) microwave amplifier designed for applications where instantaneous bandwidth, high gain, moderate harmonic levels, and high power output are required. Reliable TWT subsystems provide a conservative 1600 watts minimum from 2.5-3.0GHz, and 1700 watts minimum from 3.0-7.5GHz, measured at the amplifier output flange. Stated power specifications are at fundamental frequency.

The amplifier's front panel digital display shows forward and reflected output 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 reflected power warning and remote. Standard features include a built-in IEEE-488 (GPIB) interface, 0dBm input, VSWR protection, gain control, RF output sample ports, 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.

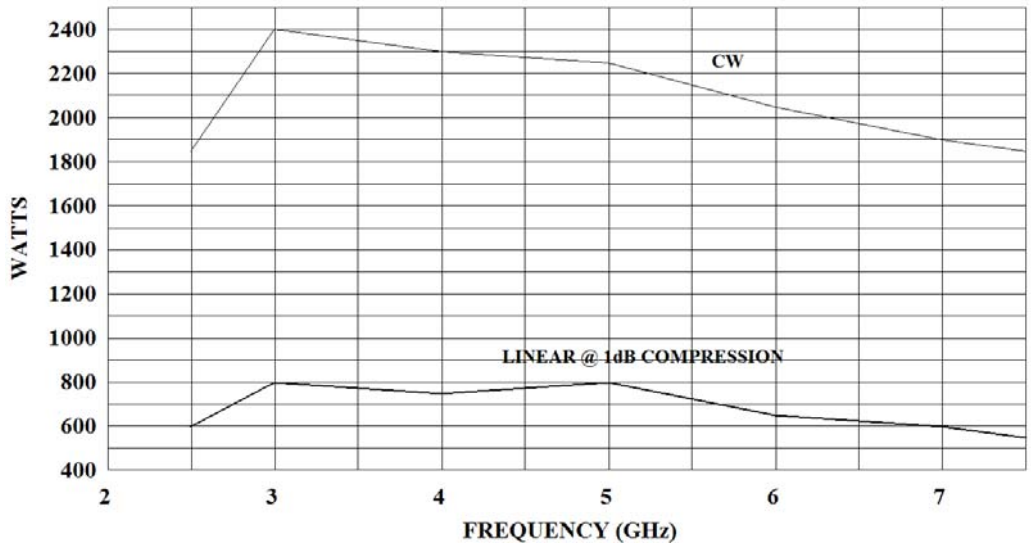
The rated power is developed by efficiently power combining the outputs from four 535 watts (nominal) microwave amplifiers that are factory matched in gain and phase, resulting in an excellent combination of wide instantaneous bandwidth with improved harmonic levels. Model includes castor wheels and lifting eyes to facilitate positioning the amplifier, and leveling feet to stabilize the unit during operation.

The Model 1500T2G8A provides readily available RF power for a variety of applications in Test and Measurement, (including EMC RF susceptibility testing), Industrial and University Research and Development, and Service applications.

Refer to the Model Configuration chart for alternative configurations.

The export classification for this equipment is EAR99. These commodities, technology or software are controlled for export in accordance with the U.S. Export Administration Regulations. Diversion contrary to U.S. law is prohibited.

1500T2G8A TYPICAL POWER OUTPUT



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1500T2G8A

- M1–M7
- 1700 Watts CW
- 2.5GHz–7.5GHz

Specifications

POWER (fundamental), CW, @ OUTPUT CONNECTOR:
Nominal: 2000 watts
Minimum: 1600 watts from 2.5–3.0 GHz,
1700 watts from 3.0–7.5 GHz
Linear @ 1 dB Compression: 400 watts minimum

FLATNESS: ±8 dB maximum, equalized for ±6 dB maximum at rated power

FREQUENCY RESPONSE: 2.5 – 7.5 GHz instantaneously

INPUT FOR RATED OUTPUT: 1.0 milliwatt maximum

GAIN (at maximum setting): 62 dB minimum

GAIN ADJUSTMENT (continuous range): 35 dB minimum

INPUT IMPEDANCE: 50 ohms, VSWR 2.0:1 maximum

OUTPUT IMPEDANCE: 50 ohms, VSWR 2.5:1 typical

MISMATCH TOLERANCE: Output power foldback protection at reflected power exceeding 300 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.

MODULATION CAPABILITY: Will faithfully reproduce AM, FM, or pulse modulation appearing on the input signal. AM peak envelope power limited to specified power.

NOISE POWER DENSITY: Minus 85 dBm/Hz (maximum); Minus 95 dBm/Hz (typical)

HARMONIC DISTORTION: Minus 15 dBc maximum, Minus 17 dBc typical

PRIMARY POWER: See Model Configurations

CONNECTORS:
RF input: Type N female on rear panel
RF output: Type WRD 250D30 waveguide flange on rear panel
RF output sample ports (forward and reflected): Type N 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: 296 kg (650 lb)

SIZE (W x H x D): 56 x 160 x 82.3 cm (22.1 x 63 x 32.4 in)

EXPORT CLASSIFICATION: EAR99

Model Configurations

P Must select one primary power from the following [P1 or P2]
P1 190-255 VAC, 3 phase, delta (4 wire) 50/60 Hz 11 KVA maximum
P2 360-435 VAC, 3 phase, WYE (5 wire) 50/60 Hz 11 KVA maximum. CE marked to comply with EMC European Directive 89/336/EEC for operation inside a shielded room.

S May select a special feature (extra cost) from the following [S1F and/or S2B]
S1F Input, forward and reflected power sample ports on front panel.
S2B Supplied with larger castor wheels and mounted on a rugged base that facilitates use of a forklift to move the TWTA. Add 46 kg (100 lbs) to weight, add 76 cm (3 inches) to height and 26 cm (10 inches) to width at base.

Model	Features	
1500T2G8A	P	S
1500T2G8A	P1	-
M1	P2	-
M2	P1	S1F
M3	P2	S1F
M4	P1	S1F& S2B
M5	P2	S1F& S2B
M6	P1	S2B
M7	P2	S2B

2. THEORY OF OPERATION

2.1 DESIGN OF THE AMPLIFIER

The Model 1500T2G8A TWT amplifier consists of six principal subsystems. From top to bottom, these are the control module, the RF combiner assembly, and the four TWT power supplies. These will be discussed in greater detail below. The system is completed by a number of cables that interconnect the subsystems, and by the rack assembly.

2.2 CONTROL MODULE

The control module houses the microprocessor control system (control head), the data steering assembly, a 5 VDC power supply, a three-output DC power supply, a 15 VDC power supply, and an AC 5-pole circuit breaker for removing the AC power from the TWT power supplies and the control module.

The control head consists of three boards: the display board provides the user interface (display, buttons, and rotary encoder); the CPU board contains the CPU, bus management hardware, DRAM, EPROMs, and static RAM; and the datalink board provides the I/O to the amplifier system as well as the IEEE-488 communication bus for computer interfacing.

The control head is provided with its own power supply and, other than thru the interface bus, is electrically isolated from the amplifier. Communication with the amplifier is via fiberoptic links. The single pair of links on the control head fans out to five pairs of links in the data steering assembly. These links go to interface boards in the RF combiner and in each of the four power supplies. The data is “steered” by an address byte in the data stream from the microprocessor.

2.3 DESCRIPTION OF THE RF ASSEMBLY

The TWTA consists of three stages of RF amplification: a high gain first-stage solid state driver amplifier, four second stage driver amplifiers, one for each TWT, and four power-combined traveling-wave tube amplifiers.

The type N RF input connector is located on the rear panel. The RF input is fed to the input connector on the solid state preamp. This preamp has a built-in voltage-controlled variable attenuator which permits control of the amplifier’s gain. The preamp’s output is split into four paths by a set of 180° hybrids. Hybrid outputs are connected to second stage solid state driver amplifiers, the outputs of which are connected to the RF inputs of four TWTs. The TWTs’ outputs are connected directly to a loop coupler at the output of each tube to add additional RF protection against high reflected power. The loop couplers are connected by waveguide to the four input ports of a pair of power combiners in the power combiner assembly. The magic tees’ sum ports, the ports that collect all in-phase products in the power combiner assembly, are terminated with waveguide loads. The magic tees’ difference ports, the ports that collect the out-of-phase products, route the RF to the RF output.

The electrical length of the circuits between the splitters and the combiners must be matched (so that the 180° out-of-phase relationship will prevail across the full bandwidth, permitting efficient combining). To achieve this, phase-matched cable assemblies and adjustable line stretchers are used.

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

ports. The residual harmonics are typically less than –20dBc, low enough in power that they can be further reduced, as needed, by a reflective filter.

A dual directional coupler is installed at the final magic tee combiner output for power metering, forward and reflected sample ports and load VSWR protection for the tubes. A reflected power foldback circuit utilizing the reflected power port reduces the system's gain under conditions of high VSWR so that a gradual increase in reflected power will not result in a VSWR fault.

The RF output is WRD-250 waveguide.

The control module monitors and controls the RF combiner assembly via the switcher-combiner interface board. This board generates the analog voltage that controls the variable attenuator and has A-to-D converters for metering the power levels.

The TWTs are mounted on cooling units. Each cooling unit contains a high density heat sink, a 400 Hz cooling fan, and a fan inverter that operates from the AC line.

2.4 DESCRIPTION OF THE TWT POWER SUPPLIES

The four TWT power supplies are housed in separate 19" chassis 3 rack units (5.25") high. Each power supply chassis contains a TWT power supply assembly, an HPA interface board, as well as an AC input line filter and a front panel circuit breaker. In addition, each chassis has a 400 Hz cooling fan and a fan inverter.

The power supply assembly is of modular construction. Low voltage power for logic and control of the entire power supply assembly is provided by the low voltage power supply module. Control logic and TWT protection circuits are contained in the HPA logic and Control Assembly.

The Heater Power Supply Module powers the TWT DC heater. Bias and pulse top voltage for the TWT grid are provided by the Modulator Assembly.

The high voltage power supply consists of the following: the Power Factor Correction module converts line voltage to DC for the high voltage switching supply. Switching transistors are on the Power Board Assembly, and switching is controlled by the PWM Board. The high voltage transformer and rectifiers are contained in the Diode Cap Assembly. The high voltage DC is filtered in the HV Filter Assembly.

Interconnects between the power supply modules are through a motherboard. It is installed in the power supply finned heat sink.

The cooling air is provided by the 400 Hz fan mounted on the rear panel inside the air outlet grill.

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.

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.

One panel of the shipping container can be removed to gain access to the TWTA. This panel may be positioned to use as a ramp when removing the TWTA from the shipping container.

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

3.2.2 Mounting

The TWTA must be located on a nominally flat surface, and restrained so that it will not inadvertently roll out of position. The casters are *not* provided with brakes. Set the leveling feet when the TWTA is properly positioned for use.

When rolling the unit, fully recess the leveling feet to maximize floor clearance.

CAUTION:

Avoid pulling more than two drawers/assemblies out of the rack at the same time. Although unlikely, the weight of the drawers/assemblies may cause the rack to tip over.

3.2.3 Cooling Requirements

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

CAUTION:

Do not position the TWTA in such a way that the air intakes or outlets are blocked, or that the exhaust air flow is directed into air intakes. See Paragraph 3.5 for location of air intakes and air outlets. Make sure that the intake air is 45°C or below. Great care must be taken to minimize any exhaust air restrictions. Avoid mounting heat-producing equipment near the TWTA, especially below the TWTA's air intakes. Pay special attention to the location of RF loads and lossy coaxial cable or waveguide connected directly to the TWTA which may conduct heat back to the TWTA. Use supplemental fans as necessary to cool these components, directing this heat away from the rear of the TWTA. Failure to provide adequate cooling can result in the unit shutting down from over-temperature conditions. The TWTA dissipates approximately 8.0 kilowatts when in the Operate mode.

3.2.4 AC Line Power Connections

AC line power connection to the TWTA is a 4-conductor cable attached the junction box. The cable is provided unterminated, and appropriate wiring to the cable must be provided by the user. The cable conductor function is color coded.

Color	Function
Black	Phase
Red	Phase
White	Phase
Green	Safety ground

This model does not use the Neutral wire. It is not necessary to connect a Neutral wire for 208 VAC operation.

The TWTA is not sensitive to phase rotation.

3.2.5 RF Connections

The RF output is WRD-250 waveguide.

CAUTION:

Never operate the TWTA without a matched output load rated for at least 3500 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 6dB or larger pad (RF attenuator) directly at the TWTA input connector to reduce risk of "looping" oscillation.

(The following procedure is to assure waveguide is inspected for defects and installed correctly.)

1. Visually inspect outside of waveguide to confirm part is not bent. If part is bent, do not proceed. Notify the manufacturing manager or RF engineer.

2. Using a flashlight, visually inspect inside of waveguide from both ends. Look for any debris. If there is debris in the part, do not proceed. Notify the manufacturing manager or RF engineer.

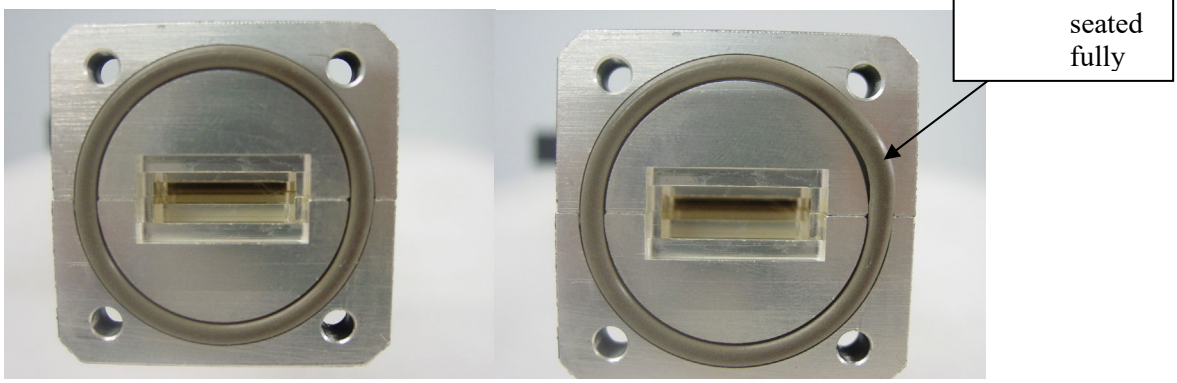
3. Visually inspect ends of waveguide for flatness. Both ends should be flat and without nicks. If it is not, do not proceed. Notify the manufacturing manager or RF engineer.

4. If gasket is required, install it at this time.
   Note: If waveguide has a gasket groove and there are no gaskets reporting to the BOM, notify the manufacturing manager or RF engineer.

5. Note: Some gaskets have a flat side and a rounded side. In these cases, install the gasket flat side first (into groove).

6. To ensure the gasket stays in place, apply a light film of H03420-000 (DOW CORNING HIGH VACUUM SILICONE GREASE)
   to the flat side of the gasket prior to installing in groove.

7. Gasket must be seated completely in waveguide groove. Note: If the gasket is not seated fully, it will pinch between the two parts and impair the connection.
   See below:



CORRECT INCORRECT

8. Align waveguide with receptacle. Loosely install all hardware. If the waveguide does not align properly, do not proceed. Notify the manufacturing manager or RF engineer.

9. Tighten hardware in a crisscross pattern to assure even torque distribution. Double check that all hardware has been tightened fully to ensure no leakage.

10. The open ends of all waveguide must be covered with either Kapton tape or plastic waveguide covers.

3.2.6 External Interlock Connector

The TWTA is provided with an external interlock capability via a 15-pin-D connector. To enable the high-voltage power supply, it is necessary to provide continuity between pins 3 and 4 of this connector. 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 section 3.4). Users may adopt this interlock feature to disable the RF output for either equipment protection or as a backup for personnel protection.

Pin	Title	Function
1	INTERNAL JUMPER	Internal jumper from pin 1 to pin 2
2.	INTERNAL JUMPER	Internal jumper from pin 1 to pin 2
3.	EXTERNAL INTERLOCK SUPPLY	Disables High Voltage power supply in continuity is opened from pin 3 to pin 4.
4.	EXTERNAL INTERLOCK RETURN	Disables High Voltage power supply in continuity is opened from pin 3 to pin 4.
5-9.	NOT USED	
10.	INHIBIT SUPPLY	Disables RF power output if continuity is opened from pin 10 to pin 15.
11-14	NOT USD	
15	INHIBIT RETURN	Disables RF power output if continuity is opened from pin 10 to pin 15.

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.

3.3 FRONT PANEL FEATURES

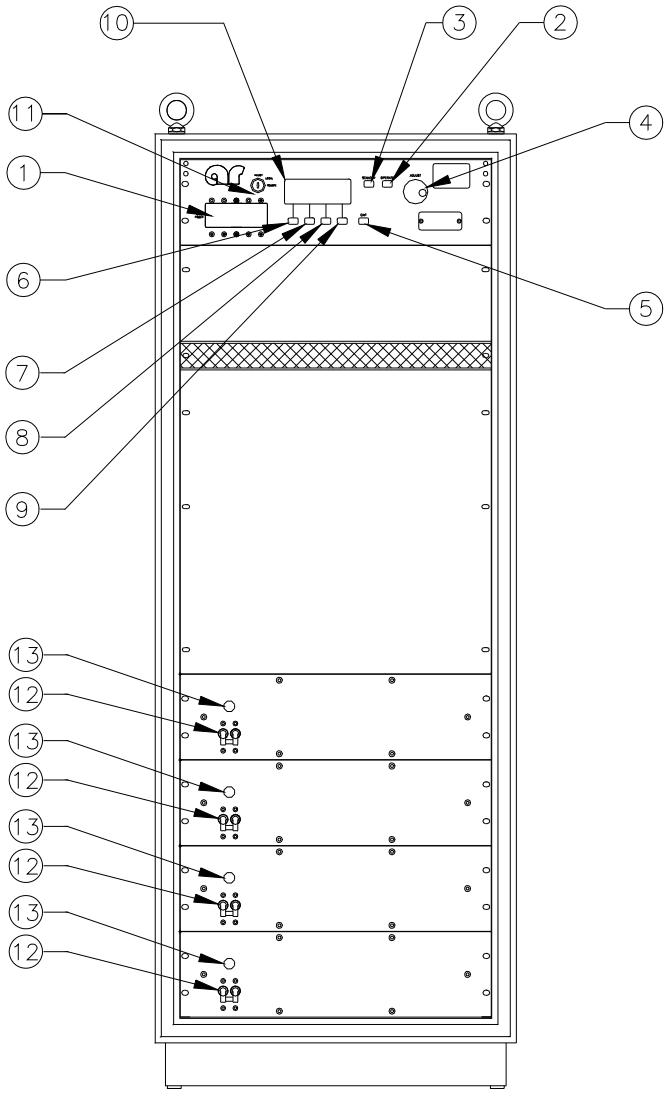


Figure 3-1. Front Panel Features

Table 3-1. Front Panel Features

Label	Title	Function
1	MAIN POWER	Switchable 5-pole circuit breaker; turns on control module and 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.	MAIN POWER	Switchable 15 A circuit breaker, provides AC power to power supply assembly for TWTs.
13.	POWER ON LIGHT	Green light indicates the PS assembly is on.

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 3-2 provides a roadmap for navigating between the screens.

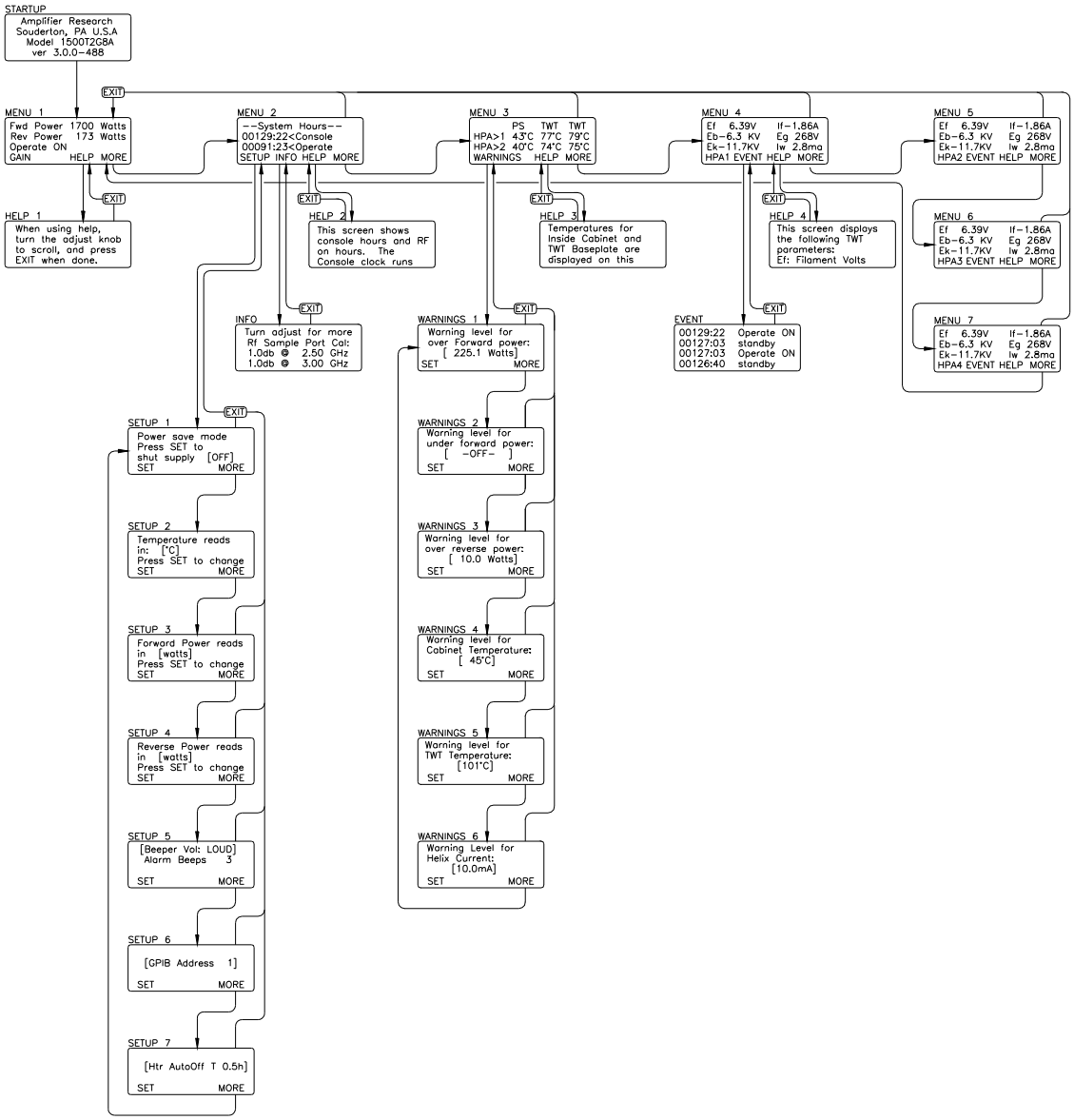


Figure 3-2. Front Panel Display Screens

Menu screens - The screens at the highest level are called menu screens. There are seven 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 7, 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	Functions
MENU 1	Forward power (watts, dBm or bar graph)
	Reverse power (watts, dBm or % forward power)
	System status (if a latched fault exists, MENU 1 is displayed with the system shutdown message)
MENU 2	Console hours (active when AC power is on)
	Operate hours (active when HV is on)
MENU 3	Power supply temperature (°C or °F), both units
	TWT baseplate temperature (°C or °F), both tubes
MENU 4	Heater voltage (Ef), HPA #1
	Heater current (If), HPA #1
	Collector voltage (Eb), HPA #1
	Grid voltage (Eg), HPA #1
	Cathode voltage (Ek), HPA #1
	Helix current (Iw), HPA #1
MENU 5	Heater voltage (Ef), HPA #2
	Heater current (If), HPA #2
	Collector voltage (Eb), HPA #2
	Grid voltage (Eg), HPA #2
	Cathode voltage (Ek), HPA #2
	Helix current (Iw), HPA #2
MENU 6	Heater voltage (Ef), HPA #3
	Heater current (If), HPA #3
	Collector voltage (Eb), HPA #3
	Grid voltage (Eg), HPA #3
	Cathode voltage (Ek), HPA #3
	Helix current (Iw), HPA #3
MENU 7	Heater voltage (Ef), HPA #4
	Heater current (If), HPA #4
	Collector voltage (Eb), HPA #4
	Grid voltage (Eg), HPA #4
	Cathode voltage (Ek), HPA #4
	Helix current (Iw), HPA #4

Help Screens - On most 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 strip-chart form, or in dBm or watts. Pressing MORE again brings up SETUP 4, which allows a choice of dBm or watts 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.

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

After activating the Sleep Mode:

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

To deactivate Sleep Mode:

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

Warnings Screens - From MENU 3, S1 (labeled WARNINGS) selects WARNINGS 1 which allows the operator to enter the maximum forward 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 power exceeds the setpoint, the audible alarm will sound (if configured in SETUP 3).

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 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 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 (A16485).

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.

From WARNINGS 5, 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 2, 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 which may be required by a service representative when providing technical assistance. The EXIT key returns the display to MENU 2.

Event Screen - From MENU 4, 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 turn HV off. Faults that do not turn off HV are specified in Table 3-5. When such faults are cleared, the system will automatically resume the standby state and users may again select the Operate mode.

Some faults (EXTERNAL INHIBIT) will turn off the grid of the tubes to disable RF output 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. This automatic return to operation is provided for selected faults due to influences external to the TWTA.

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

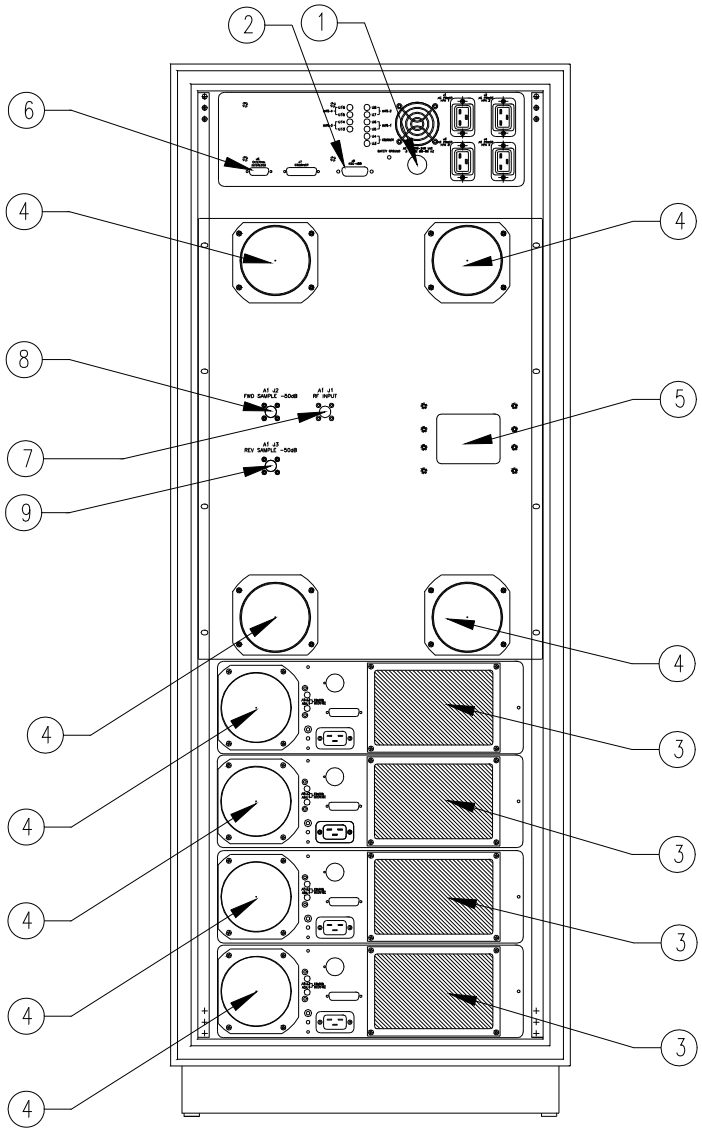


Figure 3-3. Rear Panel Features

Table 3-2. TWTA Rear Panel Features

Label	Title	Function
1.	208 VAC IN	AC power input cable
2.	REMOTE INTERFACE	Remote control connector. 24 pin hermaphrodite
3.	AIR FILTER	Cooling air intake.
4.	EXHAUST FAN	Cooling air outlet.
5.	RF OUT	Type WRD-250 waveguide flange
6.	EXTERNAL INTERLOCK	Connector to remote temperature switch protecting the isolator or load; D-sub 15-pin female
7.	RF INPUT	RF input (Type N, female)
8.	FORWARD SAMPLE	RF forward sample (Type N, female)
9.	REVERSE SAMPLE	RF reverse sample (Type N, female)

3.6 INITIAL TURN ON AND WARM-UP PROCEDURE

Install the TWTA as discussed in section 3.2. Provide an RF generator to the RF input Type N connector. Set RF generator level below -50dBm and set desired frequency in specified range. Connect a load suitable for at least 3500 watts continuous operation to the RF output connector. The load VSWR should be less than 2.0:1 A power meter and suitable attenuators may be connected to the RF sample port. (Refer to RF sample port calibration factors on the rear of the unit or on the *Info* screen in MENU 2). These show the relation between the amplifier output power and the RF sample port power as a function of frequency. Set keylock to LOCAL.

Switch on the circuit breakers on the four power supplies. Switch on the MAIN POWER circuit breakers on the control module. 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 the Standby state for extended periods of time. If the TWTA will not be used in the Operate state within an hour, shut the TWTA off or activate the Sleep Mode to have continued remote GPIB access. 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 the Standby state 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. Press MORE again to view MENU6 and verify the values for TWT #3. Press MORE again to view MENU7 and verify the values for TWT #4. The values of these parameters at the time the TWTA left the factory are logged on the test data sheet.

Push the OPERATE pushbutton. 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 0dBm to reach the desired FWD PWR on the display and power meter (connected to forward sample port). The forward power indication will become active, with maximum value when peak power output is achieved. Best performance is obtained when the input RF drive is set at or just below the level which causes peak power output. Do not set input drive above 0dBm (Input drive above +13dBm 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 0dBm 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 1700 watts RF output mid-band are logged on the test data sheet. The value of the helix current is a good qualitative indicator that RF drive is present.

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

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 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=[ ]
OPERATE;	Emulates OPERATE push-button		
STANDBY;	Emulate STANDBY push-button		
POWER:OFF;	Emulate STANDBY push-button		
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)		
RESET;	Emulates RESET softkey		
RDS/N	Returns serial number		s/n=[ ]
RDCONHR	Returns console hours		ConHr=[ ]
RDRFHR	Returns RF hours		RfHr=[ ]
RDEK1	Returns cathode voltage, HPA1	KV	Ek=[ ]
RDEK2	Returns cathode voltage, HPA2	KV	Ek=[ ]
RDEK3	Returns cathode voltage, HPA3	KV	Ek=[ ]
RDEK4	Returns cathode voltage, HPA4	KV	Ek=[ ]
RDEB1	Returns collector voltage, HPA1	KV	Eb=[ ]
RDEB2	Returns collector voltage, HPA2	KV	Eb=[ ]
RDEB3	Returns collector voltage, HPA3	KV	Eb=[ ]
RDEB4	Returns collector voltage, HPA4	KV	Eb=[ ]
RDEG1	Return grid voltage, HPA1	V	Eg=[ ]
RDEG2	Return grid voltage, HPA2	V	Eg=[ ]
RDEG3	Return grid voltage, HPA3	V	Eg=[ ]
RDEG4	Return grid voltage, HPA4	V	Eg=[ ]
RDEF1	Returns heater voltage, HPA1	V	Ef=[ ]
RDEF2	Returns heater voltage, HPA2	V	Ef=[ ]
RDEF3	Returns heater voltage, HPA3	V	Ef=[ ]
RDEF4	Returns heater voltage, HPA4	V	Ef=[ ]
RDIF1	Returns heater current, HPA1	A	If=[ ]
RDIF2	Returns heater current, HPA2	A	If=[ ]
RDIF3	Returns heater current, HPA3	A	If=[ ]
RDIF4	Returns heater current, HPA4	A	If=[ ]
RDIW1	Returns helix current, HPA1	mA	Iw=[ ]
RDIW2	Returns helix current, HPA2	mA	Iw=[ ]
RDIW3	Returns helix current, HPA3	mA	Iw=[ ]
RDIW4	Returns helix current, HPA4	mA	Iw=[ ]
RDTMPTWTHPA1F	Returns TWT temp (°F), HPA1	°F	TWTHPA1F=[ ]F
RDTMPTWTHPA2F	Returns TWT temp (°F), HPA2	°F	TWT HPA2F=[ ]F
RDTMPTWTHPA3F	Returns TWT temp (°F), HPA3	°F	TWTHPA3F=[ ]F
RDTMPTWTHPA4F	Returns TWT temp (°F), HPA4	°F	TWT HPA4F=[ ]F
RDTMPTWTHPA1C	Returns TWT temp (°C), HPA1	°C	TWTHPA1C=[ ]C
RDTMPTWTHPA2C	Returns TWT temp (°C), HPA2	°C	TWTHPA2C=[ ]C

Command	Function	Units	Response format
RDTMPTWTHPA3C	Returns TWT temp (°C), HPA3	°C	TWTHPA3C=[ ]C
RDTMPTWTHPA4C	Returns TWT temp (°C), HPA4	°C	TWTHPA4C=[ ]C
RDTMPPSHPA1F	Returns power supply temp (°F), HPA1	°F	PSHPA1F=[ ]F
RDTMPPSHPA2F	Returns power supply temp (°F), HPA2	°F	PSHPA2F=[ ]F
RDTMPPSHPA3F	Returns power supply temp (°F), HPA3	°F	PSHPA3F=[ ]F
RDTMPPSHPA4F	Returns power supply temp (°F), HPA4	°F	PSHPA4F=[ ]F
RDTMPPSHPA1C	Returns power supply temp (°C), HPA1	°C	PSHPA1C=[ ]C
RDTMPPSHPA2C	Returns power supply temp (°C), HPA2	°C	PSHPA2C=[ ]C
RDTMPPSHPA3C	Returns power supply temp (°C), HPA3	°C	PSHPA3C=[ ]C
RDTMPPSHPA4C	Returns power supply temp (°C), HPA4	°C	PSHPA4C=[ ]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
RDPOD	Returns forward power out (dBm)	dBm	Po=[ ]dBm
RDPOW	Returns forward power out (W)	watts	Po=[ ]W
RDPRD	Returns reverse power out (dBm)	dBm	Pr=[ ]dBm
RDPRW	Returns reverse power out (W)	watts	Pr=[ ]W
RDPOHID	Returns over forward power warning setpoint (dBm)	dBm	Pohi=[ ]dBm
SPOHID	Sets over forward power warning setpoint (dBm)	dBm	
RDPOLOD	Returns under forward power warning setpoint (dBm)	dBm	Polo=[ ]dBm
SPOLOD	Sets under forward power warning setpoint (dBm)	dBm	
RDPOHIW	Returns over forward power warning setpoint (W)	watts	Pohi=[ ]W
SPOHIW	Sets over forward power warning setpoint (W)	watts	
RDPOLOW	Returns under forward power warning setpoint (W)	watts	Polo=[ ]W
SPOLOW	Sets under forward power warning setpoint (W)	watts	
RDPRHID	Returns over reverse power warning setpoint (dB)	dBm	Prhi=[ ]dBm
SPPRHID	Sets over reverse power warning setpoint (dBm)	dBm	
RDPRHIW	Returns over reverse power warning setpoint (W)	watts	Prhi=[ ]W
SPRHIW	Sets over reverse power warning setpoint (W)	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)		[ ]

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 or last command was successful.
1	Last command 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.
60	Command not allowed
901	Assert error: invalid table argument *
902	Assert error: invalid table argument *

* 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	Fault Code	Meaning
0	No fault	82	TUBE ARC4
8	FIL NOT READY1	83	TWT OVER TEMP4(h)
9	LOW LINE1	84	CABINET O/TEMP4(h)
10	CATH O/VOLTAGE1	86	EXTERNAL INHIBIT4
11	BODY O/CURRENT1	87	OVER REV POWER4
12	CATH U/VOLTAGE1	90	Panel Open4
15	COLL U/VOLTAGE1	91	latched fault4
16	INVERTER FAULT1	104	FIL NOT READY3
17	INTERLK OPEN1	105	LOW LINE3
18	TUBE ARC1	106	CATH O/VOLTAGE3
19	TWT OVER TEMP1(h)	107	BODY O/CURRENT3
20	CABINET O/TEMP1(h)	108	CATH U/VOLTAGE3
21	EXTERNAL INHIBIT1	111	COLL U/VOLTAGE3
22	OVER REV POWER1	112	INVERTER FAULT3
26	Panel Open1	113	INTERLK OPEN3
27	latched fault1	114	TUBE ARC3
40	FIL NOT READY2	115	TWT OVER TEMP3(h)
41	LOW LINE3	116	CABINET O/TEMP3(h)
42	CATH O/VOLTAGE3	118	EXTERNAL INHIBIT3
43	BODY O/CURRENT3	119	OVER REV POWER3
44	CATH U/VOLTAGE3	122	Panel Open3
47	COLL U/VOLTAGE3	123	latched fault3
48	INVERTER FAULT3	136	TWT1 Over rev power
49	INTERLK OPEN3	137	TWT2 Over rev power
50	TUBE ARC3	138	TWT3 Over rev power
51	TWT OVER TEMP3(h)	139	TWT4 Over rev power
52	CABINET O/TEMP3(h)	140	Output over rev power
54	EXTERNAL INHIBIT3	186	TWT1 OVR TMP1 (s)
55	OVER REV POWER3	187	CHASSIS OVR TMP1 (s)
58	Panel Open3	188	TWT2 OVR TMP1 (s)
59	latched fault3	189	TWT1 OVR TMP2 (s)
72	FIL NOT READY4	190	CHASSIS OVR TMP2 (s)
73	LOW LINE4	191	TWT2 OVR TMP2 (s)
74	CATH O/VOLTAGE4	192	TWT1 OVR TMP3 (s)
75	BODY O/CURRENT4	193	CHASSIS OVR TMP3 (s)
76	CATH U/VOLTAGE4	194	TWT2 OVR TMP3 (s)
79	COLL U/VOLTAGE4	195	TWT1 OVR TMP4 (s)
80	INVERTER FAULT4	196	CHASSIS OVR TMP4 (s)
81	INTERLK OPEN4	197	TWT2 OVR TMP4 (s)

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 (i. e., 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 10^9) BW factor = -76 + 96=] +20 dBm, or 0.1 watts. This power is insignificant for a user operating at 200 watts (+53 dBm), but may be very noticeable to a user trying to operate below 1 watt (+30 dBm). [One watt is 0.5% of (23dB 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 [53dBm – 20dBm = 33dB 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 has 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.

The service measures involve pulsing of the tube beam current and gradually increasing the duty of the pulsing until the unit will operate continuously. Note that a similar condition can exist for tubes with grids when the TWTA is in the Operate mode (high voltage is on) but gating (control) input is set so that the grid turns off the TWT beam current. Operational procedures should also limit the time in this 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, power supply voltages and currents, and system temperatures of the TWTA should be logged on a regular basis. Maintenance should be performed if significant deviations from the logged values appear. For a unit still under warranty, contact an authorized service representative if impaired performance is suspected.

The air intake filters are the only items that require routine service. The frequency of service depends on the environment where the TWTA is used, and must be determined by inspection

If there is accumulated dust on any of the air intake filters, remove them and clean them with dry compressed air. If the filters show signs of deterioration, purchase replacement units.

If significant dust has been noted on the air intake filters, it may be desirable to vacuum the dust and debris from inside the enclosure. Perform this procedure to only one power supply at a time:

1. Access the power supply subassembly from the rack as follows:

   Disconnect power. On the front of the unit, remove the four screws (two outside screws on each side) mounting the front panel to the cabinet. Carefully slide the unit out of the front of the cabinet. Slide power supply out until the top cover is fully accessible to remove.

2. Remove the screws that secure the top cover. Remove the cover to gain access to the interior of the unit.

3. Vacuum dust and debris from inside the enclosure. Clean dust from the power supply high voltage leads. Remove any dirt from around the high voltage connectors. While the cover is off, check for loose wires, components or fasteners.

4. Reassemble in reverse order.

CAUTION:
Be especially careful with type SMA RF connectors, which are fragile and easily damaged when incorrectly aligned during the assembly process.

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
Control module display does not come up; unit does not beep when powered up	Shorted or defective control module power supply
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.
Voltages normal, but no RF output, helix current low	No RF input
	Defective SSA
	Gain turned down

After review of 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 reassembly. 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, the Grid modulator, the HV filter, and the Diode/Cap Assembly are encapsulated modules and are not repairable. Contact an authorized service representative if replacement modules are needed.

4.6 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
```

WARRANTIES: LIMITATION OF LIABILITY

Seller warrants (i) that seller has title to the goods sold and (ii) that Amplifiers (all parts excluding traveling wave and vacuum tubes), Antennas, field monitors, field probes, field analyzers, field analyzer processor units, system controllers, system interlock, power meters, leak detectors, RF conducted probes, RF conducted clamps, Multi-tone, EMI receiver systems, RF down converters, RF conducted immunity systems, conducted immunity accessories, radiated immunity test systems, safety meters, safety sensor heads, tripods, directional couplers, waveguide adapters, termination loads, load attenuators, impedance stabilization networks, and coaxial cables will be free from defects in material and workmanship for a period of three (3) years from date of shipment shown on AR RF/Microwave Instrumentation invoice.

All modules, used in the amplifiers for the 1-6 GHz, 4-18 GHz, 6-18 GHz, all HPM products, and other applications, are hermetically-sealed. This sealing process protects the internal hybrid circuitry from humidity that could compromise the long term reliability of the product. These modules are not field-repairable and should *never* be opened outside of AR's Microelectronics Lab. The modules in these product lines have a security label on two sides of the modules between the housing and lid/cover. If the security label is removed and or cut, the warranty of the module will be voided.

Vacuum tubes in the 'L' series amplifiers, traveling-wave tubes in TWT amplifiers, and power heads will be free from defects in material and workmanship for a period of one (1) year.

Contact AR RF/Microwave Instrumentation for warranty information regarding items not listed.

Seller's sole responsibility in fulfilling these warranties shall be to repair or replace any goods which do not conform to the foregoing warranties or, at seller's option, to give buyer credit for defective goods. The warranty is valid only when used in the country specified at time of order. Warranty service must be obtained from the repair facility designated at that time. If warranty service is not available in the country where the equipment is to be used, it must be returned to AR RF/Microwave Instrumentation. Warranty service will be provided only for defective goods which are returned within the warranty period, freight costs prepaid to AR RF/Microwave Instrumentation or its designated repair facility.

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

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

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