rf/microwave instrumentation

Operating and Service Manual

500T8G18M8

Model

10012342

Part Number

Serial Number

160 School House Road, Souderton, PA 18964 • 215-723-8181 • Fax 215-723-5688 • www.arworld.us

rf/microwave instrumentation

EC Declaration of Conformity

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

declare that our product(s);

the Models 500T1G2 series, 500T2G8 series and 500T8G18 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 (73/23/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

Observe the following safety guidelines to help ensure your own personal safety and to help protect your equipment and working environment from potential damage.

INTENDED USE

This equipment is intended for general laboratory use in generating, controlling, and measuring levels of electromagnetic Radio Frequency (RF) energy. Ensure that the device is operated in a location which will control the radiated energy and will not cause injury or violate regulatory levels of electromagnetic interference.

SAFETY SYMBOLS

These symbols may appear in your user manual or on equipment.

	This symbol is marked on the equipment when it is necessary for the user to refer to the manual for important safety information. The caution symbol denotes a potential hazard. Attention must be given to the statement to prevent damage, destruction, or harm.
	Dangerous voltages are present. Use extreme care.
	Indicates a terminal intended for connection to an external conductor for protection against electrical shock in case of a fault, or the terminal of a protective earth (ground) electrode.
	Indicates invisible laser radiation–do not view directly with optical instruments.
	Indicates frame or chassis ground connection terminal.
	Indicates alternating current.
	Indicates this product must not be disposed of with your other household waste.
	Indicates that the marked surface and adjacent surfaces can attain temperatures that may be hot to the touch.

EQUIPMENT SETUP PRECAUTIONS

Review the user manual and become familiar with all safety markings and instructions. Protection provided by the equipment may be impaired if used in a manner not specified by AR RF/Microwave Instrumentation (AR).

- Follow all lifting instructions specified in this document.
- Place the equipment on a hard, level surface.
- Do not use the equipment in a wet environment, for example, near a sink, or in a wet basement.
- Position your equipment so that the power switch is easily accessible.
- Leave 10.2 cm (4 in) minimum of clearance on all vented sides of the equipment to permit the airflow required for proper ventilation. Do not restrict airflow into the equipment by blocking any vents or air intakes. Restricting airflow can result in damage to the equipment, intermittent shut-downs or safety hazards.
- Keep equipment away from extremely hot or cold temperatures to ensure that it is used within the specified operating range.
- While installing accessories such as antennas, directional couplers and field probes, take care to avoid any exposure to hazardous RF levels.
- Ensure that nothing rests on your equipment's cables and that the cables are not located where they can be stepped on or tripped over.
- Move equipment with care; ensure that all casters and/or cables are firmly connected to the system. Avoid sudden stops and uneven surfaces.

BEFORE APPLYING POWER

Your AR equipment may have more than one power supply cable. Use only approved power cable(s). If you have not been provided with a power cable for the equipment or for any AC-powered option intended for the equipment, purchase a power cable that is approved for use in your country. The power cable must be rated for the equipment and for the voltage and current marked on the equipment's electrical ratings label.

Incorrectly installing or using an incompatible line voltage may increase the risk of fire or other hazards. To help prevent electric shock, plug the equipment and peripheral power cables into properly grounded electrical outlets. These cables are equipped with three-prong plugs to help ensure proper grounding. Do not use adapter plugs or remove the grounding prong from a cable.

Do not modify power cables or plugs. Consult a licensed electrician or AR trained service technician for equipment modifications. Always follow your local/national wiring rules.

Do not operate the equipment if there is physical damage, missing hardware, or missing panels.

SAFETY GROUND

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

INSTRUCTIONS FOR SAFE OPERATION

HAZARDOUS RF VOLTAGES

The RF voltages on the center pin of an RF output connector can be hazardous. The RF output connector should be connected to a load before AC power is applied to the equipment. 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.

ACOUSTIC LIMITATIONS

If equipment noise exceeds 80dB, ear protection is required.

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.

ENVIRONMENTAL CONDITIONS

Unless otherwise stated on the product specification sheet, 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.

EQUIPMENT CONTAINING LASERS

AR Field Probes (FL/PL Series) and Field Analyzers (FA Series) are Class 1 laser products containing embedded Class 4 lasers. Under normal use, the laser radiation is completely contained within the fiber optic cables and poses no threat of exposure. Safety interlocks ensure that the laser is not activated unless the cables are properly connected. Always exercise caution when using or maintaining laser products. Do not view directly with optical instruments.

RF ANTENNAS

- This equipment (antenna or antenna assembly) may be heavy, requiring two persons to lift. Use caution when installing or removing unit. Follow all equipment setup and lifting instructions specified in this document.
- Ensure connectors are appropriate for intended operation. Connectors are specified in the user manual and product specification sheet.
- Do not exceed the maximum RF input level stated in the specifications. Refer to the user manual and product specification sheet to determine the applicable RF levels.
- Excessive RF input could damage the equipment or connectors, causing safety hazards.
- When in operation, the RF voltages on the antenna elements can be hazardous. Do not come into contact with the antenna or elements when the RF input connector is connected to a live RF source.
- To avoid injury to personnel and accidental damage to power amplifier or antenna, disable the RF output of power amplifier before connecting or disconnecting the input connection to the antenna.
- Perform periodic inspections of antenna and field probe systems to verify calibration due date, proper operation, and overall condition of equipment.

RACK MOUNTED TWT MODELS

Some TWT models are supplied without the removable enclosure offered for benchtop use. These rack-mountable models may be supplied with either carry handles or slides and front handles installed. Follow all lifting instructions specified in this document and installation instructions supplied in the TWT user manual.

LIFTING INSTRUCTIONS FOR AR EQUIPMENT

Because most products must be handled during distribution, assembly and use, the risk of serious injury due to unsafe product handling should be a fundamental consideration of every user. An authoritative guideline for eliminating unwarranted risk of injury caused by lifting is provided by the NIOSH Work Practices (Publication #94-110) available at:

https://www.cdc.gov/niosh/docs/94-110/pdfs/94-110.pdf.

In general, observe the following guidelines for lifting a weight of 50 lb or more:

- Use lifting eye (for floor standing) or side handles (table top) to lift unit only.
- Use equipment of adequate capacity to lift and support unit.
- If using forklift to move unit, be sure forks are long enough to extend beyond the side of the unit.
- For additional information, follow the link specified above.

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.

ADDENDUM

This addendum is applicable to and is only for use with TWTA models that are supplied:

- without the outer cabinet
- without the outer cabinet, with carry handles
- without the outer cabinet - supplied with slides and front handles installed

Refer to the Model Specification sheet in the manual to determine the applicability to a specific model.

MODELS SUPPLIED WITHOUT THE OUTER CABINET

Some models are supplied without the removable enclosure offered for bench top use. These models may be rack mounted as described in Section 3.2, **Installation**.

MODELS SUPPLIED WITHOUT THE OUTER CABINET – SUPPLIED WITH CARRY HANDLES

Some models are supplied without the removable enclosure offered for bench top use and supplied with added carry handles on each side, and with pull handles on the front. When installing the unit in a rack, the side mounted carry handles may be used to position the unit. Before sliding the unit into the rack, lower the carry handles against the side of the unit so that the handles will clear the rack rails.

CAUTION:

Do not use front mount handles to carry unit.

Front handles are for use in sliding the unit out of a rack. Before pulling unit, remove front rack mounting screws and disconnect all connectors from the rear of the unit.

CAUTION:

This unit is heavy, requiring two persons to lift. Use caution when installing or removing unit.

MODELS SUPPLIED WITHOUT THE OUTER CABINET - SUPPLIED WITH SLIDES AND FRONT HANDLES INSTALLED

Some models are supplied without the removable enclosure for bench top use, and are supplied with front handles and slides for rack mounting. Intended for 19 inch wide rack mounting, the slides are suitable for a rack with 24 through 32 inch frame depth. Use of slides permits installation of multiple units without the 1¾ inch separation between units as described in Section 3.2, **Installation**.

CAUTION:

Do not use front mount handles to carry unit.

Front handles are for use in sliding the unit out of a rack. Before pulling unit, remove front rack mounting screws and disconnect all connectors from the rear of the unit.

The slide detents will latch in the forward position of the unit. Depress the two detents to return the unit to the rack, or to release the slides for removal of the unit.

CAUTION:

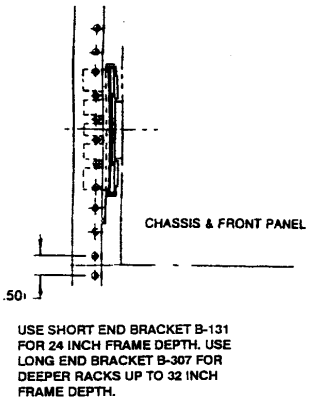
This unit is heavy, requiring two persons to lift. Use caution when installing or removing unit.

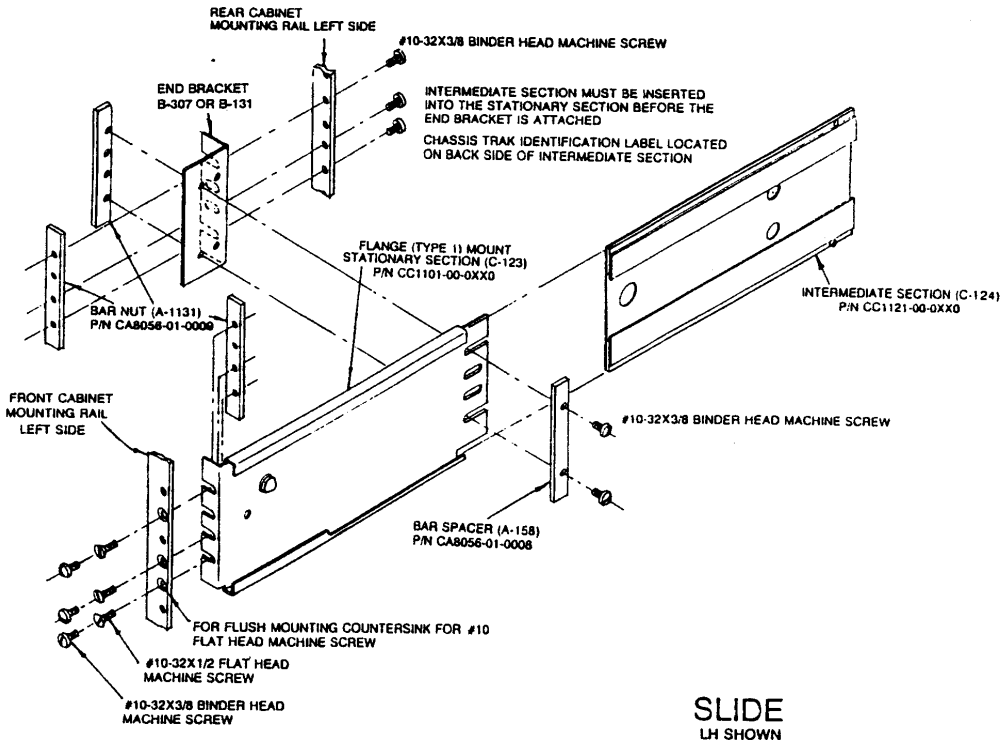
CAUTION:

Before installing or pulling unit from rack, check that rack is firmly anchored and will not tilt forward when slides are extended.

SLIDE ASSEMBLY INSTALLATION GUIDE

A slide assembly installation guide follows. Installers should check that the rack is sufficiently stable so that it will not tilt forward when slides are extended.





PART NUMBERS SHOWN ON THIS SHEET ARE GENERAL DEVICES PART NUMBERS.

SLIDE ASSEMBLY INSTALLATION GUIDE

rf/microwave instrumentation

Suggested Periodic Maintenance for TWT Amplifiers

1. Keep monthly log of the voltages, currents and temperatures as shown on Menus. Also record Date, “Console” and “Operate” hours. Take readings in Operate mode with the gain at zero (0%) percent. Leave unit in Operate mode for 20 minutes (Max Duty if Pulsed Unit), and then record data. Review the log to identify trends and contact factory if required.

2. Keep monthly log of performance with active RF. At mid-band frequency, with Gain set to 100%, apply RF drive that will provide rated power. This will help indicate if the gain or power is changing and if the traveling wave tube or pre-amp needs service. Record the following:

    a. RF Drive Level
    b. Forward Power
    c. Reverse Power
    d. Body Current (Iw)
    e. Sample Port Power reading (if possible).

3. Remove air intake filter and clean using compressed air and/or vacuum cleaner.

4. Ensure air inlet and outlet are unobstructed.

5. Check that AC Input connections are secure. Make sure the AC cable is not damaged or deteriorated.

6. Check that both input and output RF connections (waveguide or coax) are connected tightly and un-damaged.

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FIGURES

TABLES

1. DESCRIPTION AND SPECIFICATIONS

This manual provides operating, interfacing and selected service information pertinent to AR Worldwide Model 500T8G18 Broadband Microwave Amplifier. The Model 500T8G18 is a 500 watt I/J band traveling-wave tube amplifier (TWTA). This manual supports models offering three phase and single phase operation, as well models offering additional special features. Refer to the model specification sheet to determine the applicable features of this unit.

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 500 watts minimum output over the amplifier's full bandwidth. The amplifier is well suited for susceptibility and general laboratory testing where moderate harmonic levels 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. It is packaged in two sub units: a power supply/control module that is housed in a standard 19 inch rack cabinet 8.75 inches high, and an RF power unit (the supertube) that is housed in a rack cabinet 5.25 inches high. They are interconnected by low voltage and high voltage cable assemblies.

Primary power is 208 volts (±10%) 50/60 Hz., three-phase, five-wire or alternatively depending upon Model 190-260VAC single-phase 50/60 Hz. An efficient switching power supply design provides minimum power consumption. In addition, TWTs 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 enclosures 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 Amplifier Research Data Sheet at the end of this section 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.

500T8G18

- M1–M10
- 500 Watts CW
- 7.5GHz–18GHz

Features

The Model 500T8G18 is a self contained, forced air cooled, broadband traveling wave tube (TWT) microwave amplifier designed for applications where instantaneous bandwidth, reduced harmonics and high gain are required. A reliable TWT subsystem provides a conservative 500 watts minimum at the amplifier output connector. Stated power specifications are at fundamental frequency.

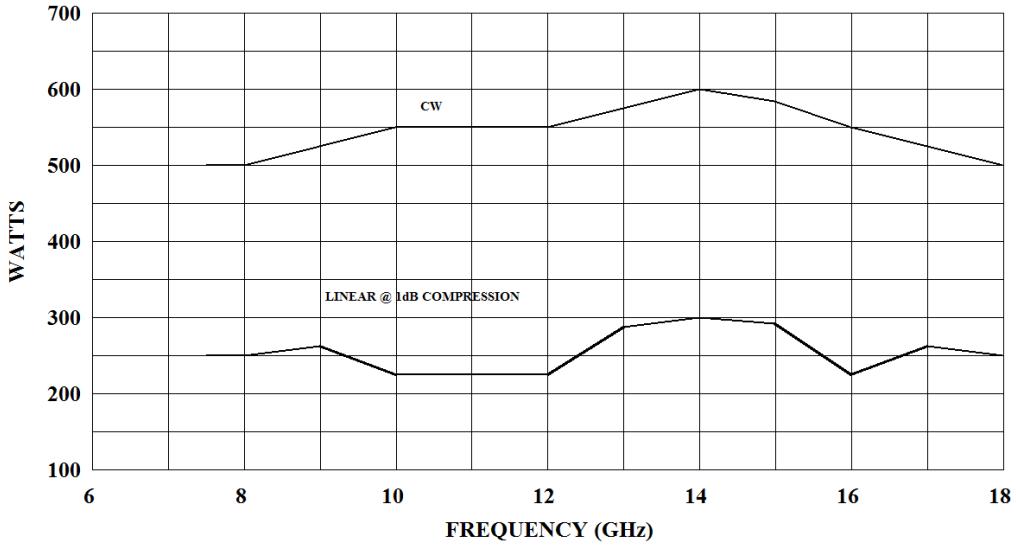
The amplifier's front panel digital display shows forward and reflected output plus extensive system status information accessed through a series of menus via soft keys. Status indicators include power on, warm-up, standby, operate, faults, excess reflected power warning and remote. Standard features include a built-in IEEE-488 (GPIB) interface, 0 dBm input, VSWR protection, gain control, RF output sample port, 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, this unit is designed for benchtop use, but can be removed from cabinet for rack mounting. The Model 500T8G18 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.

See Model Configuration for primary power, package alternatives, and selected features.

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.

500T8G18 TYPICAL POWER OUTPUT



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500T8G18

- M1–M10
- 500 Watts CW
- 7.5GHz–18GHz

Model Configurations

POWER (fundamental), CW, @ OUTPUT CONNECTOR:
Nominal, 543 watts; Minimum, 500 watts;
Linear @ 1 dB Compression, 125 watts minimum

FLATNESS: ±11 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): 57 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 100 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 70 dBm/Hz (maximum); Minus 72 dBm/Hz (typical)

HARMONIC DISTORTION: Minus 20 dBc maximum; Minus 22 dBc typical

CONNECTORS:

RF input:	Type N female, rear panel
RF output:	Type WRD-750D24 waveguide flange, rear panel
RF output sample port:	Type N female, rear panel
GPIB:	IEEE – 488 (f), rear panel
Interlock	DB-15 (f), rear panel

COOLING: Forced air (self contained fans), air entry and exit in rear.

EXPORT CLASSIFICATION: EAR99

Model Configurations

Model Number	Description	Primary Power	Weight	Size (W x H x D)
500T8G18	With removable enclosure	208 VAC ±10% 3-phase 50/60 Hz 4 KVA maximum	91 kg (200 lbs)	50.3 x 40.6 x 68.6 cm 19.8 x 16.0 x 27 in
500T8G18M1	See Separate Specification Sheet			
500T8G18M2	With removable enclosure and added reflected RF output sample port	190-260VAC single phase 50/60Hz 4KVA maximum	91kg (160lbs)	50.3 x 40.6 x 81.3 cm 19.8 x 16.0 x 32 in
500T8G18M3	See Separate Specification Sheet			
500T8G18M4	Shipped w/o an outer cabinet	208 VAC ±10% 3-phase 50/60 Hz 4 KVA maximum	73 kg (160 lbs)	48.3 x 35.6 x 68.6 cm 19.0 x 14.0 x 27 in
500T8G18M5	With removable enclosure	190-260 VAC single phase 50/60Hz 4 KVA maximum	91 kg (200 lbs)	50.3 x 40.6 x 81.3 cm 19.8 x 16.0 x 32 in
500T8G18M6	Shipped w/o an outer cabinet	190-260 VAC single phase 50/60Hz 4 KVA maximum	73 kg (160 lbs)	48.3 x 35.6 x 81.3 cm 19.0 x 14.0 x 32 in
500T8G18M7	Enclosure removed for rack mounting – slides and front handles installed	208 VAC ±10% 3-phase 50/60 Hz 4 KVA maximum	67 kg (170 lbs)	48.3 x 35.6 x 68.6 cm 19.0 x 14.0 x 27 in
500T8G18M8	Enclosure removed for rack mounting – slides and front handles installed	190-260 VAC single phase 50/60Hz 4 KVA maximum	67 kg (170 lbs)	48.3 x 35.6 x 81.3 cm 19.0 x 14.0 x 32 in

continued

500T8G18

- M1–M10
- 500 Watts CW
- 7.5GHz–18GHz

Model Configurations

Model Number	Description	Primary Power	Weight	Size (W x H x D)
500T8G18M9	Selected for 600 watts from 8 – 9GHz, with removable enclosure	208 VAC ±10% 3-phase 50/60 Hz 4 KVA maximum	91 kg (200 lbs)	50.3 x 40.6 x 68.6 cm 19.8 x 16.0 x 27 in
500T8G18M10	Shipped w/o an outer cabinet, flatness ±3 dB max at rated power, and a video pulse capability to offer blanking capability to use for noise quieting. VIDEO PULSE CAPABILITY -Pulse Width: 0.1 – 20 microseconds -Pulse Rate (PRF): 10 kHz to 100 kHz -RF Rise and Fall: 30 ns max (10% to 90%) -Delay: 300 ns max from pulse input to RF90% -Pulse width distortion: ±30 ns max (50% points of output pulse width compared to 50% points of input pulse width) NOISE POWER DENSITY (pulse off): Minus 140 dBm/Hz (typical) CONNECTOR -Video: BNC-female on rear panel	190-260 VAC single phase 50/60Hz 4 KVA maximum	73 kg (160 lbs)	48.3 x 35.6 x 81.3 cm 19.0 x 14.0 x 32 in
500T8G18M11	OBSOLETE			

2. THEORY OF OPERATION

2.1 DESIGN OF THE AMPLIFIER

The Model 500T8G18 TWT amplifier consists of two packages, the supertube and the power supply/control module. The power supply/control module, in turn, consists of three subsystems. Two of these subsystems, the microwave components and the TWT power supply, are discussed in sections 2.2 and 2.3, respectively.

The third subsystem is the microprocessor control system. This consists of a number of subassemblies. See the build tree in section 5.1 for further information about how the parts lists are structured.

The heart of the microprocessor control system is the control head assembly (A22933-300), which consists of the CPU board (A25450-000) 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 thru the IEEE-488 interface bus, is electrically isolated from the amplifier. Communication with the amplifier is via fiberoptic links to the HPA interface assembly (A25444-000).

2.2 DESCRIPTION OF THE RF CIRCUIT

The TWTA consists of two stages of RF amplification: a solid state preamp assembly with adjustable gain (E01415-000) and the dual traveling-wave tubes that are power combined in the RF chassis(E08114-001).

The type N RF input connector is located on the rear panel of the supertube module. The RF input is fed to the input connector on the solid state preamp. The solid state preamp's output drives the RF input of the TWT module. The RF output of the TWT is a type WRD-750 waveguide flange on the rear panel of the tube assembly. A dual directional coupler is built into the tube assembly. The forward output is split off by a -10 dB coupler to provide a forward sample on the rear panel of the supertube. The through output of this coupler is attenuated by a pad and detected by a zero-bias schottky RF detector. The output of the detector is buffered by an operational amplifier for noise reduction. The buffered signal is sent to the power supply/control module and is used for internal forward power metering.

The reflected RF signal is likewise detected and buffered and sent to the power supply/control module. The detected signal 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.

CAUTION:

There are two cables between the power supply/control module and the supertube assembly. See section 3.2.3, Interconnecting Cables, for instructions for interconnecting the two modules.

Amplifier gain is determined by the solid state preamp (SSA), which has a voltage-controlled variable gain stage. 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 SSA gain. The emergency bypass board (A24830-001) is mounted behind the front panel. It is provided with a circuit that increases the attenuation so that reflected power is limited to a level that can be safely sustained without damage to the amplifier (on the order of 100 watts). In emergency bypass operation (see section 3.7) the gain control signal is provided locally by means of a

potentiometer on the emergency bypass board. However, the foldback circuit remains on line in emergency bypass operation.

2.3 DESCRIPTION OF THE POWER SUPPLY

The three phase version (A22525-313) is described. The TWT power supply provides cathode, heater, grid, and collector power for both tubes in the supertube assembly. The power supply 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 (A26452-000). In addition this module provides DC power for the HPA interface and emergency bypass boards. Control logic and TWT protection circuits are contained in the HPA Logic and Control Assembly (A23050-313).

The Heater Power Supply Module (A27824-000) powers the TWT DC heaters. Grid bias and pulse top are provided by the two Grid Modulator Modules (A21422-000 and A21422-001). Two modules are used since the two tubes in the supertube sometimes require different grid pulse top levels.

The high voltage power supply consists of the following: the three-phase power input module (A23065-000) converts line voltage to DC for the high voltage switching supply. Switching transistors are on the Power Inverter Module (A27815-313), and switching is controlled by the Regulation Board (A21440-313). The high voltage transformer and rectifiers are contained in the High Voltage Rectifier and Transformer Module (A26258-000). The high voltage DC is filtered in the HV Filter Assembly (A23044-000).

Low voltage interconnects between the power supply modules are through a motherboard. It is installed in a protective housing, attached perpendicularly to the finned heat sink assembly to which the modules are bolted. The heat sink is cooled by a 400 Hz. high speed AC blower at the rear of the cabinet. The Motherboard assembly is A23013-001.

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

The TWTA is shipped in two shipping containers.

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

Save and store the shipping containers in case the TWTA needs to be returned in the future for calibration or 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.

When the amplifier is rack-mounted, it is strongly recommended that the supertube module be mounted above the power supply/control module, so that the power supply will not draw in the hot air exiting the TWT cooling ducts of the supertube module. See Section 3.2.4, **Cooling Requirements**.

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

NOTE: Due to the weight of the unit, the installation or removal of the power supply/control module portion of the amplifier is a two-person operation.

NOTE: When moving, removing, or installing the amplifier, always separate the two modules by first carefully removing the interconnect cables.

NOTE: Use great care to prevent dust or moisture from entering the high voltage connectors. Keep them and the mating receptacles capped when they are not installed. See section 4.6, ***Cleaning and Mating High Voltage Connectors****.*

Before removal, disconnect power, RF, and any other interface connectors as well as the interconnecting cables. On the rear of the units, remove any screws used to connect Transport brackets to the module. On the front of the units, remove the four screws holding each front panel to the rack. Carefully slide each chassis out of the front of the rack.

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 must be provided in a rack mount configuration.

See Figure 3-1 (below) for the locations of threaded holes on the power supply/control module that may be used for supplementary support of the rear of this unit.

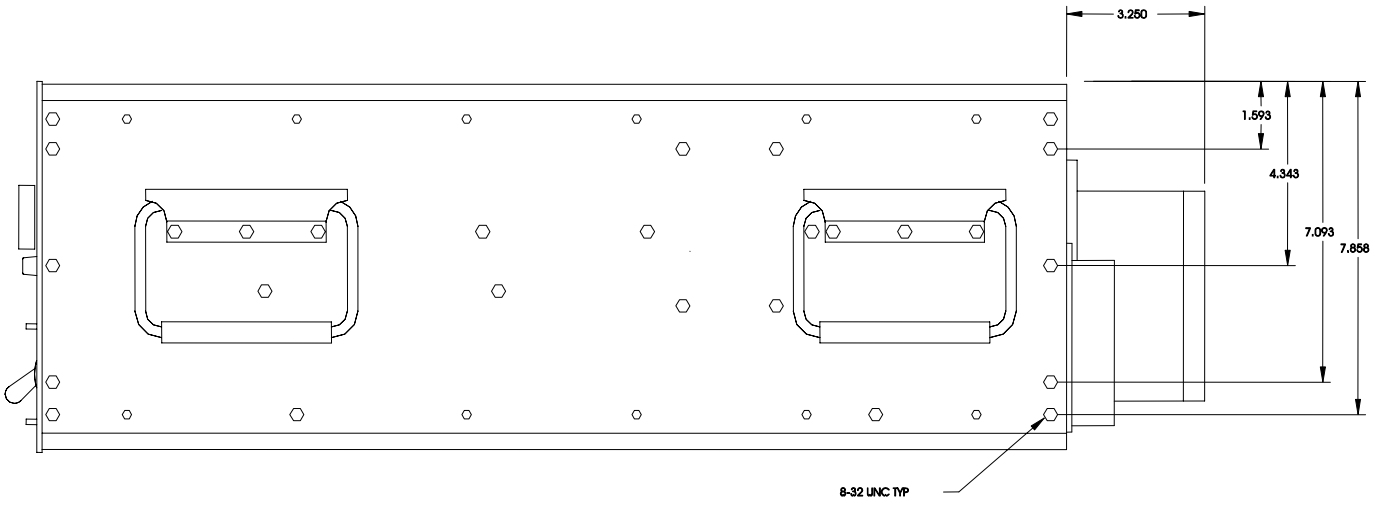


Figure 3-1. Location of Threaded Support Holes

If bottom supports are used for rack mount installation of single or multiple units, the units 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 Interconnecting Cables

Proper installation of the two interconnecting cables is essential for proper operation of the amplifier. Failure to install the cables correctly will result in failure of the unit to operate. Table 3-1 lists the interconnecting cables, and Figure 3.2 shows them pictorially.

Table 3-1. Interconnecting Cables

Cable Ref. Des.	Cable Part No.	PS Module Connector	Tube Module Connector	Signal
A3	A28014	J3	J3	Low voltage cabling
A4	E08143	J4	J4	High voltage for TWTs

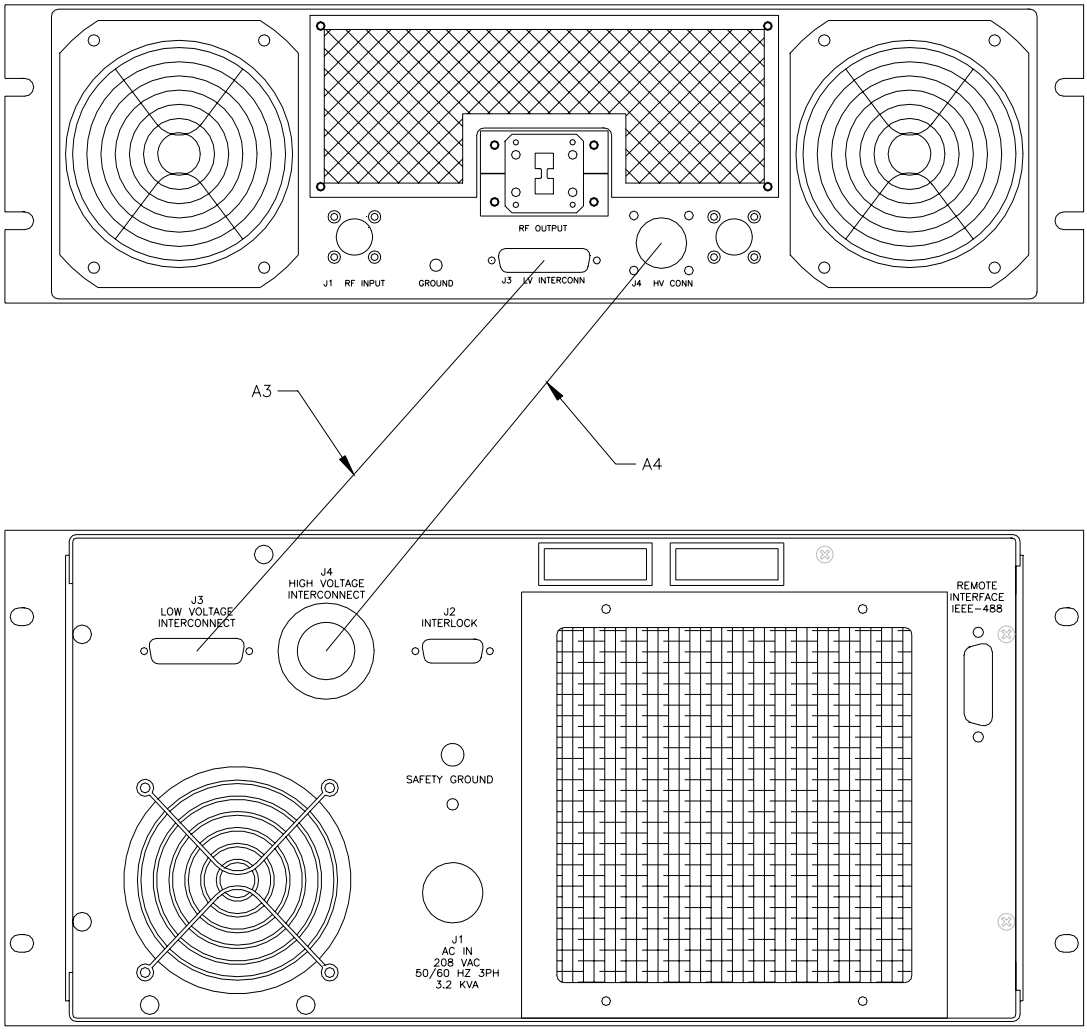


Figure 3-2. Rear Panels Showing Location of Receptacles and Interconnecting Cables

3.2.4 Cooling Requirements

The power supply/control module is provided with a single high-speed blower, and the supertube assembly has two identical high-speed blowers. It is important that air movement around the rear of the units 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 exhaust flow is directed into one of the intakes. See section 3.5 for location of air intake and air outlet. If the unit is rack mounted, make sure that the intake air is 45°C or below. If necessary, fabricate a short duct to direct the hot exhaust air from the TWTA cooling ducts out of the rack enclosure. Single-phase units are provided with user installed air duct extensions. 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 3300 watts when in the operate mode at full RF power.

3.2.5 AC Line Power Connections

3.2.5.1 Three-phase Models only

AC line power connection to the TWTA is made on a terminal block inside the power supply/control module enclosure. Access to the terminal block screws is by removal of the bottom panel. Strain relief for a 0.70 inch diameter cable is provided on the rear panel. The power cord must be five-wire, with conductors of 14 gauge or heavier. For use in North America, the following color codes for the power cable should be observed:

Color	Function
Green	Ground
White	Neutral
Red	Phase
Black	Phase
Orange	Phase

The amplifier is insensitive to phase rotation. Some amplifiers for the North American market may be provided with a power cord.

3.2.5.2 Single-phase Models only

The AC line power connection to the TWTA is made through an IEC-320 16A connector on the rear panel. The connector is provided with a bracket that can be used to secure the mating plug from accidental withdrawal. The power cord must be 3-wire, with conductors of 12 gauge or heavier.

Units are provided with an unterminated 3-wire cord. To use this line cord, it should be terminated with a suitable plug to a 190 to 260 VAC 50-60 Hz single-phase source as follows:

Color		Function
International Harmonized	**North American**	
Brown	Black	Line
Blue	White	Neutral
Yellow/Green	Green	Safety Ground

CAUTION:

Connect plug to J1 and secure plug with bracket only when no AC is supplied to the cord.

3.2.6 RF Output Connections

The RF output connector is type WRD-750 waveguide.

CAUTION:

Never operate the TWTA without a matched output load rated for at least 1000 watts, continuous. The TWTA is not provided with an output isolator. Full reflected power may irreparably damage the TWT. Even with no drive, "looping" oscillation can result in RF output of sufficient amplitude to damage the tube if it is operated without a load. The VSWR detection and foldback circuits are provided to protect the tube from progressive failure or mismatch of the output load; they should not be relied on for protection from the absence of a load.

If an external isolator is installed at the output of the TWTA, either the isolator should have a load capable of dissipating the full output of the TWTA or the isolator load should be provided with a temperature-sensing switch. The temperature switch should be normally closed, self-resetting, and with a temperature rating such that there is no possibility of damaging the load by overheating before the switch opens. The TWTA may be interlocked with the switch by connecting it between pins 10 and 11 of the external interlock connector (J2) of the power supply/control module. If no external isolator is used, retain the jumpers between pins 3 and 4 and between pins 10 and 11 in the mating connector for J2 (supplied with the amplifier). See section 3.2.7, External interlock connector, below.

If an external absorptive filter is installed at the output of the TWTA, either the absorptive filter should be capable of dissipating the full output of the TWTA, or it should be provided with a temperature sensing switch as described above.

3.2.7 External Interlock Connector

The power supply/control module is provided with an external interlock capability via a 15-pin female D-sub connector, J2, on its rear panel. To enable the high voltage power supply, it is necessary to provide continuity between J2 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 Section 3.4). Users may adopt this interlock feature to turn off the high voltage power supply, and disable the RF output, either for equipment protection or as a backup for personnel protection from high output RF power.

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 such as shutting off and unplugging the TWTA to ensure that power is removed for personnel safety.

In addition, the interlock is provided with an external inhibit function. To enable the TWT beam on, it is necessary to provide continuity between pins 10 and 11 of J2. Breaking continuity drives the grids to the bias condition, shutting off the tubes and disabling the RF output. As soon as continuity is restored, the tubes will again be turned on; no reset is required.

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.

3.3 FRONT PANEL FEATURES

Refer to Figure 3-3 below.

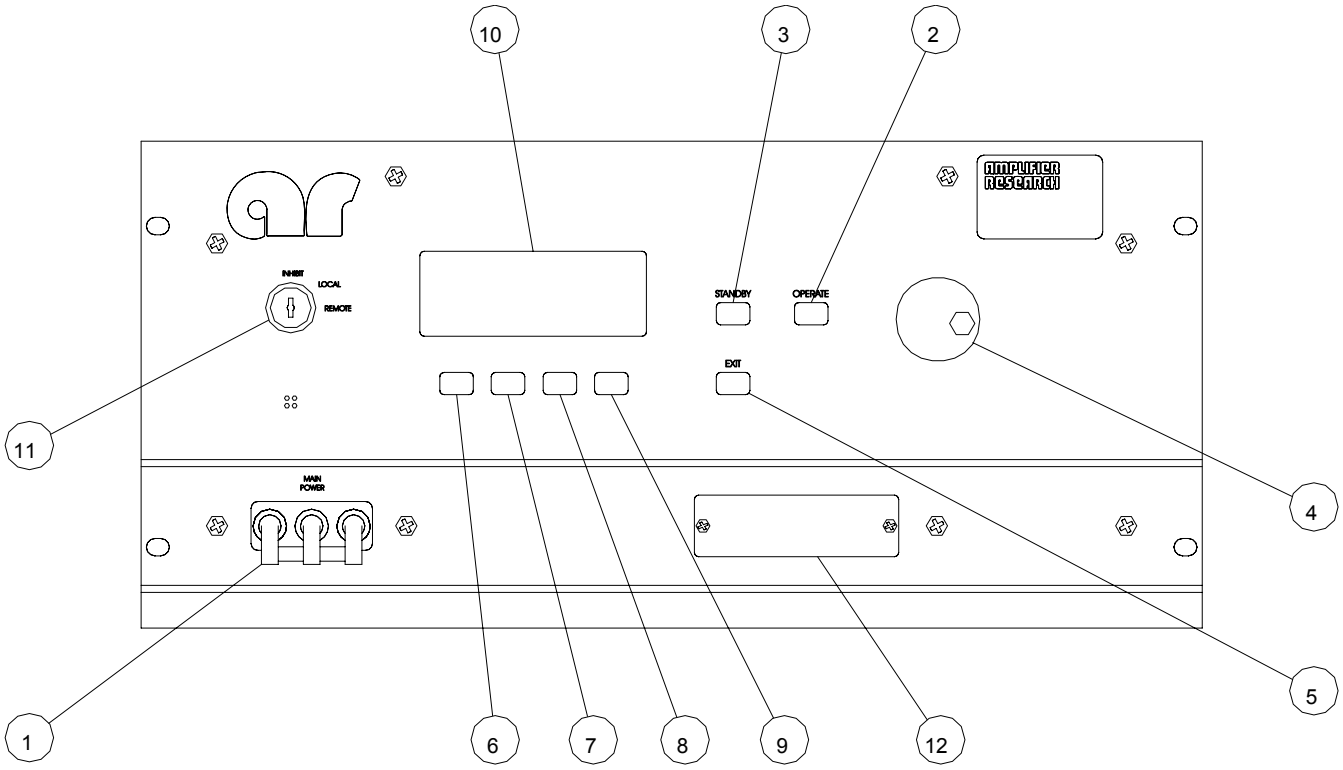


Figure 3-3. Front Panel Features

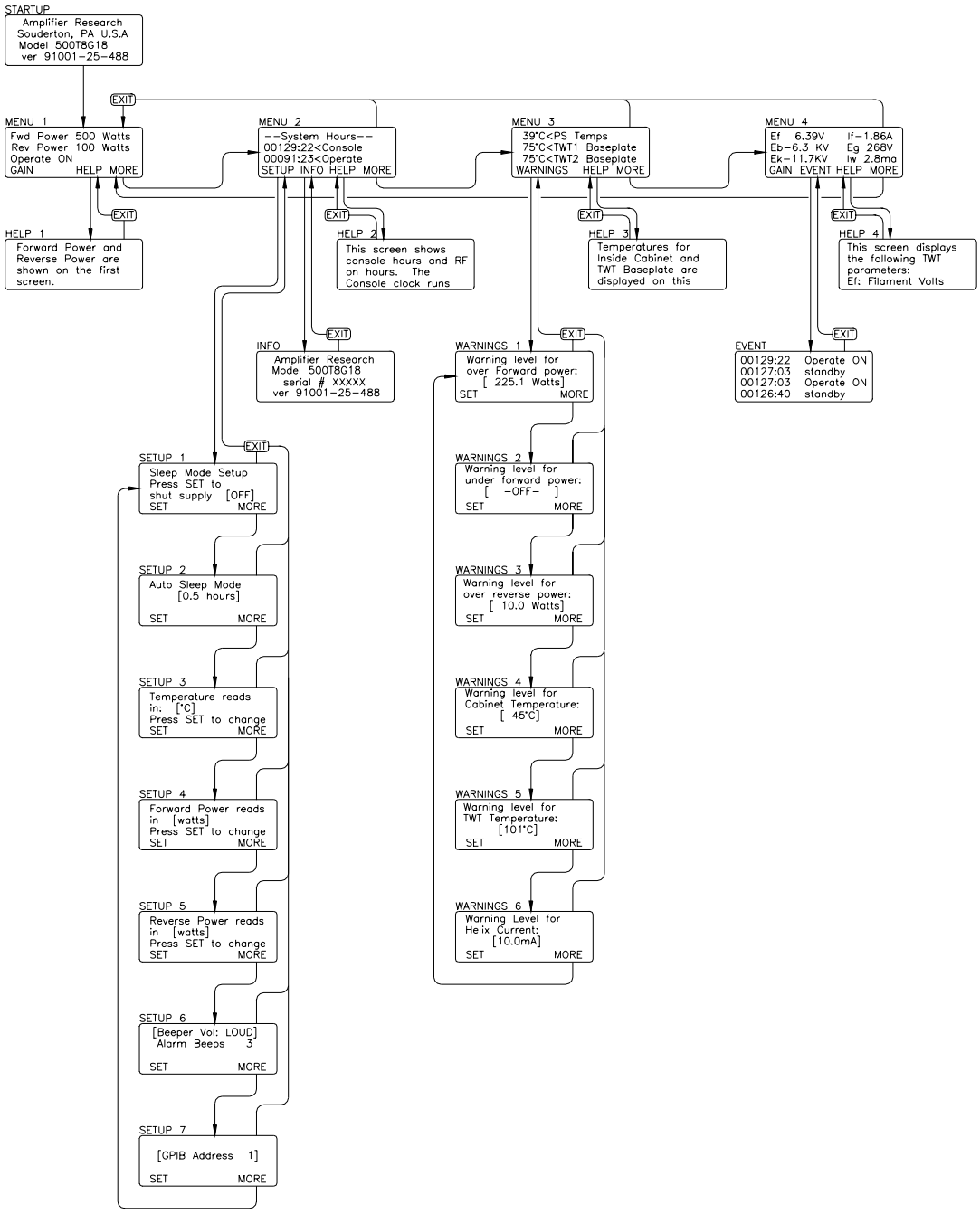
Table 3-2. Front Panel Features

Item	Title	Function
1	MAIN POWER	Switchable 15 A. circuit breaker; connects primary power-to-power supplies (3-phase shown). Single-phase model uses 30A circuit breaker.
2.	OPERATE	Push-button; turns on high voltage and SSA when all faults and heater delay are cleared.
3.	STANDBY	Push-button; shuts off SSA 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 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 3-4 provides a roadmap for navigating between the screens.

Figure 3-4. Front Panel Display Screens



Menu screens - The screens at the highest level are called menu screens. There are four 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 4, 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	FUNCTION
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	Cabinet temperature (°C or °F)
	TWT baseplate temperature (°C or °F)
MENU 4	Heater voltage (Ef)
	Heater current (If)
	Collector voltage (Eb)
	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 (see below). Pressing S1 (SET) toggles between ON and OFF. Pressing MORE again brings up the SETUP 2 screen, which allows the user to change the Auto Sleep Mode timer setting. Pressing SET will change the timer options in half hour increments from 0.5 to 3.0 hours. Pressing MORE again will save the timer setting and bring up the SETUP 3 screen, which toggles the 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 4 screen, which allows a choice of displaying forward power in watts, dBm or in strip chart form. Pressing MORE a third time brings up SETUP 5, which allows a choice of watts, dBm, or % of forward power for displaying reverse power. MORE brings up SETUP 6, 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. Setup 7 allows the IEEE-488 address to be set. 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.

To activate Sleep Mode locally:

Press the MORE soft key to get to MENU 2. At MENU 2 press the SETUP soft key to get to SETUP 1. At SETUP 1 press SET to activate Sleep Mode (turn heater and fan off). The system will ask **Are you sure?** Press SET again.

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 locally:

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.

For remote activation of Sleep Mode or to set the Auto Sleep Mode timer remotely see Table 3-5 in Section 3.8.

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 (A16485-000).

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 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 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 latched fault (i.e., a fault such as body overcurrent or power low line that requires a reset), 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. When the fault clears the system will automatically resume the standby state and high voltage on will be enabled once again.

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.

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

3.4 REAR PANEL FEATURES

See Figure 3-5 and Tables 3-3 and 3-4 for callout descriptions.

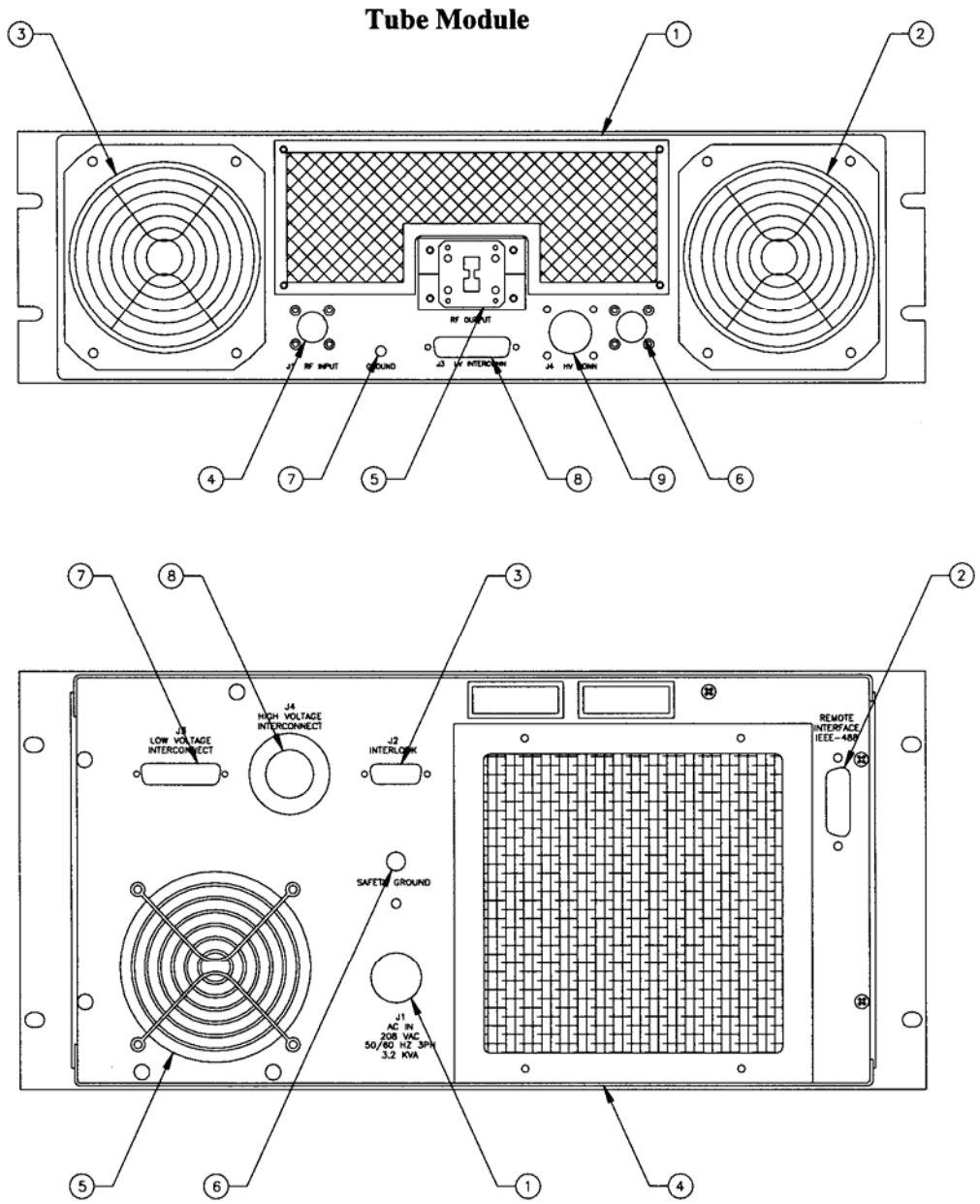


Figure 3-5. Rear Panel Features

Table 3-3. Power Supply/Control Module Rear Panel Features

Item	Ref. Des.	Title	Function
1.	1.	AC POWER IN	AC power input strain relief (3-phase model shown)
2.	J12	IEEE-488 REMOTE INTERFACE	Remote control connector: 24 pin hermaphrodite
3.	J2	EXTERNAL INTERLOCK	Connector for remote interlock and inhibit functions: D-sub 15-pin female
4.	-	—	Cooling air intake
5.	-	—	Cooling air outlet
6.		SAFETY GROUND	10-32 stud
7.	J3	LOW VOLTAGE INTERCONNECT	Provide fan power, interlock connection
8.	J4	HIGH VOLTAGE INTERCONNECT	Provide power to TWT unit

Table 3-4. Tube Module Rear Panel Features

Item	Ref. Des.	Title	Function
1.	—	—	Cooling air intake.
2, 3.	—	—	Cooling air outlets.
4.	J1	RF INPUT	Type N (female) connector
5.		RF OUTPUT	WRD-750 flange
6.	J2	RF FORWARD SAMPLE	-50 dB sample of forward power, type N (female) connectors
7.		SAFETY GROUND	10-32 stud
8.	J3	LOW VOLTAGE INTERCONNECT	Provide fan power, interlock connection
9.	J4	HIGH VOLTAGE INTERCONNECT	Provide power to TWT unit

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 J1 on the Power Supply / Control module. Set the RF generator level below -50 dBm and set the desired frequency in the specified range. Connect a load suitable for 1000 watts continuous operation to the output waveguide flange (J2) on the tube module. The load VSWR should be less than 2.0:1 A power meter and suitable attenuators may be connected to the forward RF sample port J6 on the power supply/control module. 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. When only the power of the fundamental frequency is to be measured and when operating near rated power, consider using filters, a frequency selective receiver or a spectrum analyzer to reduce the harmonic content of the measured level.

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.

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

Push the OPERATE push-button. You will now see the cathode and the collector voltages rise. Verify that the collector and cathode voltages are near nominal. The helix current should be close to 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 PWR on the display and power meter (connected to the forward sample port). The forward power display will become active, with 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 peak power output. Do not set input drive above 0 dBm (Input drive above +20 dBm may damage the unit).The reflected 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 currents with no drive and with rated RF output mid-band are logged on the test data sheet. The value of the helix current is a good qualitative indicator of RF drive present.

To shut the system down, turn down the RF generator level below -50 dBm and press STANDBY. Allow the TWTA to cool down several minutes, and then turn off the main power.

3.7 EMERGENCY BYPASS OPERATION

For reference, see schematic 10-24830-000 in section 5.2.

The TWTA is provided with a means of operating the amplifier manually in the event that there is a failure of the control module and it is imperative that the amplifier remains on line.

CAUTION:

Emergency bypass operation permits the amplifier to operate even when microprocessor-based interactive features and possibly some diagnostic features are impaired. For this reason, the emergency bypass mode of operation should be used only when the control unit fails and when it is essential to remain on line.

To access the manual controls, remove the two 4-40 screws securing the emergency switch cover on the front panel of the power supply/control module. Emergency bypass mode is selected by pushing the left-hand switch (S1) to the left. The center switch (S2) toggles between high voltage on (left) and high voltage off (right). The right-hand switch (S3) selects beam on in the left hand position, and beam off (RF off) in the right-hand position. There is a manual control for the gain adjustment as well. This is a flat, square single-turn pot (R1).

CAUTION:

Do not adjust 20-turn pot R11; its function is to set the reflected RF foldback level, and it is calibrated at the factory.

3.8 REMOTE IEEE-488 OPERATION

The TWTA is provided with a communication interface that conforms electrically to the IEEE-488 standard. It 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 3-5. Catalog of IEEE-488 Commands

Command	Function	Units	Response format
RDSTAT	Returns status code of processing of previous command (see Table 3-6)		STATUS=[ ]
RDFLT	Returns system fault code (see Table 3-7)		flt=[ ]
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=[ ]
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 3-8)		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 reflected power out (dBm)	dBm	Pr=[ ]dBm

Command	Function	Units	Response format
RDPRW	Returns reflected 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 reflected power warning setpoint (dB)	dBm	Prhi=[ ]dBm
SPPRHID	Sets over reflected power warning setpoint (dBm)	dBm	
RDPRHIW	Returns over reflected power warning setpoint (W)	watts	Prhi=[ ]W
SPRHIW	Sets over reflected power warning setpoint (W)	watts	
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)		
RDHTRAUTOOFF	Returns heater auto off delay	hours	
SHTRAUTOOFF	Sets heater auto off delay (see Table 3-11)		
*IDN?;	Returns the product model number		[ ]
*STA?;	Returns status string (see Table 3-9)		[ ]
*STB?;	Returns status string (see Table 3-10)		[ ]

Table 3-6. 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.
60	Command is not allowed in current system state.
901	Assert error: invalid table argument*
902	Assert error: invalid calibration*

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

Table 3-7. Catalog of Fault Codes Returned by RDFLT Command

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

Fault Code	Meaning
0	No fault
7	System Fault
8	Heater Fault
9	Low Line
10	Cathode overvoltage
11	Body overcurrent
12	Cathode undervoltage
15	Collector undervoltage
16	Inverter fault
17	Internal interlock open
18	Tube arc
19	TWT (hardware) overtemperature
20	Power supply (hardware) overtemperature
22	External inhibit
23	Over reflected power
26	Panel Open
27	Latched Fault
30	Grid Overvoltage
49	TWT (software) overtemperature
50	Cabinet (software) overtemperature

Table 3-8. 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	ALC
11 (MSB)	(not used)

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

Table 3-9. *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 3-10. *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 3-11. 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.

<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; or 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 5.4. 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 (host computer). 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. In remotely operated systems, periodic checking of the status is also recommended.

3.9 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 obtaining 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 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.

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 does not require routine scheduled maintenance**.** The only moving parts are the elements of switches, relays and the blowers. Preventive maintenance is recommended in Paragraph 4.3.

The TWTA should be repaired by a factory-authorized representative**.** However**,** since limited logic schematics and partial parts information is supplied in this manual (Section V), some user service organizations may choose to perform their own corrective maintenance**. Warnings and Cautions should 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 TWTA 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 grills, clean them with dry compressed air.

If significant dust has been noted on the air intake grills, it may be desirable to vacuum the dust and debris from inside the enclosures.

To open the enclosure:

1. Remove the units 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.

2. Disconnect all connections from each unit to be removed. On the rear of the unit, remove any screws used to connect brackets to the amplifier. On the front of the unit, remove the four screws holding the front panel of each unit onto rack. Carefully slide the unit out of the front of the rack.

3. Remove the screws that secure the covers of the modules to gain access to the interior.

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

5. Reassemble in the reverse order.

4.4 TROUBLESHOOTING

Symptom	Possible cause
TWT or power supply overtemperature	Air inlet filter dirty Collector heat sink dirty Inadequate clearance behind TWTA High air inlet temperature Defective blower or power supply
No response when main power turned on	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 module "datalink failure" error appears	HPA interface 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	Open external interlock Keylock switch on INHIBIT or REMOTE Defective high voltage power supply.
Voltages normal, but no RF output, helix current low	No RF input Defective remote control board 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 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 High Voltage Rectifier and Transformer Module (A26258-000), the High Voltage Filter Assembly (A23044-000), the Grid Modulator Assemblies (A21422-000 and A21422-001), and the Heater Supply (A27824-000) are encapsulated modules and are not repairable. Contact an authorized service representative if replacement modules are needed.

4.6 CLEANING AND MATING HIGH VOLTAGE CONNECTORS

The high voltage cable plugs and the mating receptacles on the rear panels need to be treated with care. These connectors rely on a silicon rubber insulation system that must be clean, void-free, and mechanically undamaged to perform reliably.

When the cables are separated from the modules, always keep the plugs and receptacles capped with the protective covers with which they were shipped.

If contamination is suspected, use a low power microscope or 10X magnifier to inspect the connectors visually. Insure that no dirt particles, lint, cloth fibers, or other foreign materials are present.

If cleaning is needed, it should be performed using a soft-bristled nylon brush or a new acid brush dipped in isopropyl alcohol. Holding the connector with the mating end down, brush into each contact cavity, allowing the excess to drip off the insulator. Immediately afterwards, blow the connector dry with with a CFC-free aerosol duster or with compressed air known to be oil and water free.

CAUTION:
If any oil or water is present in the compressed air, they will leave residues that are highly likely to result in future failure of the connector.

After cleaning, allow the connectors to air dry at least 30 minutes prior to installing them.

To mate the connectors, align the keyway in the plug with the key in the receptacle shell and insert the plug. Tighten the knurled lock ring until it is snug. The torque required is approximately 20-30 inch-pounds. Never operate the system without securely tightening the connectors. To do so will leave voids in the insulation system, which may break down when high voltage is applied, damaging both the cable and the receptacle.

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, documentation pertaining to the highest levels of the system and to system control logic is included. The three-phase and single-phase model build tree and parts lists are shown.

5.1 TOP LEVEL BUILD TREE

5.1.1 Three Phase

	A26902-313	500W TWT AMPLIFIER, IJ-BAND, THREE PHASE AR
1A1	A29400-313	PS, SUPERTUBE, THREE-PHASE, IEEE-488
1A1A1	A22525-313	HV POWER SUPPLY FOR 500W TWT, IJ BAND
1A1A1A1	A27824-000	HEATER SUPPLY, HI POWER, 6.3V 6A
1A1A1A1L1	A09594-900	MODIFIED INDUCTOR
1A1A1A1L2	A09595-900	MODIFIED INDUCTOR
1A1A1A1T1	A09553-000	XFMR,HEATER FEEDBACK
1A1A1A1T2	A09596-000	XFMR,HEATER POWER,6.3V 6A
1A1A1A4	A23044-000	H.V.FILTER
1A1A1A5	A27818-000	TANK MODULE (NO CAPS)
1A1A1A5A1-A2	A09510-000	RESONANT INDUCTOR
1A1A1A6	A26258-000	HIGH VOLTAGE RECTIFIER & XFMR MODULE
1A1A1A6T1	A09524-000	HV XFMR WINDING SET FOR MEC18
1A1A1A7	A27815-313	POWER INVERTER MODULE, 500W TWT
1A1A1A7A1	A21449-000	POWER BOARD (3.5KW HPA)
1A1A1A7A1T2	A09529-000	GATE TRANSFORMER
1A1A1A7A1T3	A09527-000	GATE TRANSFORMER
1A1A1A7A2	A21440-313	REGULATION BOARD, 500W TWT, IJ-BAND
1A1A1A7A3	A30113-000	EXTERNAL CAPACITOR BOARD, 3.5KW
1A1A1A8	A23050-313	HPA LOGIC AND CONTROL MODULE, L BAND
1A1A1A9	A26452-000	LOW VOLTAGE POWER SUPPLY MODULE
1A1A1A10	A23065-000	INPUT FILTER MODULE
1A1A1A11	A23013-001	MOTHER BOARD
1A1A2	A25444-000	HPA INTERFACE BOARD (PLASTIC FIBERS)
1A1A3	A26856-000	HPA SYSTEM CONTROL FRONT PANEL ASSY
1A1A3A1	A22700-900	HPA DISPLAY BOARD
1A1A3A2	A24830-001	EMERGENCY BYPASS BOARD
1A1A4	A22933-300	CONTROL HEAD ENCLOSURE, IEEE-488
1A1A4A2	A18450-006	DO NOT USE IN NEW DESIGNS
1A1A4A3	A22488-001	GPIB/LINK TRANSCEIVER BOARD
1A1A5	A26874-000	DUAL MODULATOR LV HARNESS
1A1A6	A23692-000	INSULATED FAN DRIVER
1A1A6T1	A09594-000	FAN DRIVER TRANSFORMER
1A1A7	A21422-000	GRID MODULATOR MODULE
1A1A7A1	A18415-000	MODULATOR HIGH VOLTAGE BOARD
1A1A7A1T1	A09227-000	PULSE TOP XFMR,HAND WOUND
1A1A7A1T2	A09228-000	FEEDBACK XFMR,HAND WOUND
1A1A7A1T3	A09229-000	BIAS XFMR,HAND WOUND
1A1A7A1T4-T5	A09230-000	XFMR,GATE DRIVE (HAND WOUND)
1A1A7A2	A23715-000	MODULATOR CONTROL BOARD
1A1A8	A21422-001	MODULATOR,ASSY STANDALONE
1A1A8A1	A18415-000	MODULATOR HIGH VOLTAGE BOARD

1A1A8A1T1	A09227-000	PULSE TOP XFMR,HAND WOUND
1A1A8A1T2	A09228-000	FEEDBACK XFMR,HAND WOUND
1A1A8A1T3	A09229-000	BIAS XFMR,HAND WOUND
1A1A8A1T4-T5	A09230-000	XFMR,GATE DRIVE (HAND WOUND)
1A1A8A2	A23715-000	MODULATOR CONTROL BOARD
1A1A9	A28341-000	WIRING KIT, 500T-IJ THREE PHASE
1A1A10	A28343-000	CABINET KIT, 500T-IJ, THREE PHASE,IEEE-488
1A2	A28007-001	500 WATT RF SUBASSEMBLY, IJ-BAND
1A2A9	A28049-000	WIRING KIT, 500W I/J SUPERTUBE
1A2A10	A28037-001	CHASSIS ASSEMBLY, IJ SUPERTUBE W/ SSA
1A2A10A1	A31191-000	MECHANICAL PARTS FOR CHASSIS
1A2A11	A26941-000	TWTA LOP BOARD
1A2A12-A13	A23692-000	INSULATED FAN DRIVER
1A2A12-A13T1	A09594-000	FAN DRIVER TRANSFORMER
1A2A17	A31263-000	HIGH VOLTAGE BOX AND HARNESS, 700 WATT
1A3	A28014-000	TWT CONTROL CABLE

5.1.2 Single Phase

	A26902-311	500W TWT AMPLIFIER, IJ-BAND, SINGLE PHASE AR
1A1	A29400-311	POWER SUPPLY, SUPERTUBE, 1 PHASE
1A1A1	A22525-900	1000T I/J-BAND HV POWER SUPPLY
1A1A1A1	A23054-000	HEATER POWER SUPPLY MODULE
1A1A1A1T1	A09553-000	XFMR,HEATER FEEDBACK
1A1A1A1T2	A09000-000	XFMR,HEATER POWER
1A1A1A2	A27784-000	MODULATOR HARNESS MODULE
1A1A1A3	A23683-003	AVR CURRENT MODE PFC, 3KW
1A1A1A3L4	A09006-000	PFC INDUCTOR FOR 100VAC-255VAC
1A1A1A4	A23044-000	H.V.FILTER
1A1A1A5	A27818-000	TANK MODULE (NO CAPS)
1A1A1A5A1-A2	A09510-000	RESONANT INDUCTOR
1A1A1A6	A26258-000	HV RECTIFIER & XFMR MODULE
1A1A1A6T1	A09524-000	HV XFMR WINDING SET FOR MEC18
1A1A1A7	A27815-001	POWER INVERTER MODULE,USED
1A1A1A7A1	A21449-000	POWER BOARD (3.5KW HPA)
1A1A1A7A1T2	A09529-000	GATE TRANSFORMER
1A1A1A7A1T3	A09527-000	GATE TRANSFORMER
1A1A1A7A2	A21440-001	REGULATION BOARD,USED WITH PFC
1A1A1A7A3	A30113-000	EXTERNAL CAPACITOR BOARD, 3.5KW
1A1A1A7	A27815-818	POWER INVERTER (FM) , 500W I-J BAND
1A1A1A8	A23050-000	HPA LOGIC AND CONTROL MODULE
1A1A1A9	A26452-000	LOW VOLTAGE PS MODULE
1A1A1A10	A23065-001	INPUT FILTER MODULE
1A1A1A11	A23013-000	MOTHER BOARD
1A1A1A12	A28495-900	FACTORY SELECT PARTS
1A1A2	A25444-000	HPA INTERFACE BOARD (PLASTIC FIBERS)
1A1A3	A26856-001	FRONT PANEL ASSY, AR 500T 1 PHASE
1A1A3A1	A22700-900	HPA DISPLAY BOARD
1A1A3A2	A24830-001	EMERGENCY BYPASS BOARD
1A1A4	A22933-300	CONTROL HEAD ENCLOSURE, IEEE-488
1A1A4A2	A18450-006	DO NOT USE IN NEW DESIGNS
1A1A4A3	A22488-001	GPIB/LINK TRANSCEIVER BOARD
1A1A5	A26874-000	DUAL MODULATOR LV HARNESS
1A1A6	A23692-000	INSULATED FAN DRIVER
1A1A6T1	A09594-000	FAN DRIVER TRANSFORMER
1A1A7	A21422-000	GRID MODULATOR MODULE
1A1A7A1	A18415-000	MODULATOR HIGH VOLTAGE BOARD
1A1A7A1T1	A09227-000	PULSE TOP XFMR,HAND WOUND
1A1A7A1T2	A09228-000	FEEDBACK XFMR,HAND WOUND
1A1A7A1T3	A09229-000	BIAS XFMR,HAND WOUND
1A1A7A1T4-T5	A09230-000	XFMR,GATE DRIVE (HAND WOUND)
1A1A7A2	A23715-000	MODULATOR CONTROL BOARD
1A1A8	A21422-001	MODULATOR,ASSY STANDALONE

1A1A8A1	A18415-000	MODULATOR HIGH VOLTAGE BOARD
1A1A8A1T1	A09227-000	PULSE TOP XFMR,HAND WOUND
1A1A8A1T2	A09228-000	FEEDBACK XFMR,HAND WOUND
1A1A8A1T3	A09229-000	BIAS XFMR,HAND WOUND
1A1A8A1T4-T5	A09230-000	XFMR,GATE DRIVE (HAND WOUND)
1A1A8A2	A23715-000	MODULATOR CONTROL BOARD
1A1A9	A28340-000	WIRING KIT, 500T-IJ, SINGLE PHASE
1A1A9XJ1	A30346-000	EMI MODIFICATION KIT FOR 400KU
1A1A9XJ1A1	A28181-000	POWER ENTRY FILTER BOARD
1A1A10	A28342-000	CABINET KIT, 500T-IJ, SINGLE PHASE
1A2	A28007-001	500 WATT RF SUBASSEMBLY, IJ-BAND
1A2A9	A28049-000	WIRING KIT, 500W I/J SUPERTUBE
1A2A10	A28037-001	CHASSIS ASSEMBLY, IJ SUPERTUBE
1A2A10A1	A31191-000	MECHANICAL PARTS FOR CHASSIS
1A2A11	A26941-000	TWTA LOP BOARD
1A2A12-A13	A23692-000	INSULATED FAN DRIVER
1A2A12-A13T1	A09594-000	FAN DRIVER TRANSFORMER
1A2A17	A31263-000	HIGH VOLTAGE BOX AND HARNESS
1A3	A28014-000	TWT CONTROL CABLE

5.2 SCHEMATICS

10-23050-000	HPA Logic and Control (A23050-000)
10-23050-313	HPA Logic and Control (A23050-313)
10-24830-000	Emergency Bypass Board (A24830-001)
10-25444-000	HPA Interface (A25444-000)
10-28007-001	500 Watt RF Subassembly (A28007-001)
10-29400-311	Power Supply, Single Phase (A29400-311)
10-29400-313	Power Supply, Three Phase (A29400-313)

5.3 PARTS LISTS

A22525-313	Power Supply, Supertube, Three Phase
A22525-900	Power Supply, Supertube, Single Phase
A23050-313	HPA logic and control assembly
A24830-001	Emergency Bypass Board
A25444-000	HPA interface board
A26902-311	500W IJ-Band TWT Amplifier, Single Phase
A26902-313	500W IJ-Band TWT Amplifier, Three Phase
A28007-001	Microwave power assembly

5.3.1 Parts List, HV Power Supply For 500W TWT, IJ, A22525-313

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
A11	A23013-001	MOTHER BOARD	1
A4	A23044-000	H.V.FILTER	1
A8	A23050-313	HPA LOGIC AND CONTROL MODULE, L BAND	1
A10	A23065-000	INPUT FILTER MODULE, PHASE LOST DETECTION NOT USED	1
A6	A26258-000	HIGH VOLTAGE RECTIFIER & XFMR MODULE	1
A9	A26452-000	LOW VOLTAGE POWER SUPPLY MODULE	1
A7	A27815-313	POWER INVERTER MODULE, 500W TWT, IJ BAND	1
A5	A27818-000	TANK MODULE (NO CAPS)	1
A1	A27824-000	HEATER SUPPLY, HI POWER, 6.3V 6A	1

5.3.2 Parts List, 1000T I/J-Band HV Power Supply, A22525-900

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
A11	A23013-000	MOTHER BOARD	1
A4	A23044-000	H.V.FILTER	1
A8	A23050-000	HPA LOGIC AND CONTROL MODULE	1
A1	A23054-000	HEATER POWER SUPPLY MODULE	1
A10	A23065-001	INPUT FILTER MODULE, PHASE LOST DETECTION NOT USED	1
A3	A23683-003	AVR CURRENT MODE PFC, 3KW , 200-250VAC INPUT (CAN OPERATE WITH A23065-001)	1
A6	A26258-000	HIGH VOLTAGE RECTIFIER & XFMR MODULE	1
A9	A26452-000	LOW VOLTAGE POWER SUPPLY MODULE	1
A2	A27784-000	MODULATOR HARNESS MODULE	1
A7	A27815-001	POWER INVERTER MODULE,USED WITH PFC	1
A5	A27818-000	TANK MODULE (NO CAPS)	1
A12	A28495-900	FACTORY SELECT PARTS	1
	N25960-000	CHASSIS,HIGH VOLTAGE FILTER	1

5.3.3 Parts List, HPA Logic and Control Module, L , A23050-313

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
REV B	B23050-000	LOGIC & CONTROL BOARD	1
C48, C49	C06103-000	CAP,10MF,25V,20%,SOLID TANT,RADIAL,(AVX TAP106M025HSB)	2
C11	C16333-000	CAP,33MF,25V,AERL,(NICHICON UVX1E330M)	1
C47	C17104-000	CAP,100MF,50V,AERL,(NICHICON UVX1J101MPA)	1
C2, C5, C15	C31028-000	CAP,1000PF,200VDC,10%,CER,1% FAILURE,(KEMET CKR05 SERIES W/"V" OPTION)	3
C3, C9, C10, C13, C14, C17, C19, C33, C36, C41, C46, C21, C22, C23, C27, C28, C29, C30, C31	C31032-000	CAP,0.01MF,200VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	19
C24, C51	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-C41, C43, C44, C45, C50	C31040-000	CAP,1MF,50VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	19
D16, D23, D31	D10965-000	ZENER,15V,(DIODES INC 1N965B)	3
D1, D3-D5, D7-D13, D17-22, D25, D26, D28-D30, D33, D35,	D14454-000	DIODE,AXIAL,(MOTOROLA 1N4454)	26
D32	D14728-000	ZENER,3.3V,1W,10%,AXIAL,(MOTOROLA 1N4728)	1
D36	D14733-000	ZENER,5.1V,1W,10%,AXIAL,(MOTOROLA 1N4733)	1
J2	J10370-000	CONN,37 PIN,MALE,D-SUB,PCB RIGHT ANGLE, (AMP 747252-4)	1
J7	J12294-000	CONN RIGHT ANGLE MALE 29 PIN,(SAME AS J12291 W/NO MODIF),(HYPERTRONIC KA29/127BPMC10T,&HARDWARE	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
L1	L00200-000	WIDE BAND CHOKE,(VK200 10/3B FERROXCUBE)	1
	N23061-000	MODULE CHASSIS LOGIC	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, R39	R01100-000	RES,100 OHM,1/4W,5%,CC,(A/B RC07GF101J)	5
R5, R7, R17, R18, R28, R34, R45, R49, R53, R59, R71, R72, R87	R02100-000	RES,1K,1/4W,5%,CC,(A/B RC07GF102J)	13
R6	R02270-000	RES,2.7K,1/4W,5%,CC,(A/B RC07GF272J)	1
R43	R02330-000	RES,3.3K,1/4W,5%,CC,(A/B RC07GF332J)	1
R30, R31, R36	R02470-000	RES,4.7K,1/4W,5%,CC,(A/B RC07GF472J)	3
R35	R05820-000	RES,8.2M,1/4W,5%,CC,(A/B RC07GF825J)	1
R23	R20301-000	RES,301 OHM,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R10	R21249-000	RES,2.49K,1%,MF,100PPM,(DALE RN55D)	1
R67	R21402-000	RES,4.02K,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R38	R21523-000	RES,5.23K,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R24	R21549-000	RES,5.49K,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R52, R73	R21887-000	RES,8.87K,1/2W,1%,MF,100PPM,(DALE RN55D)	2
R75	R21990-000	RES,9.76K,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R98	R22105-000	RES,10.5K,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R40A	R22604-000	RES,60.4K,1/2W,1%,MF,100PPM,(DALE RN55D)	1

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
R42, R60, R61, R74, R46, R47, R48, R58	R23100-000	RES,100K,1/2W,1%,MF,100PPM,(DALE RN55D)	8
R54	R23169-000	RES,169K,1W,1%,MF,100PPM,(DALE RN60D)	1
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
R40B	R24124-000	RES,1.24M,1/2W,1%,MF,100PPM,[DALE RN55D]	1
R62	R30035-000	RES,10K,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R32	R31091-000	RES,47K,1/4W,5%,CC,<=1% FAIL,(A/B RCR07)	1
R11	R32004-000	TRIMPOT,1K,1/2W,10%,CERMET,20T,SIDE ADJ,(BECKMAN 67X)	1
R12, R15, R16	R32020-000	TRIMPOT,10K,1/2W,10%,CERMET,20T,SIDE ADJ,(BECKMAN 67X)	3
R13, R14	R32049-000	TRIMPOT,5K,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
RP4, RP8	U30106-000	IC,10K,RES NETWORK,6 PIN,SIP (DALE MSP06A-01-103G)	2
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
WC20, WU2, WU7	W12803-000	WIRE,SOLID,TEFLON,28 AWG,250V,(ALPHA 2842/1-GREEN)	1

5.3.4 Parts List, 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,	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,	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
TP4	J16214-000	TEST JACK,YELLOW,VERTICAL,(EF JOHNSON 105-	1

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
		0857-001)	
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, R27, R29, R32, R37, R38, R39, R47	R31164-000	RES,100K,1/20W,1%,FILM,AXIAL,100PPM,MIL,(DALE RN50C1003F)	11
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
U36	U17545-000	DRIVER,OIL,DS75451N,DUAL AND,[NATIONAL	1

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
		SEMICONDUCTOR DS75451N]	
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, 500W TWT Amplifier, lJ-Band, Single, A26902-311

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
A2	A28007-001	500 WATT RF SUBASSEMBLY, IJ-BAND, WITH SSA	1
A3	A28014-000	TWT CONTROL CABLE	1
A1	A29400-311	POWER SUPPLY, SUPERTUBE, SINGLE PHASE, IEEE-488, AR	1
NAMEPLATE			
A4	E08143-000	HIGH VOLTAGE CABLE ASSY, [CONNECTRONICS 10641-05]	1

5.3.7 Parts List, 500W TWT Amplifier, IJ-Band, Three, A26902-313

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
A2	A28007-001	500 WATT RF SUBASSEMBLY, IJ-BAND, WITH SSA	1
A3	A28014-000	TWT CONTROL CABLE	1
A1	A29400-313	POWER SUPPLY, SUPERTUBE, THREE-PHASE, IEEE-488, AR NAMEPLATE	1
A4	E08143-000	HIGH VOLTAGE CABLE ASSY, [CONNECTRONICS 10641-05]	1

5.3.8 Parts List, 500 Watt RF Subassembly, IJ-Band, A28007-001

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
A12, A13	A23692-000	INSULATED FAN DRIVER	2
A11	A26941-000	TWTA LOP BOARD	1
A10	A28037-001	CHASSIS ASSEMBLY, IJ SUPERTUBE W/ SSA	1
A9	A28049-000	WIRING KIT, 500W I/J SUPERTUBE	1
A7	E00324-000	DUAL BROADWALL COUPLER, WRD-750 -40, -40 DB [MDC,12750-232]	1
A6	E00325-000	RF LOAD, 500W, WRD-750, AIR COOLED(MDC 12750-200)	1
	E00326-000	90 DEG. OFFSET JOGGLE, WRD-750 (PER ETM DWG. E00326)	1
A15	E01415-000	SSPA, 7.5-18 GHZ, 30 DBM @1DB, +30 DB, 0-35DB VAR,[KMIC TECH CMA75180B]	1
A3, A4	E08114-001	TWT, 7.5-18.0 GHZ, 300 W, GRID, +/-2 DB EQ PHASE COMB, ISO THERMO [MEC-5407, GRID, +/-2DB EQ SPL]	2
A8	E20066-000	ATTENUATOR,10DB,2W,DC-18GHZ,(OMNI SPECTRA 2082-6147-10)	1
A16	E20129-000	COUPLER,10DB,4-18GHZ,SMA,(MAC TECHNOLOGIES C4258-10)	1
A2	E20131-000	LINE STRETCHER DC 18GHZ,(ARRA 9428T-MF)	1
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
A1	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 10750-139]	1
A14	E20400-000	TERMINATION, 2 WATT, SMA MALE,[INMET 3004M]	1
	H00600-000	WAVEGUIDE FLANGE GASKET, WRD-650, WRD-750	7
	H10036-000	HOSE CLAMP,WORM DRIVE,4 1/8-5,(MCMASTER CARR 5415K34)	2
J1, J2	J17219-000	ADAPTER,N TO SMA,PNL MT,FEM,(HUBER & SUHNER 37N-SMA-50-1)	2
	N29110-000	WAVEGUIDE CLAMP	2
	N31104-000	BRACE, RF LOAD	1
	N31105-000	CLAMP, RF LOAD	1
	N31242-000	SUPPORT BAR	1
	N31243-000	MOUNTING PLATE SSPA	1
	N31285-000	SPACER	1
	N31707-000	AIR DUCT	2

5.4 SAMPLE PROGRAM FOR IEEE-488 COMMUNICATION

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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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