rf/microwave instrumentation

Operating and Service Manual

1000T2G8B

Model

10013175

Part Number

Serial Number

EXPORT CONTROLLED DATA.
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rf/microwave instrumentation

EC Declaration of Conformity

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

declare that our product(s);

the Models 1000T1G2 series, 1000T2G8 series and 1000T8G18 series RF amplifiers

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

This product(s) is in compliance with the requirements of the Low Voltage Directive (72/23/EEC) in accordance with safety standard IEC EN60950 (1995).

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

Donald R. Shepherd
President

Instructions for European EMC Conformity

WARNING

It is the responsibility of the user of this equipment to provide electromagnetic shielding, filtering and isolation which is necessary for EMC compliance to Directive 89/336/EEC. The equipment must therefor be operated in a shielded area which provides a sufficient level of attenuation to meet the radiated emissions and immunity specifications. All AC, DC and Control lines connected to the equipment and entering or exiting the shielded area must have sufficient isolation to meet the conducted emissions and immunity specifications. The following minimum levels are suggested for use in accordance with the rated power of the equipment.

Rated Power	Minimum shielding attenuation	Minimum line isolation
100 watts	50 dB	50 dB
101 - 1000 watts	60 dB	60 dB
1001 - 10,000 watts	70 dB	70 dB

Since this equipment is designed to generate high levels of Radio Frequency energy, it is also essential that the user read and follow the “Instructions for Safe Operation” in this manual. If other equipment is operated in the shielded room it may be disturbed by the amplifier.

ACHTUNG

Der Benutzer dieses Gerätes ist dafür verantwortlich, daß die elektromagnetische Abschirmung und Filterung gewährleistet ist, welche gemäß Richtlinie 89/336/EEC notwendig ist. Das Gerät muß deshalb in einem geschirmten Raum betrieben werden, welcher eine ausreichenden Schirmung bietet, um die Emissions- und Störfestigkeitsspezifkation einzuhalten. Alle Wechsel- und Gleichspannungsleitungen sowie Steuerleitungen, die mit dem Gerät verbunden sind und in den geschirmten Raum von außen hereingeführt werden, müssen ausreichend gefiltert sein, um die Emissionsspezifkation einzuhalten. Es werden folgenden Minimalwerte der Schirmdämpfung und Filterung in den unterschiedlichen Leistungsklassen empfohlen.

Hochfrequenzleistung	min. Schirmdämpfung	min Filterdämpfung
100 Watt	50 dB	50 dB
101-1000 Watt	60 dB	60 dB
1001-10.000 Watt	70 dB	70 dB

Falls andere elektrische oder elektronische Geräte gleichzeitig mit dem Gerät betrieben werden, kann es zu Beeinflussungen kommen. Da das Gerät zur Erzeugung von Hochfrequenzenergie dient ist es daher auch unbedingt notwendig, daß der Benutzer die Sicherheitsvorschriften in der Bedienungsanleitung liest und einhält.

AVERTISSEMENT

Il est de la responsabilité de l'utilisateur de cet équipement d'assurer la protection électromagnétique, le filtrage et l'isolation nécessaires, afin de se conformer à la directive 89/336/EEC concernant la C.E.M. Par conséquent, cet équipement doit être mis en fonctionnement dans une enceinte d'atténuation suffisante pour satisfaire aux spécifications d'émissivité et de susceptibilité. Toutes les alimentations alternatives, continues ainsi que les liaisons de contrôle connectées à cet équipement, qui entrent ou sortent de cette enceinte doivent avoir une isolation suffisante pour satisfaire aux spécifications concernant les émissions conduites et d'immunité. Pour une utilisation conforme, les niveaux d'atténuation minimums suivants sont suggérés en fonction de la puissance de sortie de l'équipement:

Puissance de sortie	Atténuation minimum de l'enceinte	Isolation minium de la ligne
100 Watts	50 dB	50 dB
101 à 1.000 Watts	60 dB	60 dB
1.001 à 10.000 Watts	70 dB	70 dB

Puisque cet équipement est destiné à générer de forts niveaux R.F., il est essentiel que l'utilisateur se conforme aux instructions de sécurité indiquées dans ce manuel. Tout autre équipement en fonctionnement dans la cage de Faraday peut-être perturbé par 1'amplificateur.

INSTRUCTIONS FOR SAFE OPERATION

BEFORE APPLYING POWER

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

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

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

INTENDED PURPOSES

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

HAZARDOUS RF VOLTAGES

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

SAFETY GROUND

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

PHYSICAL DAMAGE

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

MAINTENANCE CAUTION

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

SAFETY SYMBOLS

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

Dangerous voltages are present. Use extreme care.

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

Indicates protective earth terminal.

RANGE OF ENVIRONMENTAL CONDITIONS

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

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

COOLING AIR

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

ADDITIONAL WARNINGS & NOTES

WARNING:

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

CAUTION:

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

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1. DESCRIPTION AND SPECIFICATIONS

This manual provides operating, interfacing and selected service information pertinent to Amplifier Research Model 1000T2G8B Broadband Microwave Amplifier. The Model 1000T2G8B is a 1000 watt SC-band traveling-wave tube amplifier (TWTA).

1.1 TWTA DESCRIPTION

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

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

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

1.2 SUGGESTED APPLICATIONS

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

1.3 SPECIFICATIONS

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

1.4 ACCESSORIES

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

- Directional coupler
- Antenna
- Flexible transmission line

Refer to a current Amplifier Research catalogue for Microwave Accessories.

1.5 TEST DATA SHEET

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

1000T2G8B

- M1, M2, M3, M7–M11
- 1000 Watts CW
- 2.5GHz–7.5GHz

Features

The Model 1000T2G8B is a self contained, forced air cooled, broadband traveling wave tube (TWT) microwave amplifier designed for applications where instantaneous bandwidth, high gain and high power output are required. Reliable TWT subsystems provide a conservative 1000 watts minimum over most of the frequency range 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, 0dBm input, VSWR protection, gain control, RF output sample ports, plus monitoring of TWT helix current, cathode voltage, collector voltage, heater current, heater voltage, baseplate temperature and cabinet temperature. Modular design of the power supply and RF components allow for easy access and repair. Use of a switching mode power supply results in significant weight reduction.

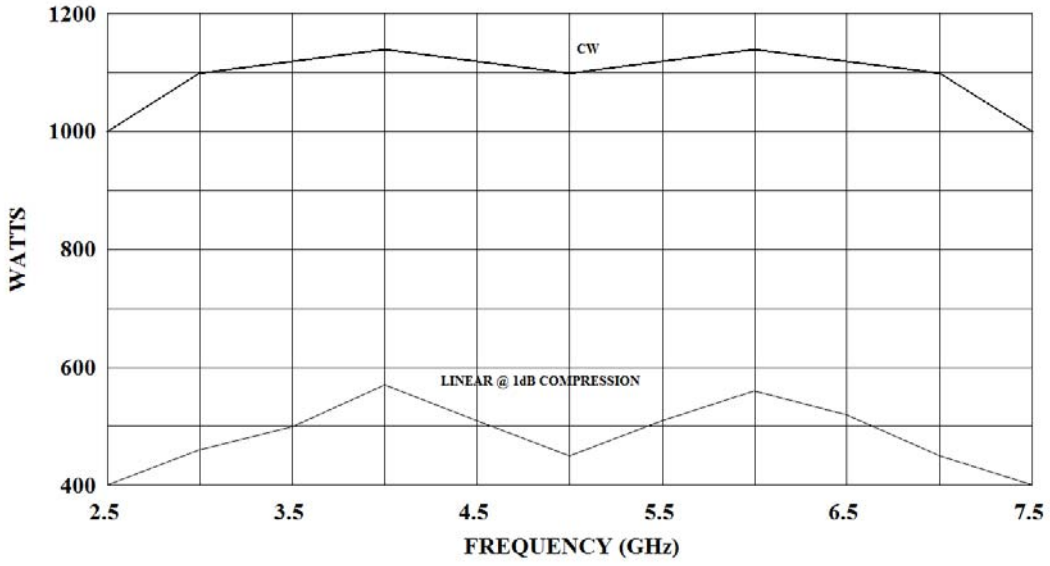
The rated power is developed by efficiently power combining the outputs from two 535 watts (nominal) microwave tubes that are factory matched in gain and phase to offer moderate harmonic levels without added filters. Amplifier includes wheels, leveling feet and lifting hooks.

The Model 1000T2G8B 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. Unit is CE marked to comply with EMC European Directive 89/336/EEC for operation inside a shielded room.

Refer to the Model Configuration Chart for alternative configurations.

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

1000T2G8B TYPICAL POWER OUTPUT



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1000T2G8B

- M1, M2, M3, M7–M11
- 1000 Watts CW
- 2.5GHz–7.5GHz

Specifications

POWER (fundamental), CW, @ OUTPUT CONNECTOR:
Nominal: 1100 watts
Minimum: 900 watts minimum, 2.5–2.7GHz; 1000 watts minimum 2.7–7.5GHz.
Linear @ 1 dB Compression: 250 watts minimum

FLATNESS: ±8 dB maximum, equalized for ±3 dB maximum at rated power

FREQUENCY RESPONSE: 2.5–7.5 GHz instantaneously

INPUT FOR RATED OUTPUT: 1.0 milliwatt maximum

GAIN (at maximum setting): 60 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 200 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 80 dBm/Hz (maximum); Minus 90 dBm/Hz (typical)

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

PRIMARY POWER: See Model Configuration

CONNECTORS:
RF input: Type N female
RF output: See Model Configuration
RF output sample ports (forward and reflected): Type N female
GPIB: IEEE-488 female, rear
Interlock: DB-15 female, rear

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

WEIGHT (approximate): 295 kg (650 lb)

SIZE (WxHxD): 56 x 160 x 82.3 cm (22.1 x 63 x 32.4 in)

EXPORT CLASSIFICATION: EAR99

1000T2G8B

- M1, M2, M3, M7–M11
- 1000 Watts CW
- 2.5GHz–7.5GHz

Model Configurations

Model Number	Primary Power	RF Output Connectors	RF input & output sample ports connector location	Features
1000T2G8B	190-255 VAC, 3 phase, delta (4 wire) 50/60 Hz, 8.0 KVA max	Type WRD250D30 waveguide flange on rear panel	rear panel	–
1000T2G8BM1	360-435 VAC, 3 phase, WYE (5 wire) 50/60 Hz, 8.0 KVA max	Type WRD250D30 waveguide flange on rear panel	rear panel	–
1000T2G8BM2	190-255 VAC, 3 phase, delta (4 wire) 50/60 Hz,8.0 KVA max	2.5-4.0GHz, WRD200D24 4-7.5GHz, WRD350D24 waveguide flange on rear panel	rear panel	Frequency response 2.5-4.0GHz instantaneously, 4-7.5GHz instantaneously, Power 900 watts minimum from 2.5-3 GHz and 7-7.5 GHz, 1000 watts minimum from 3-7 GHz
1000T2G8BM3	360-435 VAC, 3 phase, WYE (5 wire) 50/60 Hz, 8.0 KVA max	2.5-4.0GHz, WRD200D24 4-7.5GHz, WRD350D24 waveguide flange on rear panel	rear panel	Frequency response 2.5-4.0GHz instantaneously 4-7.5GHz instantaneously, Power 900 watts minimum from 2.5-3 GHz and 7-7.5 GHz, 1000 watts minimum from 3-7 GHz
1000T2G8BM4	See Individual Specification Sheet. Version offers 400 Hz primary power and a blanking input.			
1000T2G8BM5	See Individual Specification Sheet. Version offers reduced harmonics using switched external filters and other special features.			
1000T2G8BM6	See Individual Specification Sheet. Version offers front panel connectors and other special features.			
1000T2G8BM7	190-255 VAC, 3 phase, delta (4 wire) 50/60 Hz, 8.0 KVA max	Type WRD250D30 waveguide flange on rear panel	front panel	–
1000T2G8BM8	See Individual Specification Sheet.			
1000T2G8BM9	190-255 VAC, 3 phase, delta (4 wire) 50/60 Hz, 8.0 KVA max	Type WRD250D30 waveguide flange on rear panel	rear panel	Mounted in EMC-shielded cabinet providing >40 dB isolation. Cabinet dimensions: 56 x 160 x 97.5 cm, 22.1 x 63 x 38.4 in. *NOTE: No penetrations through shielded cabinet. AC & RF penetrations to be made by end-user.*
1000T2G8BM10	190-255 VAC, 3 phase, delta (4 wire) 50/60 Hz, 8.0 KVA max	Type WRD250D30 waveguide flange on rear panel	rear panel	Remote interface changed from IEEE-488 to Ethernet. Supplied in four separate 19" width rack-mountable subassemblies and slides for rack mounting; sizes 3U x 46cm (18.1"), 12U x 76.5cm (30.12"), (2) 3U x 61.2cm (24.1").
1000T2G8BM11	360-435 VAC, 3 phase, WYE (5 wire) 50/60 Hz, 8.0 KVA max	Type WRD250D30 waveguide flange on rear panel	rear panel	Supplied in four separate 19" width rack-mountable subassemblies and slides for rack mounting; sizes 3U x 46cm (18.1"), 12U x 76.5cm (30.12"), (2) 3U x 61.2cm (24.1").

2. THEORY OF OPERATION

2.1 DESIGN OF THE AMPLIFIER

The Model 1000T2G8B TWT amplifier consists of four principal subsystems. From top to bottom, these are the control module (A28010-303), the RF combiner assembly (A28005-004), and the two TWT power supplies (A28012-000). These will be discussed in greater detail below. The system is completed by a number of cables that interconnect the subsystems, and by the rack assembly.

See the build tree in section 5.1 for information about how the parts lists are structured.

2.2 CONTROL MODULE

The control module houses the microprocessor control system (control head), the data steering assembly, a three-output DC power supply, a 28 VDC power supply, and an AC contactor for removing the AC power from the TWT power supplies when the control module's AC power switch is turned off.

The control head consists of three boards: the display board (A25425-000) provides the user interface (display, buttons, and rotary encoder); the CPU board (A25450-000) contains the CPU, bus management hardware, DRAM, EPROMs, and static RAM; and the the datalink board (A22488-003) provides the I/O to the amplifier system as well as the IEEE-488 communication bus for computer interfacing.

The control head is provided with its own power supply and, other than thru the interface bus, is electrically isolated from the amplifier. Communication with the amplifier is via fiberoptic links. The single pair of links on the control head fans out to three pairs of links in the data steering assembly (A21175-000). These links go to interface boards in the RF combiner and in each of the two power supplies. The data is "steered" by an address byte in the data stream from the microprocessor. To make the connections between various chassis backpanels, the fiberoptic data is converted to twisted/shielded pairs by line driver/receiver pairs on the three F/O to RS-485 adapter boards (A28008-000). In the RF combiner and in the power supplies, the signals are converted back into fibers by means of the same boards.

2.3 DESCRIPTION OF THE RF COMBINER ASSEMBLY

The TWTA consists of two stages of RF amplification: a high-gain, 4 watt solid state driver amplifier (E01611-000), and a power-combined pair of traveling-wave tube amplifiers (E01608-000).

The type N RF input connector is located on the rear panel. The RF input is fed to the input connector on the solid state preamp with a built-in voltage-controlled variable attenuator which permits control of the amplifier's output power from the control module. The amp's output is split by a 180° hybrid. Each of the hybrid's secondaries is connected to the RF input of a TWT. The TWTs' outputs are connected by waveguide to the input ports of a magic tee (waveguide 180° hybrid) (E01607-000). The magic tee's sum port, the port that collects all in-phase products, is terminated with a 500 watt waveguide load. The magic tee's difference port, the port that collects the out-of-phase products, is connected to the RF output.

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

Since the fundamental frequencies are amplified 180° out of phase, the second harmonic products, which represent significant power in the lower part of the band, are largely in phase, and are dumped in the sum

port. The residual harmonics are typically less than –20dBc, low enough in power that they can be further reduced, as needed, by a reflective filter without harm to the TWTs.

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

The RF output is WRD-250 waveguide.

The control module monitors and controls the RF combiner assembly via the switcher-combiner interface board (A27444-001). This board generates the analog voltage that controls the variable attenuator and has A-to-D converters for metering the power levels.

The TWTs are mounted on cooling units (A28036-000). Each cooling unit contains a high density heat sink, a 400 Hz cooling fan, and a fan inverter that operates from the AC line.

2.4 DESCRIPTION OF THE TWT POWER SUPPLIES

The two TWT power supplies are housed in separate 19" chassis 3 rack units (5.25") high. Each power supply chassis contains a TWT power supply assembly (A24801-501), an HPA interface board (A25444-000), as well as an AC input line filter and a front panel circuit breaker. In addition, each chassis has a 400 Hz cooling fan and a fan inverter (A23692-000).

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

The Heater Power Supply Module (A10010-000) powers the TWT DC heater. Bias and pulse top voltage for the TWT grid are provided by the Modulator Assembly (A21422-000).

The high voltage power supply consists of the following: the Power Factor Correction module (A23683-000) converts line voltage to DC for the high voltage switching supply. Switching transistors are on the Power Board Assembly (A16487-000), and switching is controlled by the PWM Board (A10017-517). The high voltage transformer and rectifiers are contained in the Diode Cap Assembly (A21425-500). The high voltage DC is filtered in the HV Filter Assembly (A21461-500).

Interconnects between the power supply modules are through a motherboard. It is installed in the power supply finned heat sink. The Motherboard/heat sink assembly is A24823-000.

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

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

3. OPERATION

3.1 WARNINGS AND CAUTIONS

Throughout this manual, the symbol:

WARNING:

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

CAUTION:

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

WARNING: DANGER - High Voltage Present:

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

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

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

WARNING: Safety Ground

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

WARNING: Explosive Atmosphere

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

3.2 INSTALLATION

3.2.1 Unpacking

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

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

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

3.2.2 Mounting

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

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

CAUTION:

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

3.2.3 Cooling Requirements

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

CAUTION:

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

3.2.4 AC Line Power Connections

AC line power connection to the TWTA is a 5-conductor cable attached the junction box. The cable is provided unterminated, and appropriate wiring to the cable must be provided by the user. The cable conductor function is color coded

Color	Function
Black	Phase
Red	Phase
Orange	Phase
White	Neutral
Green	Safety ground

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

The TWTA is not sensitive to phase rotation.

3.2.5 RF Connections

The RF output is WRD-250 waveguide.

CAUTION:

Never operate the TWTA without a matched output load rated for at least 1500 watts, continuous duty. The TWTA is not provided with an output isolator. While the TWTA is protected from excessive reflected power by foldback and VSWR circuits, it is poor practice to power the unit up without a load or an antenna. Even with no drive, "looping" oscillation can result in RF output if the TWTA is operated without a load. The VSWR detection and foldback circuit is provided to protect the tube from *progressive* failure or mismatch of the output load; it should not be relied on for protection from the *absence* of a load.

CAUTION:

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

3.2.6 External Interlock Connector

The TWTA is provided with an external interlock capability via a 15-pin-D connector. To enable the high-voltage power supply, it is necessary to provide continuity between pins 3 and 4 of this connector. If the amplifier shuts down because the interlock was opened, it will be necessary to reset the system to return to standby (see **System Shutdown Screen** in section 3.4). Users may adopt this interlock feature to disable the RF output for either equipment protection or as a backup for personnel protection.

CAUTION:

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

3.3 FRONT PANEL FEATURES

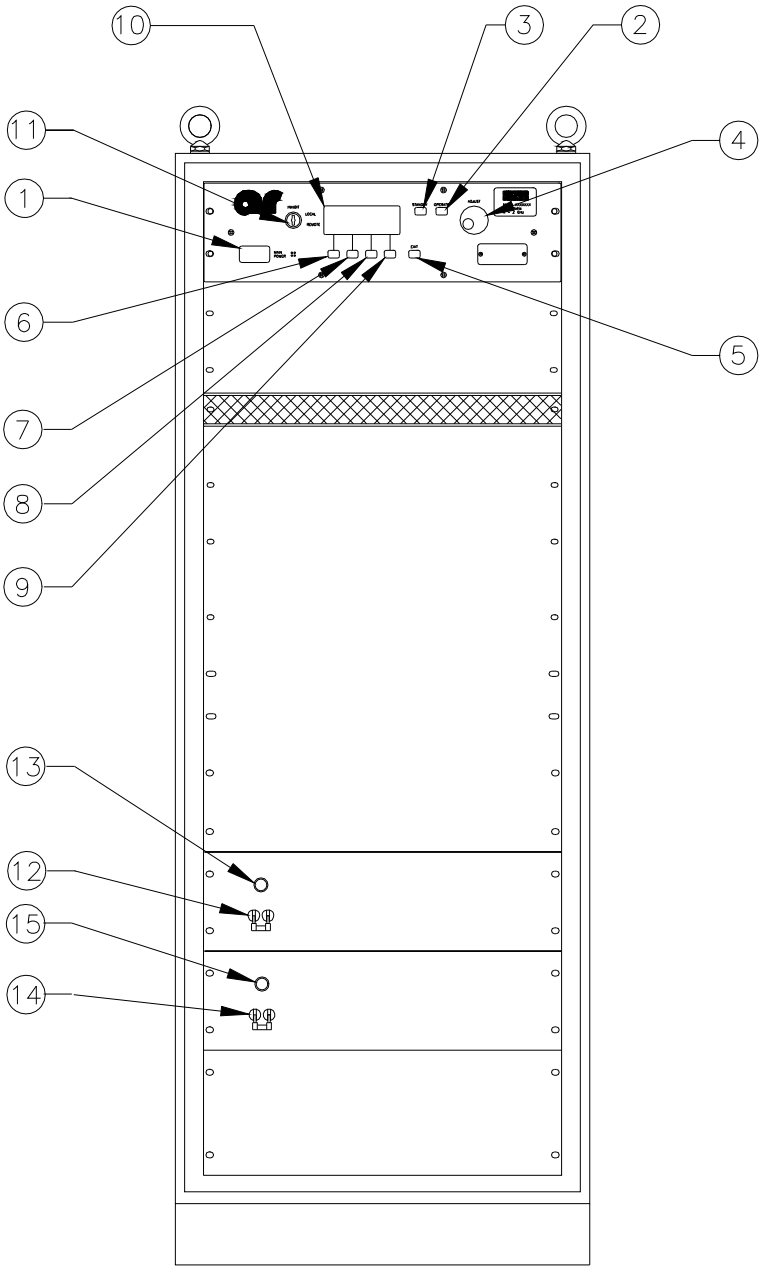

Figure 3-1. Front Panel Features

Table 3-1. Front Panel Features

Label	Title	Function
1	MAIN POWER	Switchable 7.5 A. circuit breaker; turns on control module, closes contactor providing AC to the power supply assemblies.
2.	OPERATE	Push-button; turns on high voltage when all faults and heater delay are cleared.
3.	STANDBY	Push-button; biases grid off and turns off high voltage.
4.	ADJUST	Rotary knob used as an input device to change values of a variety of parameters.
5.	EXIT	Push-button; terminates various menu selection routines and returns to the previous menu level.
6-9.	S1...S4	"Soft Key" push-buttons; various menu selection functions.
10.	Display	Displays numerous parameter values and fault messages.
11.	Keylock Switch	Allows operator to inhibit the TWTA, to enable front panel control, or to enable computer control.
12.	MAIN POWER, HPA #1	Switchable 30 A circuit breaker, provides AC power to power supply assembly for TWT #1.
13.	POWER ON LIGHT	Green light indicates the PS assembly is on.
14.	MAIN POWER, HPA #2	Switchable 30 A circuit breaker, provides AC power to power supply assembly for TWT #2.
15.	POWER ON LIGHT	Green light indicates the PS assembly is on.

3.4 FRONT PANEL DISPLAY AND SOFT KEYS

The purpose of the front panel display is to permit the operator to access extensive information about the condition and operation of the TWTA. To accomplish this, a number of informational screens are programmed. It is important for the operator to be able to select the screen with the required information. Screen selection is accomplished by pressing an appropriate soft key or by pressing the EXIT key. When a soft key is active, its function is displayed on the bottom line of the display. Figure 3-2 provides a roadmap for navigating between the screens.

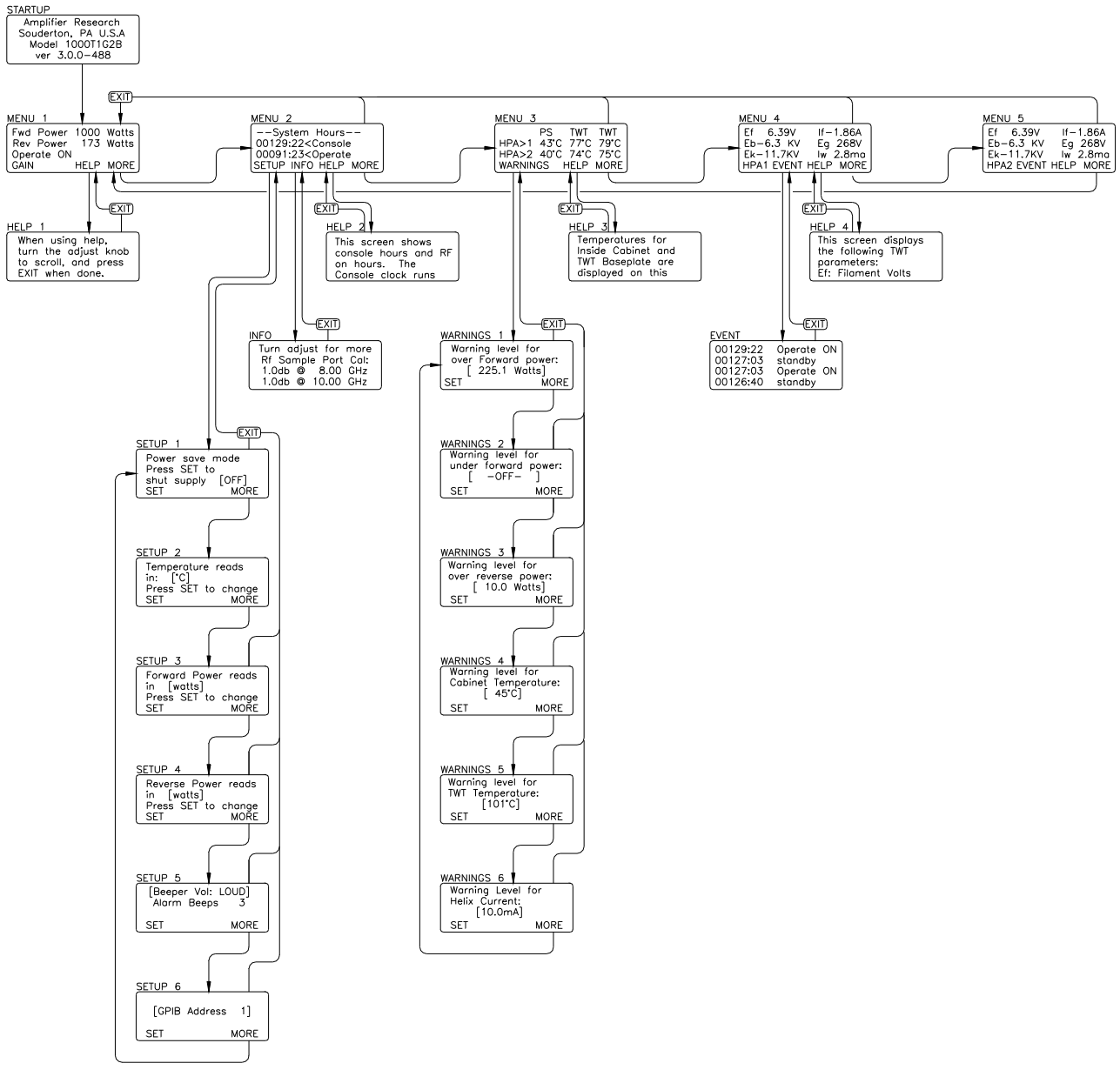

Figure 3-2. Front Panel Display Screens

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

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

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

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

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

Sleep Mode - The Sleep Mode feature allows the *user* to selectively shut off the heater module of the power supplies. This can be done manually through the front panel or remotely via the computer interface. This is typically used during extended periods of *remote* operation to improve tube life, by turning off the filaments

(Sleep Mode activated). This eliminates excessive STANDBY hours on the TWTs while still permitting remote capability to turn on the amplifier.

After activating the Sleep Mode:

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

To deactivate Sleep Mode:

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

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

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

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

In WARNINGS 3, the maximum reverse power level is set. Note that these are warning levels at which the beep sounds; the actual maximum reverse power level that generates a system fault is set in hardware in the TWT power supply HPA Logic and Control module (A16485).

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

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

From WARNINGS 5, MORE brings up WARNINGS 6, which permits setting the maximum helix current. Any helix current above this setpoint will result in an audible alarm (if configured), repeated every 30 seconds; and a warning message is displayed on the status line of MENU 1.

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

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

Event Screen - From MENU 4, S2 (labeled EVENT) provides a display of events logged by the control system. These events include AC power-up, heater warm-up, change from standby to operate, faults, and resets. The events are stored in a first-in-first-out (FIFO) software buffer that has room for 100 events; as new events are logged, the older ones are discarded.

System Shutdown Screen - In the event of a system shutdown due to a fault, refer to Table 3-5. The MENU screen is replaced by a screen indicating the nature of the fault. Softkey S4 (labeled OK) is implemented as a reset key; pressing S4 brings back the MENU screens. Line 3 of MENU 1, which normally displays the operational state of the TWTA, is used as a fault display line until the fault is cleared. Most faults turn HV off. Faults that do not turn off HV are specified in Table 3-5. When such faults are cleared, the system will automatically resume the standby state and users may again select the Operate mode.

Some faults (EXTERNAL INHIBIT) will turn off the grid of the tubes to disable RF output while the fault is being displayed on the screen. HV will remain on during these faults. Once the fault is corrected, the fault will clear and the system will turn RF back on automatically. This automatic return to operation is provided for selected faults due to influences external to the TWTA.

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

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

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

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

CAUTION:

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

3.5 REAR PANEL FEATURES

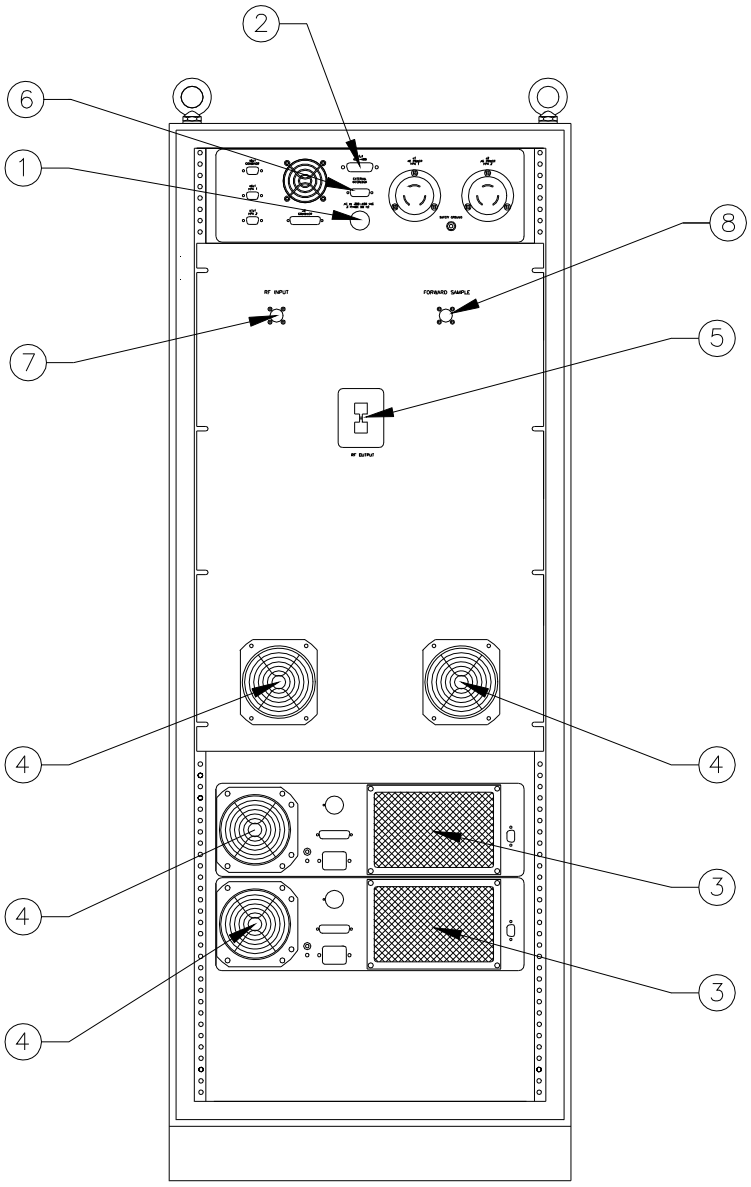

Figure 3-3. Rear Panel Features

Table 3-2. TWTA Rear Panel Features

Label	Title	Function
1.	208 VAC IN	AC power input cable
2.	REMOTE INTERFACE	Remote control connector. 24 pin hermaphrodite
3.	AIR FILTER	Cooling air intake.
4.	EXHAUST FAN	Cooling air outlet.
5.	RF OUT	Type WRD-250D30 flange
6.	EXTERNAL INTERLOCK	Connector to remote temperature switch protecting the isolator or load; D-sub 15-pin female
7.	RF INPUT	RF input (Type N, female)
8.	FORWARD SAMPLE	RF forward sample (Type N, female)

3.6 INITIAL TURN ON AND WARM-UP PROCEDURE

Install the TWTA as discussed in section 3.2. Provide an RF generator to the RF input Type N connector. Set RF generator level below -50dBm and set desired frequency in specified range. Connect a load suitable for 1500 watts continuous operation to the RF output connector. The load VSWR should be less than 2.0:1 A power meter and suitable attenuators may be connected to the RF sample port. (Refer to RF sample port calibration factors on the rear of the unit or on the *Info* screen in MENU 2). These show the relation between the amplifier output power and the RF sample port power as a function of frequency.

Set keylock to LOCAL.

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

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

CAUTION:

Do not allow the TWTA to remain in the STANDBY state for extended periods of time. If the TWTA will not be used in the OPERATE state within an hour, shut the TWTA off or activate the Sleep Mode to have continued remote GPIB access. The reason for this precaution is that in the STANDBY mode, the TWTs' cathodes run very hot since they are not cooled by electrons boiling off the surface, and small amounts of out-gassing are not cleaned up by the electron beam. *Extended operation in the standby state can result in irreparable damage to TWTs!*

Push S4 (MORE) three times to go to MENU 4. Verify that the heater voltage and current for TWT #1 are near their nominal levels. Press MORE again to view MENU5 and verify the values for TWT #2. The values of these parameters at the time the TWTA left the factory are logged on the test data sheet.

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

Set the TWTA gain to maximum. Adjust the RF generator to slowly increase the RF drive toward 0dBm to reach the desired FWD PWR on the display and power meter (connected to forward sample port). The forward power indication will become active, with maximum value when peak power output is achieved. Best performance is obtained when the input RF drive is set at or just below the level which causes peak power

output. Do not set input drive above 0dBm (Input drive above +13dBm may damage the unit). The reverse power level should remain below 10% of the forward power, assuming that the load is properly matched.

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

Observe that the helix current is sensitive to the RF drive level of the TWT. It is at a minimum with no RF drive. The helix current with no drive and with 1000 watts RF output mid-band are logged on the test data sheet. The value of the helix current is a good qualitative indicator that RF drive is present.

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

3.7 REMOTE IEEE-488 OPERATION

The TWTA is provided with an IEEE-488 interface that permits remote emulation of OPERATE, STANDBY, and RESET push-buttons as well as access to parameter measurements, system faults, gain adjustment and control unit status. The following tables summarize the commands and the return codes.

Table 3-3. Catalog of IEEE-488 Commands

Command	Function	Units	Response format
RDSTAT	Returns status code of processing of previous command (see Table 3-4)		STATUS=[ ]
RDFLT	Returns system fault code (see Table 3-5)		flt=[ ]
OPERATE;	Emulates OPERATE push-button		
STANDBY;	Emulate STANDBY push-button		
POWER:OFF;	Emulate STANDBY push-button		
SYSTEM:ON;	Emulates pressing the System ON button from System OFF (Exit Sleep Mode)		
SYSTEM:OFF;	Emulates pressing the Power Save button. (Enter Sleep Mode)		
RESET;	Emulates RESET softkey		
RDS/N	Returns serial number		s/n=[ ]
RDCONHR	Returns console hours		ConHr=[ ]
RDRFHR	Returns RF hours		RfHr=[ ]
RDEK1	Returns cathode voltage, HPA1	KV	Ek=[ ]
RDEK2	Returns cathode voltage, HPA2	KV	Ek=[ ]
RDEB1	Returns collector voltage, HPA1	KV	Eb=[ ]
RDEB2	Returns collector voltage, HPA2	KV	Eb=[ ]
RDEG1	Return grid voltage, HPA1	V	Eg=[ ]
RDEG2	Return grid voltage, HPA2	V	Eg=[ ]
RDEF1	Returns heater voltage, HPA1	V	Ef=[ ]
RDEF2	Returns heater voltage, HPA2	V	Ef=[ ]
RDIF1	Returns heater current, HPA1	A	If=[ ]
RDIF2	Returns heater current, HPA2	A	If=[ ]
RDIW1	Returns helix current, HPA1	mA	Iw=[ ]
RDIW2	Returns helix current, HPA2	mA	Iw=[ ]
RDTMPTWTHPA1F	Returns TWT temp (°F), HPA1	°F	TWTHPA1F=[ ]F
RDTMPTWTHPA2F	Returns TWT temp (°F), HPA2	°F	TWT HPA2F=[ ]F

Command	Function	Units	Response format
RDTMPTWTHPA1C	Returns TWT temp (°C), HPA1	°C	TWTHPA1C=[ ]C
RDTMPTWTHPA2C	Returns TWT temp (°C), HPA2	°C	TWTHPA2C=[ ]C
RDTMPPSHPA1F	Returns power supply temp (°F), HPA1	°F	PSHPA1F=[ ]F
RDTMPPSHPA2F	Returns power supply temp (°F), HPA2	°F	PSHPA2F=[ ]F
RDTMPPSHPA1C	Returns power supply temp (°C), HPA1	°C	PSHPA1C=[ ]C
RDTMPPSHPA2C	Returns power supply temp (°C), HPA2	°C	PSHPA2C=[ ]C
RDTWTOTF	Returns TWT overtemp warning setpoint (°F)	°F	TWTOTF=[ ]F
STWTOTF	Sets TWT overtemp warning setpoint (°F)	°F	
RDTWTOTC	Returns TWT overtemp warning setpoint (°C)	°C	TWTOTC=[ ]C
STWTOTC	Sets TWT overtemp warning setpoint (°C)	°C	
RDPSOTF	Returns power supply overtemp warning setpoint (°F)	°F	PSOTF=[ ]F
SPSOTF	Sets p. s. overtemp warning setpoint (°F)	°F	
RDPSOTC	Returns p. s. overtemp warning setpoint (°C)	°C	PSOTC=[ ]C
SPSOTC	Sets p. s. overtemp warning setpoint (°C)	°C	
RDIWOC	Returns helix overcurrent warning setpoint	mA	IwOC=[ ]
SIWOC	Sets helix overcurrent warning setpoint	mA	
RDLOGIC	Returns logic state code (see Table 3-6)		Sys=[ ]
RDA	Returns gain	%	A=[ ]
SA	Sets gain	%	
RDHTDREM	Returns remaining heater time delay	sec.	HTD=[ ]s
RDPOD	Returns forward power out (dBm)	dBm	Po=[ ]dBm
RDPOW	Returns forward power out (W)	watts	Po=[ ]W
RDPRD	Returns reverse power out (dBm)	dBm	Pr=[ ]dBm
RDPRW	Returns reverse power out (W)	watts	Pr=[ ]W
RDPOHID	Returns over forward power warning setpoint (dBm)	dBm	Pohi=[ ]dBm
SPOHID	Sets over forward power warning setpoint (dBm)	dBm	
RDPOLOD	Returns under forward power warning setpoint (dBm)	dBm	Polo=[ ]dBm
SPOLOD	Sets under forward power warning setpoint (dBm)	dBm	
RDPOHIW	Returns over forward power warning setpoint (W)	watts	Pohi=[ ]W
SPOHIW	Sets over forward power warning setpoint (W)	watts	
RDPOLOW	Returns under forward power warning setpoint (W)	watts	Polo=[ ]W
SPOLOW	Sets under forward power warning setpoint (W)	watts	
RDPRHID	Returns over reverse power warning setpoint (dB)	dBm	Prhi=[ ]dBm
SPPRHID	Sets over reverse power warning setpoint (dBm)	dBm	
RDPRHIW	Returns over reverse power warning setpoint (W)	watts	Prhi=[ ]W
SPRHIW	Sets over reverse power warning setpoint (W)	watts	
RDHTRAUTOOFF	Returns heater to auto off delay	hours	
SHTRAUTOOFF	Sets heater auto off delay (see Table 3-9)		
*IDN?;	Returns the product model number		[ ]
*STA?;	Returns status string (see Table 3-7)		[ ]
*STB?;	Returns status string (see Table 3-8)		[ ]

Table 3-4. Catalog of Status Codes

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

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

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

Table 3-5. Catalog of Fault Codes

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

Fault Code	Meaning	Fault Code	Meaning
0	No fault	72	FIL NOT READY2
40	FIL NOT READY1	73	LOW LINE2
41	LOW LINE1	74	CATH O/VOLTAGE2
42	CATH O/VOLTAGE1	75	BODY O/CURRENT2
43	BODY O/CURRENT1	76	CATH U/VOLTAGE2
44	CATH U/VOLTAGE1	77	ID_BOARD2
47	COLL U/VOLTAGE1	79	COLL U/VOLTAGE2
48	INVERTER FAULT1	80	INVERTER FAULT2
49	INTERLK OPEN1	81	INTERLK OPEN2
50	TUBE ARC1	82	TUBE ARC2
51	TWT OVER TEMP1(h)	83	TWT OVER TEMP2(h)
52	CABINET O/TEMP1(h)	84	CABINET O/TEMP2(h)
54	EXTERNAL INHIBIT1	86	EXTERNAL INHIBIT2
55	OVER REV POWER1	87	OVER REV POWER2
58	Panel Open1	90	Panel Open2
59	latched fault1	91	latched fault2

Table 3-6. Catalog of System State Codes

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

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

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

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

w bit	Meaning
12 (LSB)	(not used)
13	Sleep Mode Active
14	HPA #1 power supply off or failed
15 (MSB)	HPA #2 power supply off or failed

Table 3-7. *STA?; Response Codes

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

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

Table 3-8. *STB?; Response Codes

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

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

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

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

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

Command syntax is in this form:

<command mnemonic> <parameter> <carriage return>

where;

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

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

<carriage return> consists of an ASCII carriage return.

All commands are case sensitive.

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

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

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

A small sample program that can send commands and receive the strings returned by the TWTA is included in section 5.6. It is written in Hewlett-Packard's "Rocky Mountain" BASIC. The program assumes that the IEEE-488 bus is at address 7 and that the address of the TWTA is 01.

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

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

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

3.8 TWTA GENERAL CONSIDERATIONS

This section is intended to offer some guidelines regarding operation, storage and use of Amplifier Research TWTAs.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The service measures involve pulsing of the tube beam current and gradually increasing the duty of the pulsing until the unit will operate continuously. Note that a similar condition can exist for tubes with grids when the TWTA is in the Operate mode (high voltage is on) but gating (control) input is set so that the grid turns off the TWT beam current. Operational procedures should also limit the time in this mode.

5. MAINTENANCE

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

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

4.1 SAFETY WARNING

WARNING:

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

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

CAUTION:

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

4.2 UNAUTHORIZED REPAIRS

CAUTION:

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

4.3 PREVENTIVE MAINTENANCE

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

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

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

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

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

   NOTE: Due to the weight in excess of fifty pounds, the removal of some of the amplifier's units from the cabinet is a two person operation.

   Disconnect power. Remove any other cables. On the front of the unit, remove the four screws (two outside screws on each side) mounting the front panel to the cabinet. Carefully slide the unit out of the front of the cabinet. Depress the buttons on each slide rail to remove the unit from the rack

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

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

4. Reassemble in reverse order. Reconnect rear panel cables.

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

4.4 TROUBLESHOOTING

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

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

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

4.5 NON-REPAIRABLE MODULES

The Heater power supply (A10010-000), the Grid modulator (A21422-000), the HV filter (A21461-500), and the Diode/Cap Assembly (A21425-500) are encapsulated modules and are not repairable. Contact an authorized service representative if replacement modules are needed.

5. TECHNICAL DOCUMENTATION

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

5.1 TOP LEVEL BUILD TREE

	A28002-304	1000W TWTA SC BAND CONTINUOUS, 380 VAC 3-PHASE,
1A1	A28005-004	RF COMBINER ASSY SC BAND CONTINUOUS, FRONT
1A1A1	A27995-003	COMBINER RF COMPONENTS, 1000T SC BAND, WG
	A31673-000	COMBINER ASSEMBLY, WRD-250, S/C BAND [MDC
1A1A2	A27444-001	1000T COMBINER VPC INTERFACE BOARD, COMPONENT
1A1A3-A4	A26941-000	TWTA LOP BOARD
1A1A5	A28008-000	F/O TO RS-485 ADAPTER
1A1A6-A7	A28036-000	TWT COOLING ASSEMBLY, TET 5196
1A1A6-A7A1	A23692-000	INSULATED FAN DRIVER
1A1A6-A7A1T1	A09594-000	FAN DRIVER TRANSFORMER
1A1A9	A27998-000	COMBINER WIRING KIT, SC-BAND
1A1A10	A28032-001	CHASSIS, RF COMBINER, SC BAND, FRONT PORTS
1A2-A3	A28012-000	1000T S/C-BAND P.S.
1A2-A3A1	A24801-501	3U POWER SUPPLY FOR TWT 5296, 1 PHASE
1A2-A3A1A1	A24823-000	HEAT SINK/MOTHER BOARD
1A2-A3A1A2	A23687-001	LOW VOLTAGE POWER SUPPLY MODULE
1A2-A3A1A3	A16485-000	HPA LOGIC AND CONTROL MODULE
1A2-A3A1A4	A23683-000	1500W AVR CURRENT POWER FACTOR
1A2-A3A1A4L4	A09006-000	PFC INDUCTOR FOR 100VAC-255VAC
1A2-A3A1A5	A23719-000	H - BRIDGE BOARD FOR 2000W LOAD, SIMILAR TO
1A2-A3A1A5L1	A09405-000	INDUCTOR
1A2-A3A1A5T1 (E42)	A09402-000	XFMR,GATE DRIVE (HAND WOUND)
1A2-A3A1A5T2 (E41)	A09403-000	XFMR,GATE DRIVE (HAND WOUND)
1A2-A3A1A6	A21425-296	DIODE CAP ASSY FOR TWT 5296
1A2-A3A1A6T1	A09578-000	HV XFMR FOR TWT 5296
1A2-A3A1A7	A21461-500	HV FILTER FOR 5196
1A2-A3A1A8	A21422-000	GRID MODULATOR MODULE
1A2-A3A1A8A1	A18415-000	MODULATOR HIGH VOLTAGE BOARD
1A2-A3A1A8A1T1	A09227-000	PULSE TOP XFMR,HAND WOUND
1A2-A3A1A8A1T2	A09228-000	FEEDBACK XFMR,HAND WOUND
1A2-A3A1A8A1T3	A09229-000	BIAS XFMR,HAND WOUND
1A2-A3A1A8A1T4-T5	A09230-000	XFMR,GATE DRIVE (HAND WOUND)
1A2-A3A1A8A2	A23715-000	MODULATOR CONTROL BOARD
1A2-A3A1A9	A10010-000	HEATER POWER SUPPLY MODULE
1A2-A3A1A9T1	A09409-000	XFMR,HEATER FEEDBACK
1A2-A3A1A9T2	A09408-000	XFMR,HEATER POWER
1A2-A3A1A10	A10017-511	PWM BD FOR 500T2G8
1A2-A3A1A11	A25398-511	FACTORY SELECT FOR 500T2G8
1A2-A3A3	A25444-000	HPA INTERFACE BOARD (PLASTIC FIBERS)
1A2-A3A3U15	A31346-000	DAC REPLACEMENT BOARD FOR U00725. DUAL
1A2-A3A4	A23692-000	INSULATED FAN DRIVER
1A2-A3A4T1	A09594-000	FAN DRIVER TRANSFORMER
1A2-A3A5	A28008-000	F/O TO RS-485 ADAPTER
1A2-A3A9	A28048-000	WIRING KIT, 1000T 2KW POWER SUPPLY

1A2-A3A10	A27772-000	1000T S/C-BAND CABINET ASSY
1A2-A3A10A1	A27772-001	1000T S/C-BAND MECHANICAL KIT
1A4	A28010-303	CONTROL UNIT, 1000T W/ 15VDC SUPPLY, 380VAC,
1A4	A28010-300	CONTROL UNIT, 1000T, 380VAC, 3-PHASE (AR)
1A4A1	A25403-300	TWTA CONTROL ASSY 20 CIJ/50X
1A4A1A1	A25450-000	CPU BOARD W/POWERFAIL (20MHZ)
1A4A1A2	A25425-000	HPA DISPLAY BOARD
1A4A1A3	A22488-003	GPIB INTERFACE BOARD, 3U TWT PRODUCTS
1A4A3	A21175-000	DATA STEERING BOARD (7 PORT)
1A4A5-A7	A28008-000	F/O TO RS-485 ADAPTER
1A4A9	A28046-000	CONTROL MODULE WIRING KIT
1A4A10	A28045-000	CONTROL MODULE CABINET ASSY AR 1000T, 380VAC
1A7-A8	A28014-000	TWT CONTROL CABLE
1A9	A28015-000	COMBINER CONTROL CABLE
1A11	A30921-000	CABINET KIT 1000T

5.2 SCHEMATICS

10-16485-000	HPA Logic and Control (A16485-000)
10-24830-002	Remote Control Board, Foldback only (A24830-002)
10-25444-000	HPA Interface (A25444-000)
10-27444-000	Switcher/Combiner Interface Board (A27444-001)
10-28005-001	RF Combiner, SC-band (A28005-004)
10-28010-300	Control Module, 1000T (A28010-303)
10-28012-000	1000T SC-Band Power Supply (A28012-000)

5.3 BLOCK DIAGRAM

25-28005-000 RF Combiner for L-Band (A28005-004)

5.4 PARTS LISTS

A16485-000	HPA Logic and Control Module
A24801-501	1000T 3U Power Supply for TWT 5196
A24830-002	Emergency Bypass Board
A25444-000	HPA interface
A27444-001	Switcher/Combiner Interface Board
A27995-003	Combiner RF Components 1000T-SC
A28002-304	1000 W TWTA S/C-Band, 208VAC
A28005-004	RF Combiner Assembly, S/C-Band
A28010-303	Control Module, 1000T
A28012-000	1000T S/C- Band Power Supply

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

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
	B16485-000	HPA LOGIC AND CONTROL BOARD	2
C11	C16333-000	CAP,33MF,25V,AERL,(NICHICON UVX1E330M)	2
C2, C5, C15, C58	C31028-000	CAP,1000PF,200VDC,10%,CER,1% FAILURE,(KEMET CKR05 SERIES W/"V" OPTION)	8
C3, C9, C10, C13, C14, C17, C19, C21, C22, C27, C28, C30, C31, C33, C36, C46	C31032-000	CAP,0.01MF,200VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	32
C61	C31033-000	CAP,0.022MF,100VDC,10%,CER,1% FAILURE,(KEMET CKR06B223K W/V OPTION)	2
C24, C60	C31036-000	CAP,0.1MF,100VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	4
C1, C4, C6, C7, C16, C18, C25, C26, C32, C34, C37, C38, C39, C40, C41, C43, C44, C45, C48, C49	C31040-000	CAP,1MF,50VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	40
D16, D23, D31	D10965-000	ZENER,15V,(DIODES INC 1N965B)	6
D1, D3, D4, D5, D7, D8, D9, D10, D11, D12, D13, D17, D18, D19, D21, D22, D25, D26, D28, D30, D35, D37, D38, D40	D14454-000	DIODE,AXIAL,(MOTOROLA 1N4454)	48
D36	D14733-000	ZENER,5.1V,1W,10%,AXIAL,(MOTOROLA 1N4733)	2
	F00010-000	WASHER,#2,LOCK,SST	6
	F10086-000	PHP,2-56 X 3/16SST	6
J2	J10370-000	CONN,37 PIN,MALE,D-SUB,PCB RIGHT ANGLE, (AMP 747252-4)	2
	J18075-000	MALE SCREW LOCK,FOR D SUBMIN CONN,(AMP 205817-1)	2
J4, J5	J18086-000	CONN,,SMA,JACK RECEPTACLE,RIGHT ANGLE,0-18GHZ,PC MOUNT [JOHNSON COMPONENTS 142-0701-301]	4
J1	N25003-000	HYPERTRONICS CONN,29 PIN MALE RIGHT ANGLE,(CUT ENDS)	2
Q2	Q22907-000	TRANSISTOR,PNP,2N2907A,TO-18	2
R1, R9, R19, R37, R44, R50	R00100-000	RES,10 OHM,1/4W,5%,CC,(A/B RC07GF100J)	12
R4, R20, R27, R29	R01100-000	RES,100 OHM,1/4W,5%,CC,(A/B RC07GF101J)	8
R5, R17, R18, R28, R34, R45, R49, R53, R54, R59, R71, R88	R02100-000	RES,1K,1/4W,5%,CC,(A/B RC07GF102J)	24
R6	R02270-000	RES,2.7K,1/4W,5%,CC,(A/B RC07GF272J)	2
R30, R31, R36	R02470-000	RES,4.7K,1/4W,5%,CC,(A/B RC07GF472J)	6
R86, R87	R02510-000	RES,5.1K,1/4W,5%,CC,(A/B RC07GF512J)	4
R75	R02560-000	RES,5.6K,1/4W,5%,CC,(A/B RC07GF562J)	2
R38, R77, R90	R03100-000	RES,10K,1/4W,5%,CC,(A/B RC07GF103J)	6
R32	R03470-000	RES,47K,1/4W,5%,CC,(A/B RC07GF473J)	2
R35	R05820-000	RES,8.2M,1/4W,5%,CC,(A/B RC07GF825J)	2
R13, R14	R10002-000	TRIMPOT,5K,1/2W,10%,CERMET,20T,SIDE ADJ,(BOURNS 3296X-1-502)	4
R76	R21499-000	RES,4.99K,1/2W,1%,MF,100PPM,(DALE RN55D)	2
R10	R21523-000	RES,5.23K,1/2W,1%,MF,100PPM,(DALE RN55D)	2
R16	R21866-000	RES,8.66K,1/2W,1%,MF,100PPM,(DALE RN55D)	2
R52, R73	R21887-000	RES,8.87K,1/2W,1%,MF,100PPM,(DALE RN55D)	4

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
R67	R21953-000	RES,9.53K,1/2W,1%,MF,100PPM,(DALE RN55D)	2
R47, R48	R22200-000	RES,20K,1/2W,1%,MF,100PPM,(DALE RN55D)	4
R79, R80	R22470-000	RES,47K,1/2W,1%,MF,100PPM,(DALE RN55D)	4
R42, R60, R61, R89	R23100-000	RES,100K,1/2W,1%,MF,100PPM,(DALE RN55D)	8
R33, R55	R23698-000	RES,698K,1/2W,1%,MF,100PPM,(DALE RN55D)	4
R41	R23750-000	RES,750K,1/2W,1%,MF,100PPM,(DALE RN55D)	2
R21	R23845-000	RES,845K,1/2W,1%,MF,100PPM,(DALE RN55D)	2
R66	R23953-000	RES,953K,1/2W,1%,MF,100PPM,(DALE RN55D)	2
R12, R15	R32020-000	TRIMPOT,10K,1/2W,10%,CERMET,20T,SIDE ADJ,(BECKMAN 67X)	4
U4, U5, U6	U02390-000	IC,QUAD COMPARATOR,(NAT LM139J)	6
U7	U03240-000	IC,LOW POWER OP AMP,(NAT LM324)	2
U9	U10070-000	REFERENCE,PRECISION 10V [LINEAR TECH LT1031DCH]	2
U8	U17805-000	IC,5V REGULATOR,TO-220,(NAT LM340T-5.0)	2
U1, U2, U3	U20148-000	IC,HEX INVERTER,SCHMIDTT TRIGGER,(74HC14) (SSD)	6
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)	12
RP4	U31020-000	IC,1K RES NETWORK,SIP,(BECKMAN L061C102G)	2
W3-W8	W12200-000	WIRE, 22 AWG, BLU, 600V, TEFLON, (BELDEN 83006)	12

5.4.2 Parts List, 3U Power Supply for TWT 5196, 1 Phase, A24801-501

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
A9	A10010-000	HEATER POWER SUPPLY MODULE	2
A10	A10017-511	PWM BD FOR 500T2G8	2
A3	A16485-000	HPA LOGIC AND CONTROL MODULE	2
A8	A21422-000	GRID MODULATOR MODULE	2
A6A	A21425-296	DIODE CAP ASSY FOR TWT 5296	2
A6	A21425-500	DIODE CAP ASSY FOR TWT MEC5196	2
A7	A21461-500	HV FILTER FOR 5196	2
A4	A23683-000	1500W AVR CURRENT POWER FACTOR	2
A2	A23687-001	LOW VOLTAGE POWER SUPPLY MODULE	2
A5	A23719-000	H - BRIDGE BOARD FOR 2000W LOAD, SIMILAR TO A16487	2
A1	A24823-000	HEAT SINK/MOTHER BOARD	2
A11	A25398-511	FACTORY SELECT FOR 500T2G8	2

5.4.3 Parts List, Emergency Bypass Board, A24830-002

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	C06103-000	CAP,10MF,25V,20%,SOLID TANT,RADIAL,(AVX TAP106M025HSB)	1
C1, C2	C31032-000	CAP,0.01MF,200VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	2
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
I4	I10096-000	LED,GREEN,DIFFUSED,T1-3/4 (XC55G)	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
J2	J18086-000	CONN,,SMA,JACK RECEPTACLE,RIGHT ANGLE,0-18GHZ,PC MOUNT [JOHNSON COMPONENTS 142-0701-301]	1
J1	J31055-000	CONN,D-SUB,15 PIN,FEMALE,STRAIGHT,PCB MOUNT,[AMPHENOL 17D-A15S-U]	1
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	R01514-000	RES,510 OHM,1W,5%,CC,(A/B RC20GF511J)	1
R19	R02100-000	RES,1K,1/4W,5%,CC,(A/B RC07GF102J)	1
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
R9, R13, R15	R03100-000	RES,10K,1/4W,5%,CC,(A/B RC07GF103J)	3
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
U2	U11458-000	IC,DUAL OP AMP,(NAT LM1458CN)	1
U1	U17808-000	IC,8V REGULATOR,TO-220,(NAT LM340T-8.0 OR LM7808)	1

5.4.4 Parts List, HPA Interface Board (Plastic Fibers), A25444-000

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
	B25444-000	HPA INTERFACE BOARD	2
C161	C03105-000	CAP,0.01MF,100V,CER,10%,RADIAL,(AVX SR201C103KAA)	2
C171	C04223-000	CAP,0.22MF,35V,TANT,RADIAL, [JAMCO 33507]	2
C20, C32, C100	C05153-000	CAP,1.5MF,35V,TANT,RADIAL,(JAMECO TM1.5/35)	8
C129, C163	C05223-000	CAP,2.2MF,35V,10%,SOLID SEALED TANT,RADIAL,(SPRAGUE 199D225X9035BA1)	4
C80, C81, C164	C06103-000	CAP,10MF,25V,20%,SOLID TANT,RADIAL,(AVX TAP106M025HSB)	6
C15	C06220-000	CAP,22MF,16V,SOLID TANT,RADIAL,(AVX TAP226K016SCS)	2
C99	C16103-000	CAP,10MF,35V,AERL,(NICHICON UVX1V100)	2
C101	C17222-000	CAP,220MF,16V,AERL,(ILL CAP 227RAR016A)	2
C47, C67	C17224-000	CAP,220MF,50V,AERL,(ILL CAP 227RAR050A)	4
C44, C168, C169	C30066-000	CAP 47 MF, 35V, SOLID TANT. RADIAL, (KEMET T356M476K035AS)	6
C165, C166, C6, C7, C9, C13, C16, C39, C43, C69	C31016-000	CAP,100PF,200VDC,10%,CER,1% FAILURE,(KEMET CKR05 SERIES W/"V" OPTION)	20
10, 11, 22, 23, 24, 25, 26, 28, 30, 33, 35, 40, 41, 42, 48, 49, 50, 51, 53, 62, 63, 64, 65, 70, 71, 73, 77, 79, 83, 85, 87, 88, 89, 91, 94, 96, 97, 98, 102, 103, 105, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 121, 125, 132, 167, 1, 2, 3, 4, 5	C31036-000	CAP,0.1MF,100VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	122
C12, C14, C21, C27, C29, C31, C34, C36, C38, C17, C18, C19, C37, C54, C55, C56, C57, C58, C59, C60, C61, C118, C119, C120, C122, C123, C124, C133, C46, C52, C66, C68, C72, C75, C82, C84, C86, C90, C92, C93, C95, C104, C106, C45	C31040-000	CAP,1MF,50VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	88
D8, D10-D16, D18-D19	D14007-000	DIODE,1000V,1A,AXIAL,(MOTOROLA 1N4007)	20
D1-D7	D14454-000	DIODE,AXIAL,(MOTOROLA 1N4454)	14
D9, D17	D14733-000	ZENER,5.1V,1W,10%,AXIAL,(MOTOROLA 1N4733)	4
I1	I10074-000	LED,GREEN,ALGAAS,NON-DIFFUSED,(HEWLETT PACKARD HLMP-1540)	2
J5	J10021-000	HEADER,2 PIN,MALE,RIGHT ANGLE,SERIES 7478 (MOLEX 22-05-3021)	2
J1	J10371-000	D-SUB,37 PIN MALE,PCB MOUNT,STRAIGHT (POSITRONICS MD37M3S000)	2
XU17	J14161-000	SKT,DIP,16 PIN,MACH SLEEVES,(AUGAT 516-AG11D)	2
XU26	J14202-000	SKT,DIP,20 PIN,MACH SLEEVES,(SAMTEC ICA-320-SGT)	2
XU15	J14281-000	SKT,DIP,28 PIN,MACH SLEEVES,(SAMTEC ICA-628-SGT)	2
TP0	J16210-000	TEST JACK,BLACK,VERTICAL,(EF JOHNSON 105-0853-001)	2
TP1	J16211-000	TEST JACK,BROWN,VERTICAL,(EF JOHNSON 105-0858-001)	2
TP2	J16212-000	TEST JACK,RED,VERTICAL,(EF JOHNSON 105-0852-001)	2
TP3	J16213-000	TEST JACK,ORANGE,VERTICAL,(EF JOHNSON 105-0856-001)	2

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
TP4	J16214-000	TEST JACK,YELLOW,VERTICAL,(EF JOHNSON 105-0857-001)	2
TP5	J16215-000	TEST JACK,GREEN,VERTICAL,(EF JOHNSON 105-0854-001)	2
TP6	J16216-000	TEST JACK,BLUE,VERTICAL,(EF JOHNSON 105-0860-001)	2
J4	J18167-000	D-SUB,37 PIN,FEMALE,PCB MOUNT,RIGHT ANGLE (AMP 745784-4)	2
J3	J18180-000	CONN,D-SUB,15 PIN,MALE,STRAIGHT,PCB MOUNT (POSITRONIC MD15M3000)	2
J2	J31013-000	CONN,D-SUB,25 PIN,MALE,RIGHT ANGLE,PCB MOUNT,[AMP 747238-4]	2
XJ1-XJ4	J31014-000	SPRING LATCH KIT,D-SUB,(AMPHENOL 17-529)	8
K1-K6	K02009-000	RELAY,DPDT,5VDC,125V @ 0.5A / 30VDC @ 1A CONTACTS,PCB TERMINALS,SEALED (OMRON G6H-2-DC5)	12
L1-L4	L00200-000	WIDE BAND CHOKE,(VK200 10/3B FERROXCUBE)	8
Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8	Q22222-000	TRANSISTOR,NPN,2N2222A,TO-18	16
R2	R01220-000	RES,220 OHM,1/4W,5%,CC,(A/B RC07GF221J)	2
R41	R01680-000	RES,680 OHM,1/4W,5%,CC,(A/B RC07GF681J)	2
R1	R04200-000	RES,200K,1/4W,5%,CC,(A/B RC07GF204J)	2
R4, R7	R05820-000	RES,8.2M,1/4W,5%,CC,(A/B RC07GF825J)	4
R6, R8, R58	R20100-000	RES,100 OHM,1/2W,1%,MF,100PPM,(DALE RN55D)	6
R57	R20200-000	RES,200 OHM,1/2W,1%,MF,100PPM,(DALE RN55D)	2
R11	R20243-000	RES,243 OHM,1/2W,1%,MF,100PPM,(DALE RN55D)	2
R16	R20845-000	RES,845 OHM,1/2W,1%,MF,100PPM,(DALE RN55D)	2
R59	R22332-000	RES,33.2K,1/2W,1%,MF,100PPM,(DALE RN55D)	2
R3, R5	R30071-000	TRIMPOT,10K,1/2W,10%,CERMET,100PPM,20T,TOP ADJ,(BECKMAN 67W)	4
R9, R12, R15, R22, R35, R36, R40, R44, R45	R30103-000	RES,10K,1/8W,1%,MF,AXIAL,100PPM,(DALE CMF-50 / RN50C1002F)	18
R17, R19, R20, R21, R23, R25, R28, R31, R42, R43, R46, R18	R30140-000	RES,1K,1/8W,1%,MF,50PPM,(DALE RN50C)	24
R13, R14, R24, R26, R27, R29, R32, R37, R38, R39, R47	R31164-000	RES,100K,1/20W,1%,FILM,AXIAL,100PPM,MIL,(DALE RN50C1003F)	22
U7, U8	U00027-000	IC,ULTRA LOW NOISE PRECISION OP AMP,(ANALOG DEVICES OP27GP)	4
U26	U00029-000	CONVERTER,NO OIL,16BIT,A TO D,SERIAL OUT,[BURR-BROWN ADS7809PB,PB],[ANALOG DEVICES AD977CN]	2
U17	U00524-000	IC,INSTRUMENTATION AMP,(ANALOG DEVICES AD524A) (SSD)	2
U15	U00725-000	IC,DUAL 16 BIT DIGITAL TO ANALOG CONVERTER,(BURR-BROWN DAC-725) (SSD)	2
U1	U03171-000	IC,ADJUSTABLE VOLTAGE REGULATOR,15W,1.5A, TO-220,(NAT LM317T)	2
U9, U10, U18	U04090-000	IC,4CH ANALOG MULTIPLEXER,(DATEL MXD-409)	6
DP2, DP4, DP5, DP8, DP9	U08010-000	IC,8 COMMON CATHODE CLAMPIMG DIODES,9 PIN SIP,(ROHM DAN801)	10
DP1, DP3, DP6, DP7, DP10	U08011-000	IC,8 COMMON ANODE CLAMPING DIODES,9PIN SIP,(ROHM DAP801)	10
U27	U11165-000	IC,6.5536MHZ CLOCK OSCILLATOR,1/2 SIZE,(ECLIPTEK EC1100HS-6.5536MHZ) (SSD)	2
U40	U11528-000	IC,VERSALINK TRANSMITTER,HORIZONTAL, (200UM FIBER) (HEWLETT PACKARD HFBR-1528)	2
U54	U12521-000	IC,FIBER OPTIC RECEIVER,HORIZONTAL,(HP HFBR-2521) (SSD)	2
U36	U17545-000	DRIVER,OIL,DS75451N,DUAL AND,[NATIONAL SEMICONDUCTOR DS75451N]	2

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
U6, U19, U34, U39, U60	U20148-000	IC,HEX INVERTER,SCHMIDTT TRIGGER,(74HC14) (SSD)	10
U42	U20730-000	IC,DUAL J-K FLIP FLOP W/RESET,(7473) (SSD)	2
U51	U21328-000	IC,QUAD 2 INPUT NAND,SCHMIDTT TRIGGER,(74HC132) (SSD)	2
U52	U21388-000	IC,3 TO 8 DECODER/DEMULTIPLEXER, INVERTING, (74HC138) (SSD)	2
U32	U21536-000	IC,DUAL 4 INPUT DIGTAL MULTIPLEXER,(74F153) (SSD)	2
U35	U22598-000	IC,8 BIT ADDRESSABLE LATCH W/RESET,(74HC259) (SSD)	2
U47	U23909-000	IC,DUAL 4 BIT BINARY/BIQUINARY COUNTER (74HCT390) (SSD)	2
U41, U48	U24018-000	IC,JOHNSON DECADE COUNTER W/10 DECODED OUTPUTS,(74HC4017) (SSD)	4
U45	U24138-000	IC,8 BIT BINARY DOWN COUNTER,(74HC40103) (SSD)	2
U43	U26889-000	IC,8 BIT MAGNITUDE COMPARATOR,(74HCT688) (SSD)	2
U22, U24, U57	U28008-000	IC,QUAD 2 INPUT AND,(74HC08) (SSD)	6
U4, U49, U58	U28032-000	IC,QUAD 2 INPUT OR,(74HC32) (SSD)	6
U44, U46	U28040-000	IC,12 BIT DECADE COUNTER,(74HCT4040) (SSD)	4
U5, U13, U14, U23, U25, U33, U50	U28074-000	IC,DUAL D FLIP FLOP W/RESET,(74HC74) (SSD)	14
U2	U28123-000	IC,DUAL RETRIGGERABLE 1-SHOT,(74HC123) (SSD)	2
U31, U53	U28164-000	IC,8 BIT SERIAL IN PARALLEL OUT SHIFT REGISTER,(74HC164) (SSD)	4
U3, U12, U28, U37, U38	U28165-000	IC,8 BIT PARALLEL IN SERIAL OUT SHIFT REGISTER,(74HC165) (SSD)	10
RP6	U32001-000	IC,1K FEED-THROUGH RES NETWORK,16 PIN DIP,(A/B 316B102)	2
RP1-RP5	U32103-000	IC,10K FEED-THROUGH RES NETWORK,16 PIN DIP,(A/B 316B103)	10
U56	U40008-000	REGULATOR,OIL,5V,100MA,TO-92,[MOTOROLA MC78L05ABP]	2
U55	U40012-000	FLIP-FLOP,OCTAL D-TYPE LATCH WITH RESET,[NATIONAL MM74HC273N]	2

5.4.5 Parts List, 1000T Combiner VPC Interface A27444-001

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
REV D	B27444-000	COMBINER INTERFACE	1
C13, C49	C04105-000	CAP,0.1MF,100V,20%,MON,(KEMET C331C104M1R5CA)	2
C144, C148	C04223-000	CAP,0.22MF,35V,TANT,RADIAL, [JAMCO 33507]	2
C1, C19, C24	C05153-000	CAP,1.5MF,35V,TANT,RADIAL,(JAMECO TM1.5/35)	3
C142, C143	C05223-000	CAP,2.2MF,35V,10%,SOLID SEALED TANT,RADIAL,(SPRAGUE 199D225X9035BA1)	2
C43	C06220-000	CAP,22MF,16V,SOLID TANT,RADIAL,(AVX TAP226K016SCS)	1
C138, C139	C06473-000	CAP,47MF,25V,SOLID TANT,RADIAL,(KEMET T356K476K025AS)	2
C30	C16103-000	CAP,10MF,35V,AERL,(NICHICON UVX1V100)	1
C5	C17222-000	CAP,220MF,16V,AERL,(ILL CAP 227RAR016A)	1
C10, C23	C17224-000	CAP,220MF,50V,AERL,(ILL CAP 227RAR050A)	2
C60, C64, C81, C83, C86, C89, C95, C97, C140, C141	C31016-000	CAP,100PF,200VDC,10%,CER,1% FAILURE,(KEMET CKR05 SERIES W/"V" OPTION)	10
C48	C31028-000	CAP,1000PF,200VDC,10%,CER,1% FAILURE,(KEMET CKR05 SERIES W/"V" OPTION)	1
152, 151, 150, 149, 147, 146, 136, 132, 131, 130, 129, 123, 118, 111, 110, 109, 108, 94, 93, 80, 77, 74, 71, 63, 62, 59, 53, 52, 50, 47, 46, 42, 38, 35, 34, 32, 31, 29, 28, 27, 26, 22, 21, 20, 18, 17, 16, 15, 14, 11, 9, 8, 7, 6, 3, 2	C31036-000	CAP,0.1MF,100VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	56
145, 135, 134, 133, 128, 127, 126, 125, 124, 122, 121, 120, 119, 117, 116, 115, 114, 113, 107, 106, 105, 104, 103, 102, 101, 100, 99, 98, 96, 92, 91, 90, 88, 87, 85, 84, 82, 78, 76, 75, 73, 72, 70, 69, 68, 67, 66, 65, 61, 58, 57, 56, 51, 45, 44, 40, 39, 37, 12, 4	C31040-000	CAP,1MF,50VDC,10%,CER,1% FAILURE,(KEMET CKR06 SERIES W/"V" OPTION)	60
D4, D5, D7-D20	D14007-000	DIODE,1000V,1A,AXIAL,(MOTOROLA 1N4007)	16
D1-D3, D6	D14454-000	DIODE,AXIAL,(MOTOROLA 1N4454)	4
I1	I10074-000	LED,GREEN,ALGAAS,NON-DIFFUSED,(HEWLETT PACKARD HLMP-1540)	1
J1	J10371-000	D-SUB,37 PIN MALE,PCB MOUNT,STRAIGHT (POSITRONICS MD37M3S000)	1
XU34	J14161-000	SKT,DIP,16 PIN,MACH SLEEVES,(AUGAT 516-AG11D)	1
XU64	J14202-000	SKT,DIP,20 PIN,MACH SLEEVES,(SAMTEC ICA-320-SGT)	1
XU10	J14281-000	SKT,DIP,28 PIN,MACH SLEEVES,(SAMTEC ICA-628-SGT)	1
TPO	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 105-0857-001)	1
TP5	J16215-000	TEST JACK,GREEN,VERTICAL,(EF JOHNSON 105-0854-001)	1
J2	J18167-000	D-SUB,37 PIN,FEMALE,PCB MOUNT,RIGHT ANGLE (AMP 745784-4)	1

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
J3	J31010-000	CONN,D-SUB,15 PIN,MALE,RIGHT ANGLE,PCB MOUNT,[AMPHENOL 617-A015P-AJ121]	1
J4	J31013-000	CONN,D-SUB,25 PIN,MALE,RIGHT ANGLE,PCB MOUNT,[AMP 747238-4]	1
XJ4	J31014-000	SPRING LATCH KIT,D-SUB,(AMPHENOL 17-529)	1
K1-K16	K02009-000	RELAY,DPDT,5VDC,125V @ 0.5A / 30VDC @ 1A CONTACTS,PCB TERMINALS,SEALED (OMRON G6H-2-DC5)	16
L1-L4	L00200-000	WIDE BAND CHOKE,(VK200 10/3B FERROXCUBE)	4
Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q9, Q10, Q11, Q12, Q13, Q14, Q15, Q16	Q22222-000	TRANSISTOR,NPN,2N2222A,TO-18	16
R1, R7, R26	R01100-000	RES,100 OHM,1/4W,5%,CC,(A/B RC07GF101J)	3
R4	R01220-000	RES,220 OHM,1/4W,5%,CC,(A/B RC07GF221J)	1
R9	R01680-000	RES,680 OHM,1/4W,5%,CC,(A/B RC07GF681J)	1
R11	R04200-000	RES,200K,1/4W,5%,CC,(A/B RC07GF204J)	1
R5, R6	R05820-000	RES,8.2M,1/4W,5%,CC,(A/B RC07GF825J)	2
R27	R20200-000	RES,200 OHM,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R28	R22332-000	RES,33.2K,1/2W,1%,MF,100PPM,(DALE RN55D)	1
R2, R3	R30071-000	TRIMPOT,10K,1/2W,10%,CERMET,100PPM,20T,TOP ADJ,(BECKMAN 67W)	2
R8, R10, R13, R14, R15, R16, R17, R18, R19, R20, R21	R30103-000	RES,10K,1/8W,1%,MF,AXIAL,100PPM,(DALE CMF-50 / RN50C1002F)	11
R204-R206	R31164-000	RES,100K,1/20W,1%,FILM,AXIAL,100PPM,MIL,(DALE RN50C1003F)	3
RP4, RP8, RP14	R32104-000	RES NET,100K,200MW,1%,FILM,7 RES,PCB MNT,0.01PPM,(DALE MSP08A-01-1003F)	3
U1, U13	U00027-000	IC,ULTRA LOW NOISE PRECISION OP AMP,(ANALOG DEVICES OP27GP)	2
U64	U00029-000	CONVERTER,NO OIL,16BIT,A TO D,SERIAL OUT,[BURR-BROWN ADS7809PB,PB],[ANALOG DEVICES AD977CN]	1
U34	U00524-000	IC,INSTRUMENTATION AMP,(ANALOG DEVICES AD524A) (SSD)	1
U10	U00725-000	IC,DUAL 16 BIT DIGITAL TO ANALOG CONVERTER,(BURR-BROWN DAC-725) (SSD)	1
U43, U46, U53	U04090-000	IC,4CH ANALOG MULTIPLEXER,(DATEL MXD-409)	3
DP2, DP4, DP6, DP7, DP10	U08010-000	IC,8 COMMON CATHODE CLAMPIMG DIODES,9 PIN SIP,(ROHM DAN801)	5
DP1, DP3, DP5, DP8, DP9	U08011-000	IC,8 COMMON ANODE CLAMPING DIODES,9PIN SIP,(ROHM DAP801)	5
U14	U11165-000	IC,6.5536MHZ CLOCK OSCILLATOR,1/2 SIZE,(ECLIPTEK EC1100HS-6.5536MHZ) (SSD)	1
U32	U11537-000	IC,VERSALINK TRANSMITTER,VERTICAL,(200UM FIBER) (HP HFBR-1537)	1
U35	U12531-000	IC,FIBER OPTIC RECEIVER,VERTICAL,(HP HFBR-2531) (SSD)	1
U65	U17545-000	DRIVER,OIL,DS75451N,DUAL AND,[NATIONAL SEMICONDUCTOR DS75451N]	1
U15, U29, U51, U58, U66	U20148-000	IC,HEX INVERTER,SCHMIDTT TRIGGER,(74HC14) (SSD)	5
U47	U20730-000	IC,DUAL J-K FLIP FLOP W/RESET,(7473) (SSD)	1
U37	U21328-000	IC,QUAD 2 INPUT NAND,SCHMIDTT TRIGGER,(74HC132) (SSD)	1
U5	U21388-000	IC,3 TO 8 DECODER/DEMULTIPLEXER, INVERTING,(74HC138) (SSD)	1
U55	U21536-000	IC,DUAL 4 INPUT DIGTAL MULTIPLEXER,(74F153) (SSD)	1
U3	U22598-000	IC,8 BIT ADDRESSABLE LATCH W/RESET,(74HC259) (SSD)	1

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
U18	U23909-000	IC,DUAL 4 BIT BINARY/BIQUINARY COUNTER (74HCT390) (SSD)	1
U28, U52	U24018-000	IC,JOHNSON DECADE COUNTER W/10 DECODED OUTPUTS,(74HC4017) (SSD)	2
U2	U24138-000	IC,8 BIT BINARY DOWN COUNTER,(74HC40103) (SSD)	1
U11	U26889-000	IC,8 BIT MAGNITUDE COMPARATOR,(74HCT688) (SSD)	1
U16, U48, U68	U28008-000	IC,QUAD 2 INPUT AND,(74HC08) (SSD)	2
U17, U38, U67	U28032-000	IC,QUAD 2 INPUT OR,(74HC32) (SSD)	3
U22, U25	U28040-000	IC,12 BIT DECADE COUNTER,(74HCT4040) (SSD)	2
U12, U26, U27, U39, U49, U54, U56	U28074-000	IC,DUAL D FLIP FLOP W/RESET,(74HC74) (SSD)	7
U33	U28123-000	IC,DUAL RETRIGGERABLE 1-SHOT,(74HC123) (SSD)	1
U4, U6, U19	U28164-000	IC,8 BIT SERIAL IN PARALLEL OUT SHIFT REGISTER,(74HC164) (SSD)	3
U23, U36, U44, U50, U57	U28165-000	IC,8 BIT PARALLEL IN SERIAL OUT SHIFT REGISTER,(74HC165) (SSD)	5
RP1, RP2, RP10, RP11	U32001-000	IC,1K FEED-THROUGH RES NETWORK,16 PIN DIP,(A/B 316B102)	4
RP5, RP7, RP9, RP13, RP15	U32103-000	IC,10K FEED-THROUGH RES NETWORK,16 PIN DIP,(A/B 316B103)	5
U63	U40008-000	REGULATOR,OIL,5V,100MA,TO-92,[MOTOROLA MC78L05ABP]	1
U61, U62	U40012-000	FLIP-FLOP,OCTAL D-TYPE LATCH WITH RESET,[NATIONAL MM74HC273N]	2
W1-W16	W12400-000	WIRE,24 AWG,BLUE,TEFLON,(BELDEN)	1

5.4.6 Parts List, Combiner RF Components, 1000T SC, A27995-003

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
	A31673-000	COMBINER ASSEMBLY, WRD-250, S/C BAND [MDC TBD]	1
A5, A6	E01608-000	TWT, 2.5-7.5 GHZ, 535 W, GRID, WRD-250,+/-2 DB EQ, PHASE COMB, ISO THERMO (MEC-5498, GRID,+/-2 EQ)	2
A2	E01611-000	SSPA, 2.5 -8 GHZ. 36DBM,35DB GAIN, 35DB VGA[KMIC KMA2580B2]	1
A20	E20066-000	ATTENUATOR,10DB,2W,DC-18GHZ,SUB-MINATURE,(INMET, 18A-10)	1
A4	E20131-000	LINE STRETCHER DC 18GHZ,(ARRA 9428T-MF)	1
A19	E20245-000	DIRECTIONAL COUPLER,10DB,2-8 GH8,(MAC TECH C2045-10)	1
D1, D2	E20284-000	ZERO-BIAS SCHOTTKY DETECTOR,10MHZ-18.5GHZ,POSITIVE OUT PUT POLARITY,(RLC, M-3747)	2
A3	E20384-000	HYBRID COUPLER, 180 DEGREE, 2 TO 8 GHZ, OPTIMIZEDFOR <5 DEGREES PHASE IMBALANCE 2.5 TO 7.5 GHZ,[KRYT	1
XA3	E20400-000	TERMINATION, 2 WATT, SMA MALE,[INMET 3004M]	1
J1, J2	J00299-000	ADAPTER, PRECISION N FEMALE TO SMA FEMALE, PANEL MT (HUBER & SUHNER 37N-SMA-50-51/1-NE)	2
	J18160-000	CONN,1 PIN,FEMALE,20KV,10A,0.180 DIA. LEAD,[CONNECTRONICS 11039-02]	5

5.4.7 Parts List, 1000W TWTA SC Band Continuous, 208, A28002-304

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
A1	A28005-004	RF COMBINER ASSY SC BAND CONTINUOUS, FRONT PORTS	1
A4	A28010-300	CONTROL UNIT, 1000T, 380VAC, 3-PHASE (AR)	1
A2, A3	A28012-000	1000T S/C-BAND P.S.	2
A8, A7	A28014-000	TWT CONTROL CABLE	2
A9	A28015-000	COMBINER CONTROL CABLE	1
A11	A30921-000	CABINET KIT 1000T	1
A5, A6	E08143-000	HIGH VOLTAGE CABLE ASSY, [CONNECTRONICS 10641-05]	2

5.4.8 Parts List, RF Combiner Assy SC Band, A28005-004

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
A3, A4	A26941-000	TWTA LOP BOARD	2
A2	A27444-001	1000T COMBINER VPC INTERFACE BOARD, COMPONENT SIDE CONNECTORS	1
A1	A27995-003	COMBINER RF COMPONENTS, 1000T SC BAND, WG OUTPUT TWT,NO SUBBAND SWITCHING, WITH INT. COMBINER ASSY	1
A9	A27998-000	COMBINER WIRING KIT, SC-BAND	1
A5	A28008-000	F/O TO RS-485 ADAPTER	1
A10	A28032-001	CHASSIS, RF COMBINER, SC BAND	1
A6, A7	A28036-000	TWT COOLING ASSEMBLY, TET 5196	2

5.4.9 Parts List, Control Unit, 1000T, 208VAC, 3-Phase, A28010-303

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
A3	A21175-000	DATA STEERING BOARD (7 PORT)	1
A1	A25403-300	TWTA CONTROL ASSY 20 CIJ/50X	1
A5-A7	A28008-000	F/O TO RS-485 ADAPTER	3
A10	A28045-000	CONTROL MODULE CABINET ASSY AR 1000T, 380VAC	1
A9	A28046-000	CONTROL MODULE WIRING KIT	1
A2	E00765-000	P.S.,85-264VAC,47-440HZ TO 5VDC & 3.0A,(KEPCO FAW 5-3K/CA 24)	1
A8	E00810-000	POWER SUPPLY,+5V,+/-15VDC, 35W, 115V/230V, 50/60HZ,(KEPCO MRW 151KV)	1
XA8	E00811-000	POWER SUPPLY CABLE CONNECTOR KIT (E00810,MRW 151KV),(KEPCO 219-0184)	1
A4	E00885-000	P.S.,120/240VAC,50/60HZ,28VDC @ 5.0A,150W, W/COVER, (KEPCO 28-5K / CA-28)	1
	N28043-001	COMPONENT PLATE	1

5.4.10 Parts List, 1000T S/C-Band P.S., A28012-000

REF. DESIG.	ETM P/N	DESCRIPTION	QUANTITY
A4	A23692-000	INSULATED FAN DRIVER	2
A1	A24801-501	3U POWER SUPPLY FOR TWT 5196, 1 PHASE	2
A3	A25444-000	HPA INTERFACE BOARD (PLASTIC FIBERS)	2
A10	A27772-000	1000T S/C-BAND CABINET ASSY	2
A5	A28008-000	F/O TO RS-485 ADAPTER	2
A9	A28048-000	WIRING KIT, 1000T 2KW POWER SUPPLY	2

5.5 RECOMMENDED SPARE PARTS

A10010-000	Heater Supply Module
A21422-000	Grid Modulator Assembly
A21461-500	HV Filter
A21425-500	Diode/Cap Assembly
A16487-000	Power Board Assembly
A23687-001	Low Voltage Power Supply Module
A23683-000	Average Current Power Factor 100V-250V
A23692-000	Insulated Fan Driver
N26677-000	Fan, Modification (Y10038)

5.6 SAMPLE PROGRAM FOR IEEE-488 COMMUNICATION

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

WARRANTIES: LIMITATION OF LIABILITY

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

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

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

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