rf/microwave instrumentation

Operating and Service Manual

1500W1000A

Model

10044529

Part Number

Serial Number

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rf/microwave instrumentation

Declaration of Conformity

Issue Date: October 2020
Model #/s: Model 1500W1000A Series
Type of Equipment: RF Broadband Amplifier
Function: Designed to be used in a RF immunity test system or for research. The unit is intended to amplify an RF signal and inject it into a load.

The equipment described above is declared to be in conformity with the following applicable national and international standards. The conformity is valid only when equipment is used in a manner consistent with the manufacturer's recommendations and the reference documents.

EMC:
DIRECTIVE 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility
EN 61326-1:2013 Electrical equipment for measurement, control and laboratory use–EMC requirements–Part 1: General Requirements
SAFETY:
DIRECTIVE 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits
CENELEC EN 61010-1 Issued 2010/10/01 Ed: 3 Safety Requirements for Electrical Equipment for Measurement Control and Laboratory Use – Part 1: General Requirements
UL 61010-1 Issued 2012/05/11 Ed: 3 Safety Requirements for Electrical Equipment for Measurement Control and Laboratory Use – Part 1: General Requirements
CAN/CSA C22.2 #61010-1 Issued 2012/05/11 Ed: 3 Safety Requirements for Electrical Equipment for Measurement Control and Laboratory Use – Part 1: General Requirements
HAZARDOUS SUBSTANCES (RoHS):
DIRECTIVE 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast) Commission Delegated Directive (EU) 2015/863 of 31 March 2015 amending Annex II to Directive 2011/65/EU of the European Parliament and of the Council as regards the list of restricted substances **Directive (EU) 2017/2102 of the European Parliament** and of the Council of 15 November 2017 amending Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment
RECYCLING (WEEE):
DIRECTIVE 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) (recast)
SUBSTANCES OF VERY HIGH CONCERN (REACH):
REGULATION (EC) 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorization and Restriction of Substances of Very High Concern Chemicals (SVHC)

Supporting documentation is held by AR RF/Microwave Instrumentation's Quality department in Pennsylvania, United States.

Place of issue: AR RF/Microwave Instrumentation
160 Schoolhouse Road
Souderton, Pennsylvania 18964 USA

Authorized officer of the company:

Patricia Thrasher
Manager Quality & Service

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 2014/30/EU. The equipment must therefore be operated in a shielded area which provides a sufficient level of attenuation to meet the radiated 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
100 watts	50 dB
101 - 1000 watts	60 dB
1001 - 10,000 watts	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 2014/30/EU notwendig ist. Das Gerät muß deshalb in einem geschirmten Raum betrieben werden, welcher eine ausreichenden Schirmung bietet, um die Emissions- und Störfestigkeitsspezifkation einzuhalten. Es werden folgenden Minimalwerte der Schirmdämpfung und Filterung in den unterschiedlichen Leistungsklassen empfohlen.

Hochfrequenzleistung	min. Schirmdämpfung
100 Watt	50 dB
101-1000 Watt	60 dB
1001-10.000 Watt	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 2014/30/EU 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. 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
100 Watts	50 dB
101 à 1.000 Watts	60 dB
1.001 à 10.000 Watts	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

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

INTENDED USE

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

SAFETY SYMBOLS

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

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

EQUIPMENT SETUP PRECAUTIONS

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

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

BEFORE APPLYING POWER

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

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

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

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

SAFETY GROUND

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

INSTRUCTIONS FOR SAFE OPERATION

HAZARDOUS RF VOLTAGES

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

ACOUSTIC LIMITATIONS

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

MAINTENANCE CAUTION

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

ENVIRONMENTAL CONDITIONS

Unless otherwise stated on the product specification sheet, this equipment is designed to be safe under the following environmental conditions:

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

EQUIPMENT CONTAINING LASERS

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

RF ANTENNAS

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

RACK MOUNTED TWT MODELS

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

LIFTING INSTRUCTIONS FOR AR EQUIPMENT

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

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

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

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

TABLE OF CONTENTS

1. GENERAL INFORMATION

1.1 GENERAL DESCRIPTION

The Model 1500W1000A is a self-contained, broadband solid-state amplifier designed for laboratory applications where instantaneous bandwidth, high gain, and moderate power output are required. A **GAIN** control, which is conveniently located on the unit's front panel, can be used to decrease the amplifier's gain by 25 decibels (dB) or more. Solid state technology is used exclusively to offer significant advantages in reliability and cost. A Model 1500W1000A, used with a frequency-swept signal source, will provide 1500 watts of swept power output from 80–1000 megahertz (MHz). Typical applications include antenna and component testing, wattmeter calibration, and electromagnetic interference (EMI) susceptibility testing, as well as usage as a driver for frequency multipliers and high-power amplifiers. The Model 1500W1000A can be operated locally by using the unit's front panel controls, or remotely by using the unit's IEEE-488, RS-232 interface, USB, or Ethernet interface.

Special features incorporated into the Model 1500W1000A include the following:

- **A Digital Control Panel (DCP)** that allows both local and remote (via a computer interface) control of the amplifier (including adjustment of the amplifier's RF Gain during CW mode operation) and provides graphical displays of the amplifier's Forward and Reflected power levels.
- **RF output level protection.**
- **A General Purpose Interface Bus (GPIB)/IEEE-488.2 interface** for remote control of the amplifier's operating functions.
- **RS232 serial communications** including both wire and fiber-optic ports for remote control.
- **USB Communication port** for remote control.
- **Ethernet Communication port** for remote control.
- **Protection** is provided by DC current limiting, over-temperature shut down and RF power limiting.

1.2 SPECIFICATIONS

Refer to the AR RF/Microwave Instrumentation Data Sheet at the end of this section for detailed specifications.

1.3 POWER SUPPLIES

The Model 1500W1000A contains three 500 watt power amplifiers and a driver amplifier.

The 500 watt power amplifiers each contain two switching power supplies. The input voltage range to the power supplies is 200–240 VAC, 50-60Hz, selected automatically. The AC input power, combined for these two supplies is approximately 1500 watts.

PS1 is a +23 volt, 1500 watt supply for the drain supply of the A7 through A14 W-Series modules.

PS2 is a multiple output supply. The main +24 volts DC supplies voltage to the cooling fans. The +12 volts DC supplies voltage to the (A2) Overdrive Sense board. The -12 volts supplies the gates of A7-A14 modules. Primary AC circuit protection is provided by the circuit breaker in the Power Entry Module.

The driver amplifier also contains two switching power supplies. The input voltage range to the power supplies is 120–240 VAC, 50-60Hz, selected automatically. The AC input power, combined for these two supplies is approximately 1000 watts.

PS1 is a multiple output supply. The main +24 volts DC supplies voltage to the RF low level A1 and A7 overdrive sense board. The +12 volts DC is for operating the cooling fans and the –12 volts DC is supplied to the A1, A3, A4 and A5 RF modules. Primary AC circuit protection is provided by the circuit breaker in the Power Entry Module.

PS2 is a +23 volt, 44S switching power supply that supplies the drain voltage to driver modules A3, A4 and A5.

The 1500W1000A cabinet also contains a 3-phase power distribution unit 360-435 VAC, 30 amp, 50/60Hz. This allows the driver amplifier and the 500 watt amplifiers to operate from one power source.

1.4 PROTECTION CIRCUITS

Features incorporated into this unit include RF output level protection circuits, thermal protection circuits, and internal DC level sensing and monitoring circuits that sense the voltage on each of the final and driver amplifier modules. There is protection for the AC main circuit. All switching supplies are short circuit protected. Reaching a threshold of either of the RF forward (incident) or reverse (reflected) power limit adjustments, which are adjusted to approximately 1900 watts and 1500 watts respectively, will initiate limiting, or smooth drive level fold-back, in a low-level stage of the amplifier chain. If the limiting circuits cannot keep the amplifier's levels below the limit threshold, the protection circuits will invoke a shutdown of the main power supplies and low-level driver in the amplifier. Power amplifier modules are monitored for both over-current and under-current. A **RESET** function is provided to permit re-powering of the amplifier in case of transient or temporary activation of the amplifier's protection circuitry. The low-level driver and output amplifier subassemblies are thermally monitored.

The digital control panel monitors all fault signals, stores and displays any that are invoked and asserts the required action.

1.5 INSTALLATION

Before proceeding, thoroughly inspect the amplifier for signs of physical damage that may have been incurred during shipment and completely read the following installation and operating instructions, paying special attention to all **CAUTION** notes.

1.5.1 Location

Select an operating location that will permit air to circulate freely around the amplifier's cabinet. The Model 1500W1000A utilizes air cooling and should be located where the normal flow of air into or exiting from the unit will not be restricted, diverted, or re-circulated through the unit itself; in particular, the flow of warm air exiting the rear of the amplifier should not be impeded.

Do not position the unit next to a wall or other equipment that would restrict the flow of air into the bottom of the unit or out of the rear of the unit.

1.5.2 Power

The Model 1500W1000A is designed for a four-wire, three-phase power input: the four wires are for the three phases and a safety ground (GND). The primary input voltage range is 200-240 VAC phase-to-phase. A 50-amp common trip circuit breaker is used to supply power to the Model 1500W1000A.

CAUTION:

Dangerous voltages are present in the amplifier whenever plugged into an AC outlet. Always disconnect the AC power line to the amplifier before servicing the unit.

Due to the variety of power systems available internationally, line cords are not shipped with this unit. The user must determine and install the appropriate line supply to the unit. To install the line cord, first remove the three screws that hold the AC power input cover in place. Carefully lay the panel down horizontally to gain access to the AC Power feed-thru terminal block. Prepare a line cord capable of safely supplying 50 amps or more and insert the line cord through the Romex strain relief on the AC power input cover.

Figure 1-1 shows how to properly connect the wires. Tighten the Romex strain relief and reinstall the cover using the three screws removed previously.

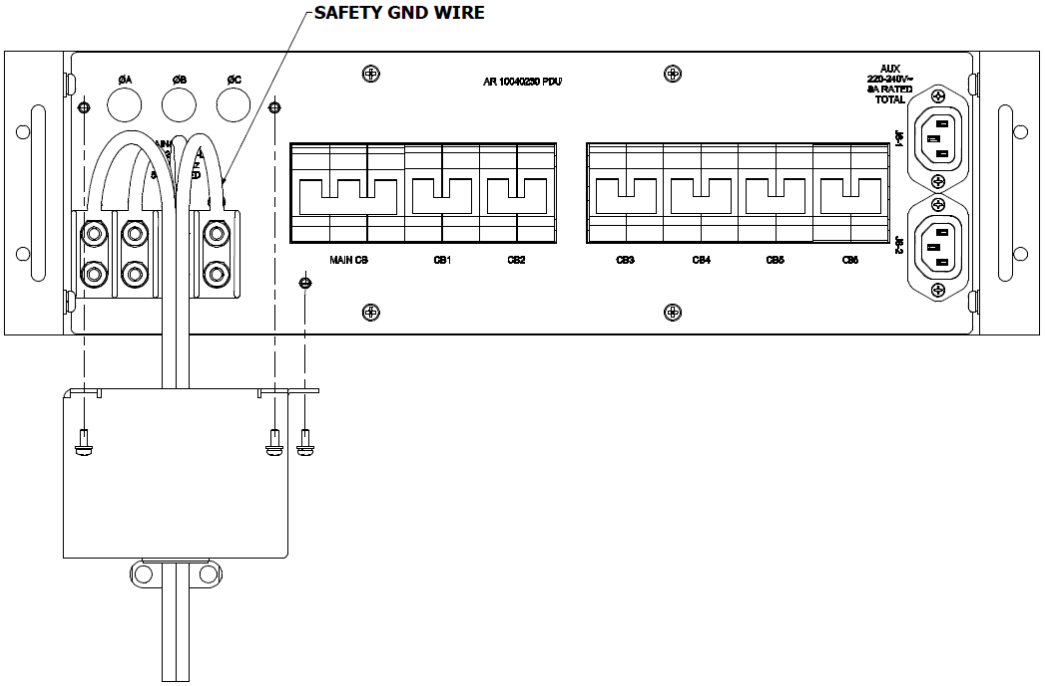


Figure 1-1. AC Line Cord Installation

1.5.3 Model 1500W1000A Driver Amplifier/500 Watt Amplifier Interconnection

- RF outputs from the controller/driver amplifier to the 500 watt amplifier inputs are located at the rear of the unit.
- RF outputs from the 500 watt amplifiers to the RF inputs of the two 12-way power combiners located in the controller cabinet.

  NOTE: The coaxial cables between the inputs and outputs of the driver and the outputs of the 500 watt amplifiers to the Inputs of the 12-way combiner are phase matched. Do not alter the coaxial cables length or substitute other coaxial cables for them. The outputs of the sub-amplifiers will not combine properly, if these coaxial cables are not matched in phase, this will cause low power output and cause additional stress to be placed on the sub-amplifiers and the final combiner.

- Fiber optic system control cables link each 500 watt amplifier to the driver amplifier for system control signals and fault reporting.
- 9-pin sub-miniature D cable assemblies link each 500 watt power amplifier to the driver for overdrive sense and interlock protection.

  NOTE: Fiber optic and 9-pin subminiature D cables must be in place for the amplifier to operate. Reference block diagram 10036948 and assembly drawing 10036983 for interconnections.

1500W1000A

- 1500 Watts CW
- 80MHz–1000MHz

Features

The Model 1500W1000A is a self-contained, air-cooled, broadband, completely solid-state amplifier designed for applications where instantaneous bandwidth and high gain are required. Push-pull circuitry is utilized in all high power stages in the interest of lowering distortion and improving stability. The Model 1500W1000A, when used with an RF sweep generator, will provide a minimum of 1500 watts of RF power.

The Model 1500W1000A is equipped with a Digital Control Panel (DCP) which provides both local and remote control of the amplifier. The DCP uses a color LCD touch screen and a single rotary knob to offer status reporting and control capability. The display provides operational presentation of Forward Power and Reflected Power plus amplifier status. Special features include a gain control, internal automatic level control (ALC) with front panel control of the ALC threshold, forward and reflective RF sample ports for precise power measurements and RF output level protection. Protection is provided by DC current level sensing of all output stages.

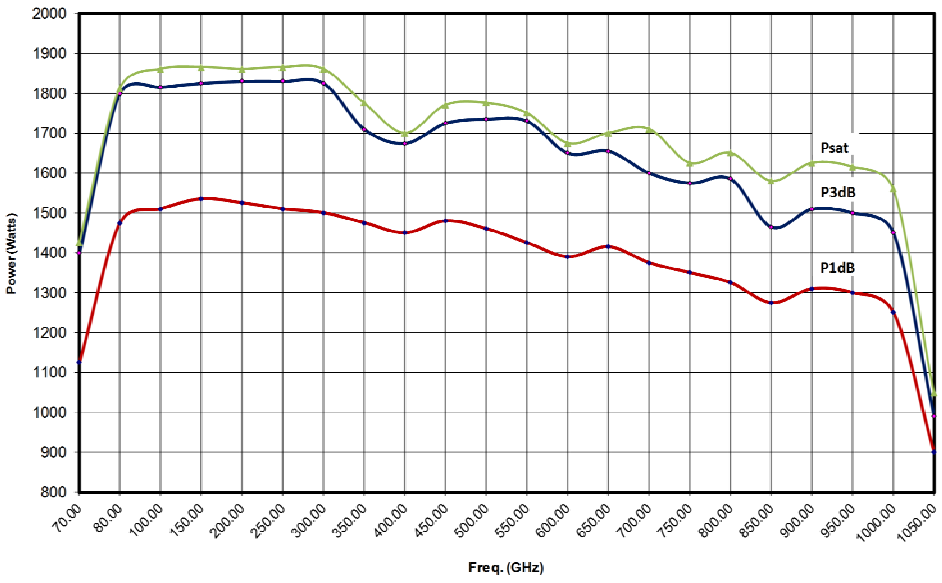
All amplifier control functions and status indications are available remotely in GPIB/IEEE-488 format and RS-232 hardware and fiber optic, USB and Ethernet. The buss interface connector is located on the back panel and positive control of local or remote operation is assured by a keylock on the front panel of the amplifier.

Housed in a single equipment rack, the 1500W1000A provides readily available RF power for typical applications such as RF susceptibility testing, antenna and component testing, watt meter calibration, and as a driver for frequency multipliers and higher power amplifiers. A safety interlock can be implemented via a rear panel connector.

The 1500W1000A has the ability to be upgraded at a later date to the 2000W1000D, 3000W1000B, or 4000W1000B.

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.

Typical Output Power 1500W1000A



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1500W1000A

- 1500 Watts CW
- 80MHz–1000MHz

Specifications

RATED OUTPUT POWER: 1600 watts typical; 1500 watts minimum

INPUT FOR RATED OUTPUT: 1.0 milliwatt maximum

POWER OUTPUT @ 3 dB compression:
Nominal 1600 watts, 1500 watts min up to 700 MHz, 1400 watts from 700 to 1000 MHz

POWER OUTPUT @ 1 dB compression:
Nominal 1450 watts, 1400 watts min up to 700 MHz; 1250 watts min from 700 to 1000 MHz

FLATNESS: ±2.0 dB maximum; ±1.5 dB typical

FREQUENCY RESPONSE: 80–1000 MHz instantaneously

GAIN (at maximum setting): 61.8 dB minimum

GAIN ADJUSTMENT (continuous range): 25 dB minimum

INPUT IMPEDANCE: 50 ohms, VSWR 1.5:1 maximum; 1.3:1 typical

OUTPUT IMPEDANCE: 50 ohms nominal

MISMATCH TOLERANCE: 100% of rated power without foldback. Will operate without damage or oscillation with any magnitude and phase of source and load impedance. (See Application Note #27)

MODULATION CAPABILITY: Faithfully reproduces AM, FM, or Pulse modulation appearing on input signal.

HARMONIC DISTORTION: Minus 20 dBc maximum at 1250 watts, -20 dBc typical @ 1500 watts

THIRD ORDER INTERCEPT POINT: 68 dBm typical

NOISE FIGURE: 8 dB maximum, 6 dB typical

PRIMARY POWER (specify voltage):
200-240 VAC Delta connected (4-wire)
360-435 VAC ye connected (5-wire)
50/60 Hz, three phase, 7000 watts

CONNECTORS

RF Input:	Type N female, rear panel
RF Output:	Type 1-5/8 female, rear panel
Forward sample:	Type N female, front (-63 dBc)
Reverse sample:	Type N female, front (-63 dBc)
Remote Interfaces:	
IEEE-488	24-pin female
RS-232	9-pin Subminiature D, female
Fiber Optic	ST Conn Tx and Rx RS-232
USB 2.0	Type B
Ethernet	RJ-45
Safety Interlock:	15-pin Subminiature D, rear panel

COOLING: Forced air (self contained fans), enters front and bottom

WEIGHT (approximate): 182 kg (400 lb)

SIZE (W x H x D): 56.1 x 175.3 x 97.6 cm (22.1 x 69 x 38.4 in)

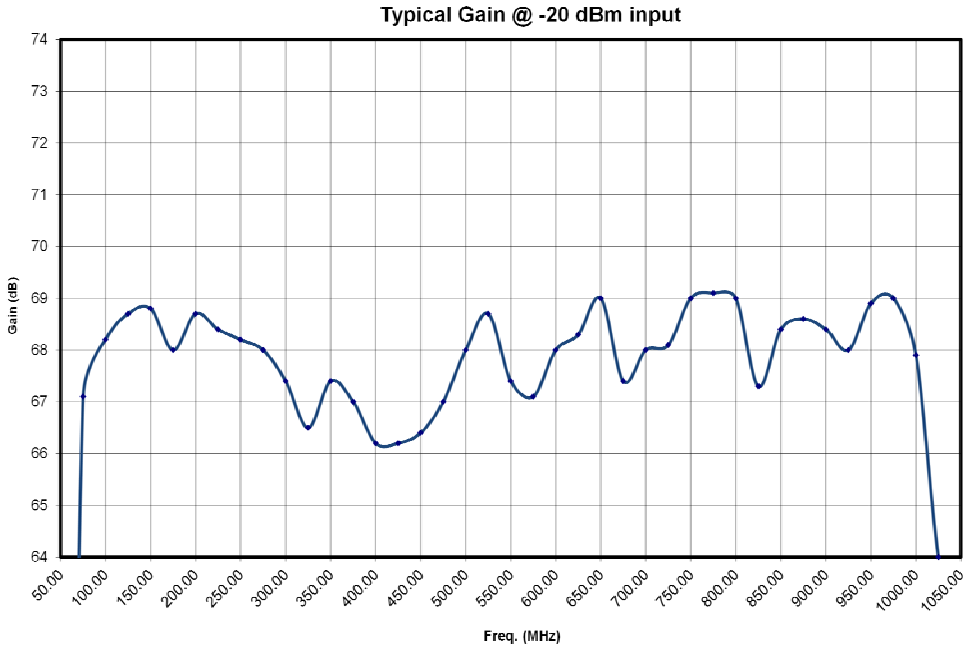
ENVIRONMENTAL:
Operating Temperature: 5°C / +40°C
Operating Altitude: Up to 2000M
Shock and vibration: Normal Truck Transport

REGULATORY COMPLIANCE:

EMC	EN 61326-1
Safety	UL 61010-1
	CAN/CSA C22.2 #61010-1
	CENELEC EN 61010-1
RoHS	DIRECTIVE 2011/65/EU

EXPORT CLASSIFICATION: EAR99

Graphs

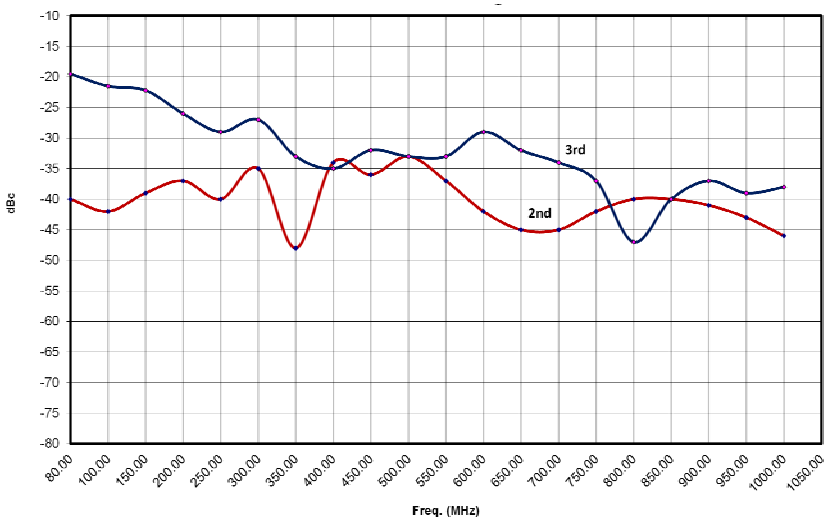


Graphs

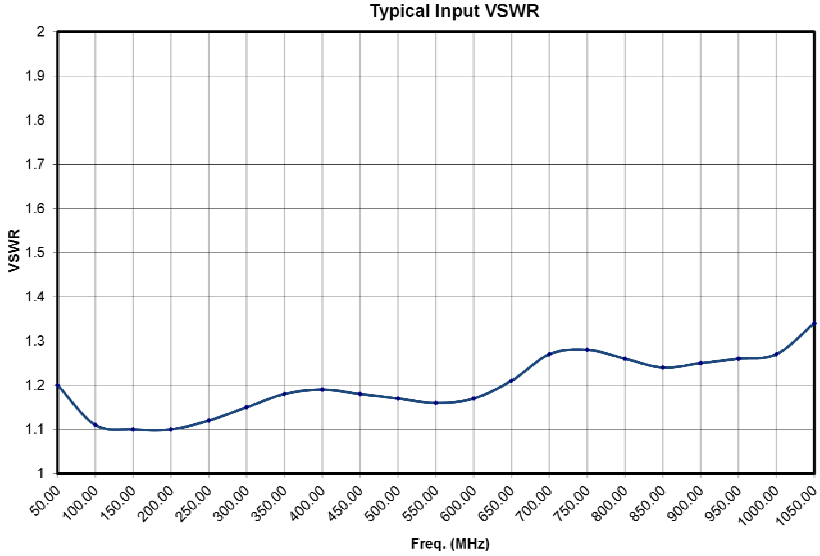
1500W1000A

- 1500 Watts CW
- 80MHz–1000MHz

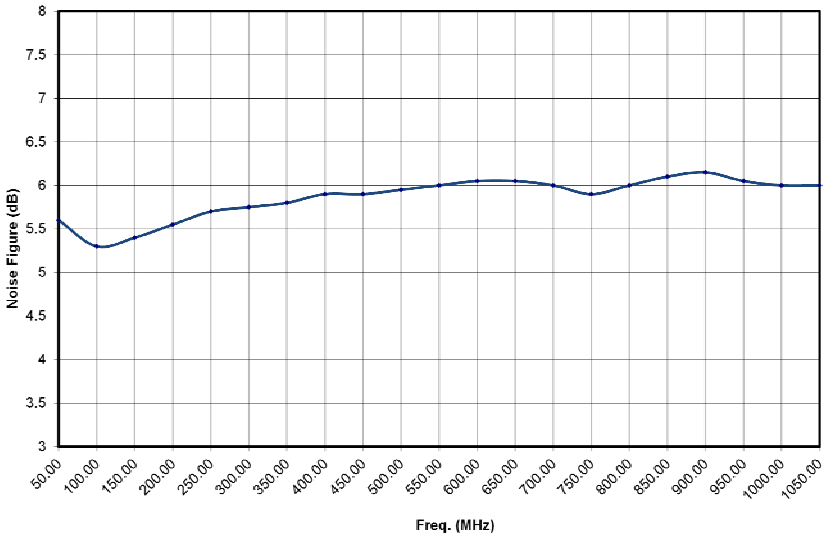
1500W1000 Harmonics @1500 watts



Typical Input VSWR



Typical Noise Figure vs. Frequency



2. OPERATING INSTRUCTIONS

2.1 GENERAL

Operation of the Model 1500W1000A broadband amplifier is quite simple. The amplifier's input signal, whether swept or fixed in frequency, is fed into the jack marked **RF INPUT,** and the amplifier's output signal is taken from the jack labeled **RF OUTPUT**. The unit is turned on by activating the front panel **POWER** switch. In the event of a major malfunction, protection is provided by a circuit breaker located on the unit's rear panel.

CAUTION:

The Model 1500W1000A Amplifier is *typically* not critical in regard to source and load Voltage Standing Wave Ratio (VSWR) and will remain unconditionally stable with any magnitude and phase of source and load VSWR. *However, placing the amplifier in the operate mode without a load connected to the output connector is not recommended*. It has also been designed to withstand, without damage, RF input power levels up to twenty (20) times its rated input of 1mW. However, signal levels higher than 20mW or transients with high peak voltages can damage the amplifier. Also, accidental connection of the Model 1500W1000A's output to its input (either through direct connection or parasitic feedback paths) will cause oscillations that may permanently damage the unit's input transistors.

The 1500W1000A Amplifier is protected from input overdrive by an automatic level control circuit. The 1500W1000A RF power transistors are protected from over temperature by sensing the chassis temperature near the RF output transistors. In the event of a cooling fan failure or an airflow blockage, the DC voltage will be removed from the RF stages, when the chassis temperature reaches approximately 70°C.

Normal operation can be resumed after the chassis temperature drops below 70° C.

2.2 CONTROL AND INDICATOR FUNCTIONS

The Model 1500W1000A's front panel is shown in Figure 2-1; the unit's rear panel features are detailed in Figure 2-2.

2.2.1 Keylock Switch

The Keylock Switch is provided for protection from unauthorized use or unexpected remote control of the amplifier. The amplifier can only be turned on locally when the Keylock Switch is in the **LOCAL** position. Likewise, the unit can only be turned on or controlled remotely when the Keylock Switch is in the **REMOTE** position. Placing the Keylock Switch in the **INHIBIT** position places the amplifier in the RF Off mode and prohibits any control of the amplifier.

2.2.2 POWER Switch

The momentary **POWER** switch turns the main power to the amplifier on and off. The status of the green light-emitting diode (LED) in the switch indicates whether the amplifier's power is on or off. The main power supply fans are active when power is on. The graphic display is active as long as the main power circuit breaker of the amplifier power entry module is on.

Figure 2-1 Digital Control Panel (DCP) Features

Item	Title	Function
1	INHIBIT, LOCAL, REMOTE	Keylock Switch, 3-position; key removal in INHIBIT position only
2	POWER	POWER control with indicator LED
3	DISPLAY (TOUCH SCREEN)	Numerous parameter values and fault messages, plus manual input control
4	ADJUST	Adjust knob to change selected variables
5	RF INPUT	Type N female connector
6	FWD Sample Port	Type N female connector
7	REV Sample Port	Type N female connector

2.2.3 Main Power

The Main Power circuit breaker and the RF output (N female) are located on the rear panel of the amplifier.

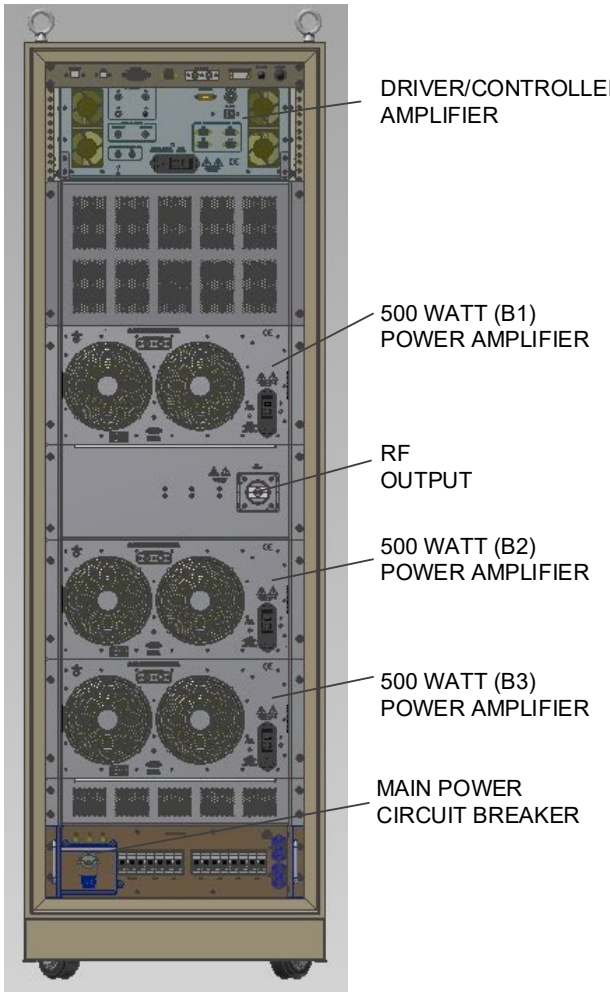


Figure 2-2. Rear Panel Features

2.2.4 RF ON/OFF

The RF ON/OFF touch screen button toggles the amplifier from a Standby to an Operate mode. The status of the function is indicated on the display as RF ON or RF OFF. In the RF ON state, RF output is enabled according to control settings and amplifier RF input. Main cooling fans will operate. In the RF OFF state, there will be no RF output.

2.2.5 RESET Function

The RESET function, selected by the touch screen button, will cause the amplifier to attempt to reset. Selecting Reset may clear the fault, depending upon the type of fault that has occurred. If the amplifier is in an over-driven condition, lowering the amplifier's gain or RF input level should enable the function to reset the amplifier.

2.3 DIGITAL CONTROL PANEL (DCP) OPERATIONS

The operations described in this section assume that the user is performing these operations from the amplifier's front panel with the Keylock Switch in the LOCAL position. Remote control using a personal computer is available when the Keylock Switch is set to REMOTE. Refer to Section 2.5.5 for information on remote operation.

Amplifier functions are visually monitored on the front panel display. POWER is controlled by a dedicated push-button switch to the left of the display. The safety Keylock Switch is located to the lower left of the display.

In the center of the digital control panel is the graphic touch display. It is used to provide amplifier status information and a set of menu functions for controlling the amplifier. The menu selections are typically found as software generated buttons on the right side of the display screen. In some cases, these buttons can also be found in other areas of the screen. From the MAIN MENU the user can access the RF ON/OFF button. The RF ON/OFF button causes the power amplifier sections to produce RF output power from the output connector, based on the various settings and the input level to the amplifier.

To the far right is an ADJUST knob. This knob is used to adjust many of the variables shown on the graphic touch display.

The graphic touch display is active and illuminated whenever AC power is supplied to the unit and the main circuit breaker is on.

At the top of the Main Menu screen is a bar graph and numeric value (blue) which is used to indicate whichever user adjustable parameter is selected. These parameters are RF Gain, ALC Threshold Level, ALC Detector Gain, and ALC Response. (Not all adjustments are available on every amplifier.) The Select button from the Main Menu is used to select these parameters.

Below the adjustment value section is an indicator for the RF state and the amplifier mode. The RF state can be changed using the RF On/Off button found in the lower right of the Main Menu.

Below the RF state indicator is the amplifier mode indicator. Possible modes are Manual, Pulse, ALC Internal, and ALC External. (Not all modes are available on every amplifier.) The amplifier mode can be changed using the Mode button from the Main Menu.

Toward the bottom of the display are two bar graphs and two numeric values used to indicate the forward and reflected power (green and red respectively). These indications are developed using a dual-directional coupler located within the amplifier near the RF output port, and should be used as un-calibrated indicators of approximate power level.

General Display Navigation is shown in Figure 2-3, **Touch Display Menu Map**.

Figure 2-3. Touch Panel Display Menu Map
Values shown on screens are for illustration only.

2.3.1 RF GAIN Control

The RF GAIN control is used to adjust the input attenuator of the preamplifier-leveler module. This control simply adjusts the output power level for a fixed input power level.

To adjust the RF Gain, press the Select button from the Main Menu and then press the RF Gain button in the subsequent menu. Adjust the value using the adjust knob. Please note that the display panel is limited in resolution compared to the control signals, which are generated and sent to the leveler electronics module.

2.4 INPUTS AND OUTPUTS

The input and output connectors described in the following sections are located on the unit's front or rear panels; refer to the Front and Rear Panel Features drawings (Figure 2-1, Figure 2-2).

2.4.1 RF Input

This Type N connector is the RF input to the amplifier. It should be connected to a RF signal generator or sweep generator.

2.4.2 RF Output

This Type 1-5/8" EIA female connector is the RF output of the amplifier.

CAUTION:

Do not connect or disconnect any loads or cables from the amplifier's RF Output when the amplifier is in the Operate mode. Dangerous voltages that could cause serious injury to the user exist at the RF Output when the amplifier is under power.

2.4.3 IEEE-488, USB, and RS-232 Interfaces

The Model 1500W1000A's remote interfaces allow remote control, via a computer, of all amplifier functions (except for the Keylock Switch position) that can be controlled from the front panel. When the amplifier is in the Remote mode (as determined by the position of the Keylock Switch), a special Remote display is shown (see Figure 2-3). Front panel controls are deactivated, except for the Keylock Switch, which can be rotated to LOCAL or INHIBIT in order to prevent remote control commands from being executed.

Refer to section 2.6 for information on remote operation of the amplifier.

2.4.4 Safety Interlock Connector

The safety interlock connector interface provides for external safety switch interlocks that will prevent the amplifier from entering or being placed in the Operate mode unless an external connection is made. A connection between Pins 1 and 8 must be completed to operate the amplifier.

2.5 AMPLIFIER OPERATION

2.5.1 Local Operation

1. Connect the input signal to the unit's RF INPUT connector. The input signal level should be 0dBm maximum.
2. Connect the load to the unit's RF OUTPUT connector.
3. Set the REMOTE/LOCAL switch to LOCAL.
4. Check to see that the MAIN POWER switch on the unit's rear panel is set to the 1 (on) position.
5. Press the POWER switch.
6. Place the unit in the Operate mode by pressing the RF On/Off touch screen button.
7. Adjust the amplifier's gain by rotating the ADJUST knob.
8. In the event of a fault, press the RESET touch screen button; if the fault does not clear, refer to Section 4.3 **Troubleshooting** of this manual.

2.6 REMOTE OPERATION

This section describes remote operation of this amplifier using the provided remote communication ports connected to a device such as a personal computer. All ports are active at all times, however only one port may be used at a time. Communicating through two or more ports at one time will cause data collisions and lost commands or queries.

The Keylock switch on the front panel allows the amplifier to be controlled using the remote communications ports, the front panel controls, or neither depending on its position. All remote queries will work in any switch position. All remote commands will only work when the switch is set to REMOTE. When the switch is set to REMOTE all front panel controls are disabled. However, faults can be reset locally by way of the Reset button displayed on the touch screen regardless of Keylock switch position.

2.6.1 IEEE-488 (GPIB) Communication

For IEEE-488 operation, the device address is set using the front panel touch screen. Ensure that each device connected to the IEEE-488 bus is set to a unique address.

Specific IEEE-488 bus commands depend on which software package you are using. To send commands be sure that the amplifier's address is set properly and that the controller has correctly identified the unit as a "listening" device.

When sending commands via the GPIB interface, terminate the command with a Line Feed character, an EOI, or both. The amplifier will ignore characters following the termination.

2.6.1.1 Setting the IEEE-488 (GPIB) Address

The IEEE-488 device address can be set to any number between 1 and 30. This selection is made by navigating to the GPIB address selection screen. To get there from the Main Menu, touch the User menu button followed by the I/O menu button and finally the GPIB menu button. Touching any of the buttons labeled 1 to 30 immediately sets the GPIB address to the corresponding value. A thin black outline indicates the present address selection. When the back button is pushed, the address selection is stored to non-volatile memory. Therefore, if power is lost prior to hitting the back button, any address selection changes will be lost.

2.6.2 RS-232 Communication

The RS-232 port is a serial communications bus. All commands and queries through this port must be terminated with a Line Feed character. When a valid query is received, it is processed and the result is immediately transmitted back over the RS-232 interface. This port is designed to time-out if there is no activity on the bus for more than 5 seconds. At this time the internal buffer is cleared and a **TIMEOUT_ERROR** message followed by a Line Feed character is sent out from this port.

The baud rate for the RS-232 port is user selectable from the RS-232/Fiber-Optic Serial Baud Rate selection screen. To get there from the Main Menu, touch the User menu button followed by the I/O menu button and finally the Serial menu button. A thin black outline indicates the present baud rate selection. When the back button is pushed, the baud rate selection is stored to non-volatile memory. Therefore, if power is lost prior to hitting the back button, any baud rate selection changes will be lost.

NOTE: This baud rate setting is shared by both the RS-232 port and the Fiber-Optic serial port.

The RS-232 port is setup as a Data Circuit-terminating Equipment (DCE) port. When connecting to a Personal Computer (PC) a straight one-to-one cable should be used. A null modem is NOT needed. The settings and pin-out diagram for this port can be found below.

Table 2-1. RS-232 Port Settings

Word Length	8 bits
Stop Bits:	1
Baud Rate:	User selectable (default is 19200)
Parity:	None
HW Handshake:	None

Table 2-2. RS-232 (DCE) Port Pin-out Diagram DB-9 Female

Pin 1	DCD
Pin 2	TD
Pin 3	RD
Pin 4	DTR
Pin 5	GND
Pin 6	DSR
Pin 7	CTS
Pin 8	RTS
Pin 9	Unused

2.6.3 Fiber-Optic Communication

The Fiber-Optic port is a serial communications bus. All commands and queries through this port must be terminated with a Line Feed character. When a valid query is received, it is processed and the result is immediately transmitted back over the Fiber-Optic interface. This port is designed to time-out if there is no activity on the bus for more than 5 seconds. At this time the internal buffer is cleared and a **TIMEOUT_ERROR** message followed by a Line Feed is sent out from this port.

The baud rate for the Fiber-Optic Serial port is user selectable from the RS-232/Fiber-Optic Serial Baud Rate selection screen. To get there from the Main Menu, touch the User menu button followed by the I/O menu button and finally the Serial menu button. A thin black outline indicates the present baud rate selection. When the back button is pushed, the baud rate selection is stored to non-volatile memory. Therefore, if power is lost prior to hitting the back button, any baud rate selection changes will be lost.

NOTE: This baud rate setting is shared by both the Fiber-Optic serial port and the RS-232 port.

The Fiber-Optic port provides the user with the ability to optically isolate the controlling PC from the amplifier. This can be useful in an environment where RF/Microwave energy could be coupled onto a connection to one of the "wired" communications ports and fed back to the controlling PC.

Both optical connections (TX and RX) are optimized to work with light at a wavelength of 820nm. For more detailed specifications on this port, consult the Avago HFBR series datasheet found at www.avagotech.com.

A glass, multi-mode, fiber-optic cable of 200um is recommended, however fiber-optic cable as small as 50um can be used. The connector type for this port is ST.

This port can be used in conjunction with either an AR model IF7000 RS-232 to Fiber-Optic Interface (1200 to 9600 baud only) or an AR model IF7001 USB to Fiber-Optic Interface (19200 baud only). Note that these devices use SMA connectors so a fiber-optic cable is needed with ST connectors on one end and SMA connectors on the other. This cable can be obtained from a fiber-optic cable distributor such as Fiber Instrument Sales (FIS). Their web-site can be found at www.fiberinstrumentsales.com. An example cable that will work for this connection is FIS Part Number D615M7FIS. The 7 in the part number refers to the length of the cable. In this case the length is 7 meters.

Table 2-3. Fiber-Optic Serial Port Settings

Word Length	8 bits
Stop Bits:	1
Baud Rate:	User selectable (default is 19200)
Parity:	None
HW Handshake:	None

2.6.4 USB Communication

The USB port is a USB 2.0 port. It also complies with the USB Test and Measurement Class (USBTMC) Standard. Communications with this port requires the host computer to have a USBTMC driver available. All commands and queries through this port must be terminated with a Line Feed character.

The cable required to make this connection is a USB 2.0 A-B peripheral device cable. The cable can be no longer than 5 meters. If a longer distance is required a USB hub must be used. A cable carrying the official USB logo is recommended.

When connected to a PC running Windows 2000 or XP a window will pop-up labeled Hardware Wizard. If this PC has National Instruments LabView installed it will have a USBTMC driver that will work with this port. This driver will allow the device to be easily controlled using National Instruments Measurement and Automation Explorer or LabView. It should be noted that the USBTMC driver provided by National Instruments is a Virtual Instrument Software Architecture (VISA) driver which can be used with other programming languages besides LabView. For more information on this please consult the National Instruments Website found at www.ni.com.

NOTE: All firmware updates are done through the USB port.

2.6.5 Ethernet Communication

The Ethernet port allows remote control through a Transmission Control Protocol (TCP) data channel. All commands and queries through this port must be terminated with a Line Feed character.

By default, this port is setup to work on a network with a Dynamic Host Configuration Protocol (DHCP) server. Upon connection, an Internet Protocol (IP) address is assigned based on the internal Media Access Control (MAC) address. The MAC address is printed on a label located near the Ethernet port.

If the connected network does not have DHCP enabled, then the device can be assigned an IP address by the user. To do this, download the utility called DeviceInstaller™ from www.Lantronix.com. For assistance using this utility please consult the utilities embedded help file.

The DeviceInstaller™ utility will scan the network and find all connected Lantronix Ethernet devices. This list of found devices will include any connected AR Ethernet devices. By selecting one of the connected devices from the list, its IP address and subnet mask can be changed along with a number of other settings. One should use caution in adjusting any settings he/she is unfamiliar with as doing so may cause the port to become unresponsive. By default the port for the TCP data channel is 10001.

* DHCP is a protocol used to assign a dynamic IP address to a device. Network server software will assign an available IP address to a device when it is connected and powered on. Different IP addresses may be assigned at different times.

2.6.6 Remote Commands

- If a command or query is unrecognized it is echoed back out the port it came in on.
- All commands and queries are terminated with a Line Feed character.
- A Line Feed character is indicated by <LF> in subsequent command and query definitions.
- All queries can be sent when the Keylock switch is in the INHIBIT, LOCAL, or REMOTE position.
- All commands can only be sent when the Keylock switch is in the REMOTE position.
- All spaces in command and query definitions are indicated by <space>.
- If a query is recognized, its associated response is echoed out the port it came in on.

A **COMMUNICATIONS_ERROR**<LF> can occur if the time between commands or queries is too short, or the internal RS-485 link between the IO Board assembly and the Multipurpose Board (MPB) assembly is broken.

The development of application programs requires an understanding of the operation of the amplifier as well as the intended application.

An application program on the computer/controller should issue only one character string (command or query) at a time. After each functional command is issued, the amplifier's 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 the checking of the status just prior to issuing a command, since the status could have been changed by a fault condition or by operator actions.

Variables represented by wild card characters i.e. x, y, z etc. do not indicate or delimit the number of characters actually specified.

Table 2-4. Relationship between DCP Controls and Remote Communication

AC Power and Circuit Breaker		Power		Keylock Switch			Remote Communication	
On	**Off**	**On**	**Off**	**INHIBIT**	**LOCAL**	**REMOTE**	**Command**	**Query**
	√						X	X
√			√			√	√	√
√		√				√	√	√
√		√			√		X	√
√		√		√			X	√
√			√		√		X	√
√			√	√			X	√

X = No, √ = Yes

2.6.6.1 Power On/Off

This command controls the power on/off state of the amplifier.

Syntax: **POWER:x**

Parameters: State(x):

OFF = power off
ON = power on

Response Format: None (No query for this command)

Example: To turn the power on, send the following command:

POWER:ON<LF>

To turn the power off, send the following command:

POWER:OFF<LF>

2.6.6.2 RF On/Off

This command controls the RF on/off state of the amplifier.

Syntax: **RF:x**

Parameters: State(x):

OFF = power off
ON = power on

Response Format: None (No query for this command)

Example: To turn the RF on, send the following command:

RF:ON<LF>

To turn the RF off, send the following command:

RF:OFF<LF>

2.6.6.3 Reset Faults

This will clear all faults, if possible.

Syntax: **RESET**

Parameters: None

Response Format: None (No query for this command)

Example: To clear any faults, send the following command:

RESET<LF>

2.6.6.4 Mode Select

This command sets the ALC mode of the amplifier.

Syntax: **MODE:x**

Parameters: Mode(x):

MANUAL = Set to Manual mode
PULSE = Set to Pulse mode*
ALC<space>INT = Set to ALC Internal mode
ALC<space>EXT = Set to ALC External mode*

Response Format: None (No query for this command)

Example: To set the ALC mode to Manual mode, send the following command:

MODE:MANUAL<LF>

**Not available on all amplifier models*

2.6.6.5 Level Adjust

This command sets the RF Gain, ALC Detector Gain, ALC Threshold, and ALC Response Time.

Syntax: **LEVEL:xy**

Parameters: Parameter(x):

GAIN = RF Gain
DET = ALC Detector Gain
THR = ALC Threshold
RESP = ALC Response Time

Value(y):

For RF Gain, ALC Detector Gain, and ALC Threshold:
0 = Minimum
100 = Maximum

For ALC Response Time:
0 = Minimum
7 = Maximum

Response Time Setting	Time (mS)
0	1
1	5
2	10
3	30
4	100
5	1000
6	3000
7	3000

Response Format: None (No query for this command)

Example: To set the RF Gain to minimum, send the following command:

LEVEL:GAIN0<LF>

To set the RF Gain to 50%, send the following command:

LEVEL:GAIN50<LF>

To set the ALC Response Time to max, send the following command:

LEVEL:RESP7<LF>

2.6.6.6 Identity

Query to identify the amplifier.

Syntax: ***IDN?**

Parameters: None

Query only (always requires a ? character)

Response Format: **f,m,n,<LF>**

Where:

f = manufacturer
m = model designation
n = firmware revision

Example: To get the identity of the amplifier, send the following command:

***IDN?<LF>**

Response: **AR-RF/MICROWAVE-INST,*MODEL*,1.0<LF>**

2.6.6.7 IO Board Firmware Revision

Query to get the firmware revision of the I/O Board.

Syntax: ***IOB?**

Parameters: None

Query only (always requires a ? character)

Response Format: **INTERFACE_BOARD_SW_REVx<LF>**

Where:

x = firmware revision

Example: To get the firmware rev. of the I/O Board, send the following command:

***IOB?<LF>**

Response: **INTERFACE_BOARD_SW_REV3.00<LF>**

2.6.6.8 Machine State

This query reads the RF gain, detector gain, ALC threshold, and ALC response time of the amplifier.

Syntax: **MSB?**

Parameters: None

Query only (always requires a ? character)

Response Format: **RF<space>GAIN=x,**
DT<space>GAIN=x,
THRES=x,
RESP=y<LF>

Value(x):

For RF Gain, Detector Gain, and ALC Threshold:
0 = Minimum
100 = Maximum

Value(y):

For Response Time:
0 = Minimum
7 = Maximum

Response Time Setting	Time (mS)
0	1
1	5
2	10
3	30
4	100
5	1000
6	3000
7	3000

Example: To get the machine state, send the following command:

MSB?<LF>

Response: **RF<space>GAIN=100,DT<space>GAIN= 50,THRES= 75,RESP=1 <LF>**

(RF gain is 100%, Detector Gain is 50%, ALC Threshold is 75%, and ALC Response Time is set to 5mS)

2.6.6.9 State

Query to find the state of the amplifier.

Syntax: **STATE?**

Parameters: None

Response Format: **STATE=<space>xyza<LF>**

Where:

x, y, z, and **a** are each an ASCII character representing a hexadecimal character. They can be 0 to 9 or A to F.

Each hexadecimal character represents a 4-bit binary number. This 4-bit number is a bit pattern which contains information about the state of the amplifier. The definitions of these bit positions can be found in the table below.

NOTE: Bits labeled NOT USED may be read as a bit state of 1 or 0

			BIT STATE		
	BIT POSITION	**BIT DESCRIPTION**	**0**	**1**	**NOTES:**
x	0	PULSE STATUS	OFF	PULSE	
	1	(NOT USED)			
	2	(NOT USED)			
	3	REMOTE CONTROL	DISABLED	ENABLED	Response to key-switch position
y	0	POWER STATUS	OFF	POWER ON	
	1	STANDBY STATUS	OFF	STANDBY	Also known as RF OFF
	2	OPERATE STATUS	OFF	OPERATE	Also known as RF ON
	3	FAULT STATUS	OFF	FAULT EXISTS	
z	0	KEYLOCK INHIBIT	OFF	INHIBITED	Response to key-switch position
	1	(NOT USED)			
	2	(NOT USED)			
	3	(NOT USED)			
a	0	MODE MANUAL	DISABLED	ENABLED	
	1	MODE PULSE	DISABLED	ENABLED	
	2	MODE ALC INTERNAL	DISABLED	ENABLED	
	3	MODE ALC EXTERNAL	DISABLED	ENABLED	

Example: To read the state, send the following query.

STATE?<LF>

Response: **STATE=<space>8301<LF>**
(Remote Mode, Power On, RF OFF, and Manual Mode)

2.6.6.10 Forward Power

Query to get the forward power.

Syntax: **FPOW?**

Parameters: None

Response Format: **FPOW=x<LF>**

Where:

x = 0 to 99999

Values are corrected and linearized. They can be up to five digits in length. Leading zeros are read as spaces. Units are Watts.

Example: To find out the forward power, send the following query.

FPOW?<LF>

Response: **FPOW=<space><space><space>54<LF>** *(54 Watts of forward power)*

2.6.6.11 Reverse Power

Query to get the reverse power.

Syntax: **RPOW?**

Parameters: None

Response Format: **RPOW=x<LF>**

Where:

x = 0 to 99999

Values are corrected and linearized. They can be up to five digits in length. Leading zeros are read as spaces. Units are Watts.

Example: To find out the reverse power, send the following query.

RPOW?<LF>

Response: **RPOW=<space><space><space><space>9<LF>** *(9 Watts of reverse power)*

2.6.6.12 RF Gain

Query to get the RF gain.

Syntax: **RFG?**

Parameters: None

Response Format: **RFG=<space>x<LF>**

Where:
x = 0000 to 0100

Example: To find out the RF gain of the amplifier, send the following query:

RFG?<LF>

Response: **RFG=<space>0075<LF>** *(75% Gain)*

2.6.6.13 Faults (1500W1000A)

Query to find the faults that have occurred with the amplifier.

Syntax: **FSTA?**

Parameters: None

Response Format: **FSTA=<space>xxxx**

Where:

xxxx = **0000** to **00BD (Hexadecimal)**

xxxx	Dec	Description
0000	00	No Fault
0001	01	AC Interlock
0002	02	Interlock
0003	03	PS1
0004	04	PS2
0005	05	(unused)
0006	06	Thermal A2
0007	07	Thermal A5
0008	08	Thermal A4
0009	09	(unused)
000a	10	Monitor Interlock
0013	19	(unused)
0014	20	Amp A2
0015	21	Amp A5
0016	22	Amp A4
0017	23	(unused)
0019	25	485 Error
001a	26	ALC
0046	70	System Error

The fault table for all RF blocks is the same, however, they are offset by a value of 40 decimal (0028 hexadecimal). The following table is for RF block number 1 (B1). RF block number 2 (B2) for example, has the same faults, but starts at 83 decimal (0053 hexadecimal).

xxxx	Dec	Description
002b	43	PS2
002c	44	PS1
0030	48	Thermal A14
0031	49	Thermal A13
0032	50	Thermal A12
0033	51	Thermal A11
0034	52	Thermal A10
0035	53	Thermal A9
0036	54	Thermal A8
0037	55	Thermal A7
0038	56	Amp A14
0039	57	Amp A13
003a	58	Amp A12
003b	59	Amp A11
003c	60	Amp A10
003d	61	Amp A9
003e	62	Amp A8
003f	63	Amp A7

Example: To find out what faults have occurred, send the following query. **FSTA?<LF>**

Response: **FSTA= 0002<LF>** *(Interlock Fault)*

2.6.6.14 Operating Hours (RF On)

Query to get the RF On operating hours.

Syntax: **OH?**

Parameters: None

Response Format: **OH=x<LF>**

Where:

x = **0** to **100000**

Units are Hours. Values can be up to six digits in length. Leading zeros are read as spaces.

Example: To find out the RF On operating hours, send the following query.

OH?<LF>

Response: **OH=<space><space><space><space>37<LF>**
(The system has spent 37 Hours in an RF On state)

2.6.6.15 Operating Hours (Power On)

Query to get the Power On operating hours.

Syntax: **OHP?**

Parameters: None

Response Format: **OHP=x<LF>**

Where:

x = **0** to **100000**

Units are Hours. Values can be up to six digits in length. Leading zeros are read as spaces.

Example: To find out the Power On operating hours, send the following query.

OHP?<LF>

Response: **OHP=<space><space><space>428<LF>**
(The system has spent 428 Hours in a Power On state)

2.6.6.16 AC Power-On Defaults

Default settings that are applied at AC mains power-on can be changed by adding the following prefix to select commands.

Syntax: **DEFAULT:**

Compatible commands:

Level Adjust

LEVEL:GAIN	
LEVEL:DET	**(Not available on all models)**
LEVEL:THR	**(Not available on all models)**
LEVEL:RESP	**(Not available on all models)**

Mode Select

MODE:MANUAL	**(Not available on all models)**
MODE:PULSE	**(Not available on all models)**
MODE:ALC<space>INT	**(Not available on all models)**
MODE:ALC<space>EXT	**(Not available on all models)**

NOTES:

1. *Use the command **DEFAULT:FACTORY** to reset all applicable settings back to their factory defaults.*
2. *All applicable defaults can be queried, except **DEFAULT:FACTORY**, by adding a ? character in place of the setting parameter.*
3. *If the ALC Lockout Feature (not available on all models) is engaged, the default ALC values set with this command will not be used.*

Example 1: To set the default RF Gain to 75%, send the following command:

DEFAULT:LEVEL:GAIN75<LF>

Example 2: To query the default RF Gain setting, send the following command:

DEFAULT:LEVEL:GAIN?<LF>

Response: **DEFAULT:LEVEL:GAIN75<LF>**

Example 3: To set the default mode to manual, send the following command:

DEFAULT:MODE:MANUAL<LF>

3. THEORY OF OPERATION

3.1 INTRODUCTION

The Model 1500W1000A RF amplifier consists of a driver amplifier assembly, three 500 watt power amplifier assemblies, two 12-way combiners, a 2-way combiner and a directional coupler. The driver amplifier amplifies low level RF signals and provides RF signals that are matched in amplitude and phase to the 500 watt amplifiers. The three 500 watt power amplifiers provide a total of 24 output signals combined in the final 16-way combiners and the 2-way combiner, yielding a combined power of 1500 watts or more. The driver amplifier provides power and operate signals to each 500 watt power amplifier and also monitors the 500 watt power amplifiers for any fault indications.

3.2 RF AMPLIFIER OPERATION

3.2.1 A1 Variable Gain Amplifier (Schematic No. 10033908, 10031972, 10032111)

The A1 variable gain amplifier consists of 3 subassemblies: the A1 Pre-Amplifier PWB Assembly, the A2 High Isolation Switch Assembly, and the A3 Two-Watt Amplifier Assembly.

3.2.1.1 A1 Pre-Amplifier PWB Assembly (Schematic 10033908)

The Pre-Amplifier PWB Assembly consists of a stage of gain (U1), a variable attenuator (U2), a resistive splitter (R3, R5, R4), another stage of gain (U3) an RF power detector (U9) and control circuitry. The overall gain of the pre-amplifier assembly is approximately 17 dB at minimum attenuation. The power detector (U9) is used to sense the input RF power and it increases the attenuation of U2 if an input overdrive condition is detected.

3.2.1.2 A2 High Isolation Switch (Schematic 10031969)

The High Isolation switch is normally in the thru mode. The switch can reduce the amplifier gain by more than 40 dB when the pulse input (E4) is pulled low.

3.2.1.3 A3 Two-Watt Amplifier

The Two-Watt Amplifier has a gain of approximately 16 to 18 dB. The Two-Watt Amplifier increases the overall variable gain amplifier to approximately 31 to 32 dB of gain. The output RF power is approximately 30 dBm at the 1 dB compression point.

3.2.2 A3, A6, A7 Two-Way Splitter

The Two-Way splitter splits the input signal into two equal-amplitude, equal-phase signals. The amplitude of each signal is 3–3.5 dB below the input signal when both outputs are terminated into 50Ω loads.

3.2.3 A2, A4, A5 Driver Amplifiers (Schematic 10034945)

The A2, A4, A5 Driver amplifiers consist of RF matching circuits, RF transistors, DC current control circuits, DC switching circuits and fault detection circuits.

The RF input is fed to a 4:1 transformer composed of T1, T2, and T3. The push-pull output signal of the 4:1 transformer is connected to the gates of push-pull connected Q1. The drains of Q1 are connected to a 4:1 transformer composed of T4, T4 and T6. The RF transistor , Q1, has approximately 22.5 VDC applied to the drains at 4 amps current for the driver and 7 amps current for the finals. The RF stage has approximately 18 dB of gain for the finals and an output compression point of 50 watts or greater from final amplifiers A7-A14.

Voltage comparator U1 senses the presence of the –8 VDC. The output of U1 is high if the –8V supply is –5.5 or less. The output of U1 pulls low when the –8 volts is present turning on Mosfet Q2 which supplies the DC voltages to the drain of Q1.

The current through Q1 is monitored by U2. The output of U2 is fed to an op amp (U5) which has a reference voltage on the non-inverting input and it compares the output of U2 to the reference voltage and generates an error signal to vary the gate voltage of the RF transistor Q1 which controls the drain current.

U3 is a positive 5V regulator. It supplies DC to the current sense circuit, U2, the op amp, U5, and the fault detection circuit, U6. SW1 is a thermal switch. It closes at a heat sink temperature of approximately 70° to protect the module in the event of an over-temperature condition.

3.2.4 A10 Dual Detector Assembly (Schematic 10033688)

The Dual Detector monitors the outputs from the A15 dual directional coupler. The dual detector provides sample outputs of the forward and reverse powers and also DC outputs proportional to the forward and reverse powers of the amplifier.

There are two identical channels in the dual detector; only the one J1 input is described. The input from J1 is connected to a two-way splitter. The two-way splitter outputs go to a 6 dB attenuator (U3) and the RF input of the power detector (U2). The power detector provides a DC output which provides a signal to display output power and for amplifier protection. The output of attenuator (U3) is fed to a stage of gain (U4) which is connected to a 3 dB attenuator (U5). The output from U5 provides an RF sample output which can be used to monitor the amplifier output power. The gain from J1 to J2 is approximately 1.0 to 1.5 dB of gain.

3.2.5 Power Supplies, Driver Amplifier (PS1 and PS2)

Power supply PS1 supplies a +5VDC housekeeping supply for the control system assemblies A12 Control Panel Assembly, A14 Interface Board, and A11 ALC board.

PS1 also supplies +23 VDC at 10 amps, +12 VDC at 13 amps, -12 VDC at 5 amps. PS1 is a switching supply that automatically sets the AC input circuits to the correct connections for the line voltage 90-264 VAC input ranges 47-440 Hz.

The +23 VDC at 10.0 amp power supply is fed to the A1 Pre-Amplifier to supply the FET drain voltage for this amplifier. The +12 VDC at 13 amps is for fans B1 through B4.

The –12 V at 5 amps power supply is fed to the A1 Pre-Amplifier and the A2, A4, A5 Driver Modules to provide gate voltage for these modules.

PS2 supplies +23 VDC at 44 amps. PS2 is a switching power supply that automatically sets the AC input circuits to the correct connections for the line voltage 120-240 VAC, 50-60 Hz.

PS2 supplies +23 VDC to amplifiers A3-A5 to provide the drain voltage for these amplifiers.

3.3 RF AMPLIFIER OPERATION (500 WATT POWER AMPLIFIER SCHEMATIC, 10039099)

3.3.1 A4 Two-Way Splitter

The Two-Way splitter splits the input signal into two equal-amplitude, equal-phase signals. The amplitude of each signal is 3–3.5 dB below the input signal when both outputs are terminated into 50Ω loads.

3.3.2 A5, A6 Four-Way Splitters

Each Four-Way splitter splits the input signal into four equal-amplitude, equal-phase signals. The amplitude of each signal is 6–6.5dB below the input signal when both outputs are terminated into 50Ω loads.

3.3.3 A7-A14 Final Amplifiers (Schematic 10036697)

Each A7-A14 Final Amp consists of RF matching circuits, an RF transistor a DC current control circuit, a DC switching circuit and a fault detection circuit.

The RF input is fed to a 4:1 transformer composed of T1, T2, and T3. The push-pull output signal of the 4:1 transformer is connected to the gates of push-pull connected Q1. The drains of Q1 are connected to a 4:1 transformer composed of T4, T4 and T6. The RF transistor , Q1, has approximately 22.5 VDC applied to the drains at 4 amps current for the driver and 7 amps current for the finals. The RF stage has approximately 18 dB of gain for the finals and an output compression point of 50 watts or greater from final amplifiers A6-A13.

Voltage comparator U1 senses the presence of the –8 VDC. The output of U1 is high if the –8V supply is –5.5 or less. The output of U1 pulls low when the –8 volts is present turning on Mosfet Q2 which supplies the DC voltages to the drain of Q1.

The current through Q1 is monitored by U2. The output of U2 is fed to an op amp (U5) which has a reference voltage on the non-inverting input and it compares the output of U2 to the reference voltage and generates an error signal to vary the gate voltage of the RF transistor Q1 which controls the drain current.

U3 is a positive 5V regulator. It supplies DC to the current sense circuit, U2, the op amp, U5, and the fault detection circuit, U6. SW1 is a thermal switch. It closes at a heat sink temperature of approximately 70° to protect the module in the event of an over-temperature condition.

3.3.4 Power Supplies, 500 Watt Power Amplifiers (PS1 and PS2)

Power supply PS2 supplies a +5VDC housekeeping supply for the control system assemblies A1 Switch Breakout Assembly and A3 Fiber Optic interface for the system control.

PS2 also supplies +24 VDC at 10 amps, +12 VDC at 13 amps, -12 VDC at 5 amps. PS2 is a switching supply that automatically sets the AC input circuits to the correct connections for the line voltage 90-264 VAC input ranges 47-440 Hz.

The +24 VDC at 10.0 amp power supply is fed to the fans B1 and B2. The +12 VDC is fed to the A3 overdrive sense board.

The –12 V at 5 amps power supply is fed to the A7-A14 final modules to provide gate voltage for these modules.

PS1 supplies +23 VDC at 60 amps. PS1 is a switching power supply that automatically sets the AC input circuits to the correct connections for the line voltage 120-240 VAC, 50-60 Hz.

PS1 supplies +23 VDC to amplifiers A7-A14 to provide the drain voltage for these amplifiers.

3.4 TWELVE-WAY COMBINER

The 12-way combiner has impedance-matching. When the outputs of the 12 final amplifiers are fed to the 12-way combiner, the combined output will be approximately 10.8 dB above the output of a single final amplifier.

3.5 A15 TWO-WAY COMBINER/DUAL DIRECTIONAL COUPLER

The 63 dB dual directional coupler is connected to the output of the 2-way combiner. The coupler monitors the forward and reflected power.

3.6 CONTROL SYSTEM

3.6.1 A12 Display Assembly, 4.3", LCD (Schematics 10029679, 10030013)

The A12 Display Assembly board consists of two 16-bit microcontrollers and about nine other ICs that monitor and indicate the status of the amplifier. Power is supplied using only a single 5-volt power supply. The board offers the following:

Feature	Quantity
Open drain outputs	4
Digital outputs	14 (8+6)
Digital inputs (5-volt tolerant)	24
Analog outputs	2
Mixed signal inputs	4
2-channel encoder input	1
Inputs for a keypad	6
Display connectors	1
Serial communication jacks	2

3.6.2 A14 Interface Board (Schematic #10020073)

3.6.3 A11 ALC Board (Schematic #10023927)

This section describes the operation of the level control board. The level control board performs the following functions:

- Provides automatic level control of the amplifier's output when the amplifier is placed in the ALC mode.
- Limits RF input level to the amplifier and turns on the audio alarm when forward or reflected power levels exceed specified levels.
- Drives forward and reflected indicators on the front panel display.

4. TROUBLESHOOTING AND REPAIR

4.1 GENERAL

Because it is a relatively simple instrument, the Model 1500W1000A should require very little maintenance. It is built with solid state devices and printed wiring boards (PWBs) that should ensure long, trouble-free life. Should trouble occur, special care must be taken when servicing the unit to avoid damaging the solid state devices and PWB's.

Since the amplifier's components are soldered in place, substitution of components should not be resorted to unless there is some indication that they are faulty. In addition, care must be taken not to short voltages across the amplifier when troubleshooting, because small bias changes may damage the amplifier due to excessive dissipation or transients.

Components used in AR RF/Microwave Instrumentation instruments are conservatively operated to provide maximum instrument reliability. In spite of this, parts may fail. Usually, the instrument must be immediately repaired with a minimum of down time. A systematic approach can greatly simplify and thereby speed up repairs. The Model 1500W1000A incorporates fault control and detection circuits, including display panel indications that can expedite troubleshooting of the unit. For a description of how these indications can be used to assist in troubleshooting the unit, please see Section 4.3, **Fault Signal Interpretation and Diagnosis.**

Shipping instructions are as follows. To return an item, contact AR Customer Service for an RMA number and shipping instructions. Returns from outside the United States are not permitted without prior authorization. If shipping from outside of the United States, closely follow all directions on the RMA form for return shipping and marking. See warranty statement at rear of manual.

4.3 FAULT SIGNAL INTERPRETATION AND DIAGNOSIS

CAUTION:

Extreme caution should be exercised when troubleshooting this unit, particularly when measuring voltages in the power supply section, as hazardous voltages exist in the unit that could cause serious injury to personnel performing such measurements.

4.3.1 General - Reading Faults

The Model 1500W1000A incorporates relatively simple fault detection circuitry, which makes use of the digital display panel to alert the user or technician which component(s) need service. Use of these indications can usually expedite troubleshooting of the amplifier. Most faults can be immediately determined down to the assembly level. If a reset is still indicated, turn off the RF power signal to the input of the amplifier, read and record the fault indication displayed on the digital control panel for later reference. Then, use the RESET function to see if the fault clears. If the fault clears, slowly bring the amplifier's drive level back up and ensure that recommended RF power levels are not exceeded. If the fault indication is no longer visible, the fault may have been brought about by a temporary transient condition, component thermal condition or excessive RF drive to the amplifier's input. If the fault does not clear with the RF drive off, some other problem exists in the amplifier.

4.3.2 Power Supply Faults

The 500 Watt Power Amplifiers and Driver Control Unit have self-contained power supplies. In the event of a power supply failure, the front panel display will identify which units power supply is at fault.

4.3.3 Thermal Faults

RF module thermal faults are detected. See section 4.3.5. The heatsink temperature is monitored and will trigger a thermal fault if it overheats.

4.3.4 ALC Fault

Indication – **ALC**

As stated previously, the power limit controls could not limit either the forward or reverse power to the preset threshold. This can be a transient type of problem, if the fault can be cleared. If the fault cannot be cleared with no RF input drive power, then there is a malfunction in the ALC board or associated circuit.

4.3.5 RF Module Faults

Any RF module fault will trigger amplifier shut down, including main power supplies. There are three possible module faults – Amplifier and Thermal. Module faults are displayed as **AMP?** or **THERM?**, where **?** indicates the defective module within the 500 watt amplifier or driver amplifier.

Thermal faults usually indicate ambient temperature is too high, there is inadequate air-flow through the module heat sinks or there is a problem with the sensor in the module.

Amplifier faults usually indicate there is a short circuit that would not clear on the module printed wiring board or component, or the module current limit is not adjusted correctly or one of the output devices is defective and/or not drawing enough current.

4.3.6 Fault Troubleshooting Guide

Driver		
Fault	**Type of Fault**	**Possible Reasons**
485 driver	Communication	Disconnected or faulty W23 or W22 CAT5 cable.
Therm driver (A2, A4, A5)	Thermal	Driver fan blocked or clogged.
Amp Fault (A2, A4, A5)	Under Current, Over-Current	Driver FET is damaged and drawing no current, Gate voltage is being pulled down. Driver FET had been over driven. Usually resettable and cured by backing off input drive.
PS1, PS2	Power Supply	PS1 or PS2 has failed
ALC	Leveling	ALC circuit is not working and allowing the RF power to exceed a preset limit
500 Watt Power Amplifier	**B1, B2, and B3**	
Fault	**Type of Fault**	**Possible Reasons**
Therm (B1-B3) (A7-A14)	Thermal	
Amp Fault (B1-B3) (A7-A14)	Under Current Over-Current	Final module FET is damaged and drawing no current, insufficient gate voltage to FET. Final module FET had been over driven. Usually resettable and cured by reducing input drive.
PS1 Final (B1-B3)	Power Supply	PS1 has failed inside MPA listed
PS2 Final (B1-B3)	Power Supply	PS2 has failed inside MPA listed

4.4 DIAGNOSING AND REPLACING AMPLIFIER MODULES

4.4.1 Locating Modules

See Figures 4-1 and 4-2.

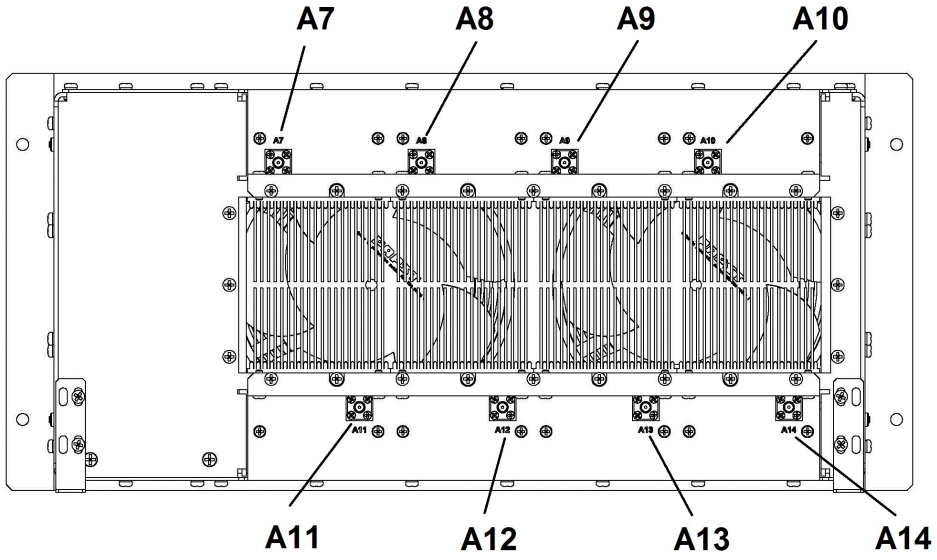


Figure 4-1. 500W Amp Module Locations (Front View)

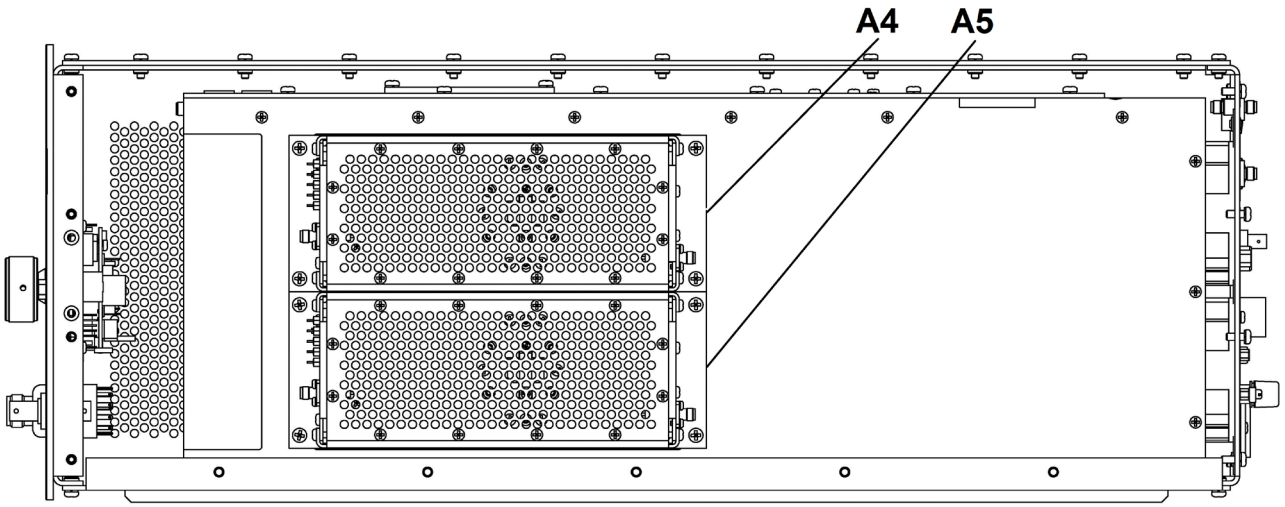


Figure 4-2. Driver Amp Module Locations (SideView)

Appendix A. Installing Software Upgrades

The 1500W1000A has the capability to upgrade software. The first step that should be taken is to power-down the unit from the front panel.

1. Go to the AR Website and download the AR Firmware Upgrade Utility along with the model specific upgrade file for the device being upgraded.

2. Unzip the AR Firmware Upgrade Utility and run the installer executable.

3. After the installation completes, unzip the model specific firmware and save it to a safe place on the hard drive (do not rename the file). The utility will ask for this file later.

4. Run the AR Firmware Upgrade Utility and follow the instructions provided.

5. Once the utility successfully connects, click the Update button for the control firmware. The utility will prompt for the model specific firmware file.

WARRANTIES: LIMITATION OF LIABILITY

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

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

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

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

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

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

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

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