

ALPHA 8410

HF LINEAR AMPLIFIER OPERATING MANUAL



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Specifications subject to change without notice - Rev. 102



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Specifications

Frequency	1.8-29.7 KHz
Input drive Level	50 Watts Nominal
Power Output	1500 watts
SWR Tolerance	3:1
Duty Cycle	100 %
Tubes	2x VTH-H118 Alpha, [4CH1000A]
Inter Modulation Level	30 dB minimum, Two Exciter
Harmonics	-50 dBc
Mode of Operation	CW, SSB, FM
Input AC Voltage	100-240 Selectable
AC Current	<13 5mps @240 VAC @1500 watts
Input Impedance	50 Ohms
Output Impedance	50 Ohms
RF Connectors	SO-239
Cooling	Forced Air
Size	17.3 W x 7 H x 21.0 D Including Fan
Space	
Weight	70 lbs., 31.8 kg
T/R Relay	Vacuum QSK
Tuning /Band switching	Manual
Display	Bargraph LED
Interface	USB
Protection	Against all common faults
RF Bypass Level	less than 500 watts

This amplifier meets or exceeds all technical specifications listed above.

Technician _____ Date _____

1 Introduction

1.1 General Description

Congratulations on your purchase of a professional quality Alpha 8410 amplifier! With proper installation and care, you can expect to enjoy your Amateur Radio hobby with this amplifier improving your signal for many years to come. Please study this manual carefully before operating your amplifier for the first time.

The Alpha 8410 is a self-contained manual tune HF linear power amplifier capable of continuous operation at 1500 W peak power output on SSB, keyed CW, SSTV, RTTY, digital modes or FM, with no time limit.

Other Alpha products available to enhance your use and enjoyment of the 8410 amplifier include:

- Alpha 2100 full 1500-watt rated 50-ohm dummy loads and
- Alpha 4500 series SWR meters / Wattmeter

See our web site at www.alpharadioproducts.com or call 303-473-9232 for further information.

1.2 Amplifier Capabilities

CAUTION:

It is extremely important to thoroughly review the Installation and Operation sections of this manual before attempting to use the Alpha 8410. Failure to do so could result in serious damage that may not be covered under warranty.

- Continuous RF Output. The 8410 is capable of 1.5 kW continuous RF output on all commonly used modes and on any authorized amateur frequency from 1.8 to 29.7 MHz.
- Compatibility with popular amateur transceivers and exciters. The 8410 requires approximately 50-65 W peak RF drive for 1.5 kW output.
- Capable of full CW break-in, QSK and all digital modes when used with any appropriate transceiver.
- Protective functions are built in. The control system incorporates protective functions that minimize the probability of accidental damage to the amplifier or its power tubes. In most cases, when one of the protective functions is “tripped,” the amplifier will go to Standby.

1.3 Shipping Information

The Alpha 8410 amplifier ships in two heavy-duty cardboard cartons. One carton holds the power transformer and weighs 43 lb (20 kg) and the second carton contains the amplifier and weighs 38 lb.(17 kg). Both of these cartons are mounted on a wooden pallet and strapped down for a total weight of 98 lb.(45 kg).

Alpha recommends that you retain the pallet and the cartons after installation in the unlikely situation that you need to ship the unit later. Contact Alpha at 303-473-9232 for shipping advice and assistance.

1.4 Safety Information Installation and Operation

- Make sure the Alpha 8410 is located where there is good air circulation all around and on top of the cabinet. The unit may become hot during operation.
- The Alpha 8410 weighs approximately 70 pounds when the transformer is installed. Use proper lifting techniques and two people when moving the amplifier. Note that amplifier should NEVER be transported with the transformer in place.
- The Alpha 8410 is designed to meet international safety standards and FCC regulations. However, one should always remember that the equipment works with high voltages that can be LETHAL!

This operating manual holds information, cautions and warnings that must be followed to ensure safe installation and operation. Read Chapter 1 before attempting to unpack or operate the Alpha 8410 amplifier.

Warnings: What Not to Do

- **Never open the amplifier case without unplugging the unit from the wall outlet.**
- **Always resist the temptation to immediately hit the ON button after the amplifier faults to power off.**
- **Never touch an antenna during transmission.**
- **Never attempt to turn on the amplifier without the cover securely in place [all attachment screws reinserted].**
- **Never turn the amplifier back on after a hard fault without waiting at least 20 seconds.**
- **Never allow liquids to enter the amplifier through the cover holes.**
- **Never stick objects into holes in the case.**

Warnings posted in this manual should be read and thoroughly understood by users. Failure to perform procedures properly may result in amplifier damage, fire hazard, or electric shock.

1.5 Owner Assistance

Technical Assistance from Alpha Radio Products is available from several sources.

- The Alpha Radio Products web site is www.alpharadioproducts.com. Click on Support and follow the instructions. Many typical problems and their solutions are listed on this site. On this site you can get the following assistance:
 - Technical Support
 - Repair Information
 - Software Downloads
 - Manuals
 - Tech Tips
 - Legacy Equipment Information
 - FAQ's
 - Alpha Forum

You can email us for customer support at service@alpharadioproducts.com or you can send your request by fax to 303-473-9660, or call us at 303-473-9232

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2 Quick Start Information

2.1 Overview

This section explains in brief the items you need to consider when setting up your Alpha 8410 amplifier.

If you already have a well-designed shack and have used an amplifier before, please review the items below to make sure you have considered all the critical items for proper installation and operation.

If you are using an amplifier for the first time, please skip this section and go to sections 3, 4, and 5 for a more detailed explanation of how to set up your shack for maximum safety and operating enjoyment.

If you have installation questions, do not hesitate to contact Customer Support. We much prefer to address questions prior to power up.

2.2 Station Engineering Considerations - Checklist

Make sure you have properly addressed the following concerns (Section 2.3 below) before installation of your Alpha 8410 amplifier. If you are unsure of any of these items, please read the noted sections carefully.

2.3 Preparation

- 240V AC Power in shack? (Section 3.2)
- Amplifier placed with proper airflow? (Section 3.3)
- Antenna ready for 1,500W? (Section 3.4)
- Adequate RF cabling? (Section 3.5)

2.4 Unpacking

- Unit Checked for Damage?
- Transformer Installed? (Section 4.2.1, 4.2.2)
- Power Cord Connector Attached? (Section 4.2.3)
- AC Primary Voltage Set? (Section 4.3.6)
- Amplifier Grounded Properly? (Section 4.4.1)
- Amplifier Cover Replaced and Secured? (Section 4.3.6)

2.5 Operation

- All Exciter Interconnections Set? (Section 6.2)
- Exciter Drive Correctly Set? (Section 6.1.1)
- Amplifier Tuned to Antenna System? (Section 6.3.6)

3 Station Engineering Considerations

3.1 Overview

The Alpha 8410 is capable of dramatically improving the performance of your amateur station. It is important that you observe good engineering practices to achieve all the benefits of such a station in a safe and reliable manner. This section provides a few hints for important operational considerations, but it is recommended that the user also consult a good source of general information such as “The Radio Amateur’s Handbook” by the ARRL, especially if this is the first high-power amplifier you have used.

3.2 AC Power Source

This amplifier runs best when powered by a 200V - 240V AC circuit. If you do not have a 240V AC outlet in your shack, you will need to get a licensed electrical contractor to install one. A minimum of a 20 amp capacity is required. A 20 amp breaker on your 240V circuit is sufficient. There are many styles of plugs, some of which are country-specific. For this reason, the amplifier is not shipped with a power plug. Select a location for the outlet as close as possible to where you expect to operate the 8410. If you are not sure, or contemplate moving the amplifier, you may choose to get a second outlet installed at the same time. Ask your contractor for two or three matching plugs during installation as there are several styles of connector available. Ask the contractor to measure the voltage and record it, so you can set the line voltage tap on the 8410 appropriately. If possible, have the contractor measure the line voltage with a 10 amp current draw, and use this value for setting the transformer tap. The Alpha 8410 can run when connected to an 120V AC outlet. However, you WILL NOT achieve full legal limit output in this case. If the amplifier is connected to an 120V AC outlet, you should not expect more than 1000 W output.

3.3 Air Flow

It is critical that airflow around the Alpha 8410 remain unimpeded at all times. Keep the top of the amplifier clear of any restrictions. If you are mounting the amplifier in a console, make sure that the exhaust air is properly and fully removed from the console.

Figure 3.3 -Minimum clearance for proper airflow



Make sure the exhausted air cannot be recirculated back into the amplifier air intake.

To ensure adequate cooling, make sure the top and rear of your amplifier have at least 3" of clearance to allow unobstructed airflow.

Poorly designed consoles can result in outlet air being drawn back into the amplifier air intake and recirculated, thus getting hotter and hotter and resulting in degraded amplifier performance or even failure. If you are designing your own console, consider putting in additional fans and/or ducting to deal with waste heat. Try to minimize the possibility of dust or other contamination getting drawn into or falling on the amplifier. It is also advisable to periodically (at least annually) clean the dust out of your amplifier for continued flawless operation. Alpha Radio Products recommends the use of compressed air for dust removal.

3.4 Antennas

Many antennas that are suitable for general use are unsuited for operation with a full

1500 W of power. At this power level in a 50-ohm circuit, the RMS current is 5.5 amps and the peak RF voltage is 387 volts. With a 2:1 SWR, these values double to 11 amps and 775 volts. The actual voltage and current at various points in or on your antenna may actually be many times these values. On a simple dipole with sharp wire ends, corona (localized ionization) can easily occur. Corona can (and has!) led to fire in nearby objects. Traps in beams and verticals can heat up significantly during high power operation. Instances of melting or flashover of traps have occurred in many installations where insufficient thought has been given to their ratings. If an antenna has been deployed for a long period of time, it may be worth taking it down for inspection prior to full power operation. If any insulators are cracked or show signs of “tracking”, in this part of the band.

3.5 Coax and Connectors

The importance of a well-constructed feed-line system cannot be overstated. After all, the purpose of the amplifier is to provide approximately 2 S units (12+ dB) of improvement in your radiated signal. All too often, installation problems are encountered where cheap, poor or under-rated coax and connectors are used. These often are responsible for at least one S unit of degradation. (This means you could have bought a 375 W amplifier and achieved the same radiated signal by buying good quality feed-line components!) Use the lowest loss 50-ohm coaxial cable you can obtain. Use new, clean connectors installed according to the manufacturer’s recommendation. Clean the connectors after soldering them, and before mating them with the amplifier. Make sure any excess solder is removed from the connector; likewise remove any fragments of braid etc. Never use old coax, which may have had moisture penetrate under the jacket. Support the coax frequently using non-compressive clips so that it does not hang or stretch under its own weight. Avoid sharp or kinked bends (most manufacturers will specify a minimum bend radius for their product). Make sure the connection from feed-line to antenna is waterproof. Provide for disconnection of the feed-line when it is not in use; this protects against damage caused by power surges and lightning strikes, which are not covered under the amplifier warranty.

3.6 RF Safety

The FCC requires users to check their installations for compliance with published values for allowable exposure to RF fields. This information is available in ARRL publications, FCC printed rules, and on the web. Alpha Radio Products strongly recommends that this be done for any installation, both fixed and at an expedition or contest site.

If you have any questions regarding engineering your 8410 into your amateur radio station, please visit our online technical support website at:

www.alpharadioproducts.com

4 Unpacking & Preparation

4.1 Unpacking

Remove the strap securing the two boxes to the pallet. Inspect both boxes for physical damage. Save all packing material and pallet for possible future use. Contact 303-473-9232 if shipping damage is found. Carefully unpack the amplifier and transformer.

Carefully remove the amplifier and place it on a workbench or table where you can install the power transformer.

4.2 Installing the Power Transformer

It is recommended that the power transformer be installed when the amp is at or near the place it is to be used. The chassis of the 8410 is designed for the mechanical loads it experiences when the amplifier is on a flat surface with the tilt-bail up or down. If the amplifier is tilted too far, such that the transformer is cantilevered or “hanging out” to any degree, the chassis of the amplifier can distort. This may affect a number of things, from the alignment of screw holes on the top cover to the band-switch alignment and tension. If the amplifier is moved, even if only from one site to another locally, remove the transformer to avoid the possibility of damage.

CAUTION:

Do not operate amplifier without the cover in place and all cover screws installed. Do not operate the amplifier without a good ground connection on the rear panel ground terminal.

Make sure all RF cables have a solid ground shield in place.

WARNING!

The transformer is very heavy and must be moved with due caution using only the lifting handle.

CAUTION:

PROCEED SLOWLY to avoid bumping and damaging adjacent wires, connectors or components.

While the top cover is removed, make sure each tube is firmly seated in its socket, rubber exhaust chimneys are fully and correctly installed, and anode connectors are tightly clamped to each tube. The silicone rubber chimneys installed on the VTX-X118 tubes are a critical part of the cooling system. Make sure the chimneys are straight and fully installed so the bottom of the chimney is firmly against the tube deck and completely covers the airflow openings in the deck. Make sure that the silicone rubber chimneys are flush with the top cover when it is placed back on the amplifier. Tube cooling exhaust must exit only through the tube anode fins; it must not be allowed to escape outside them. Failure to ensure proper cooling airflow may result in tube damage or destruction, which is not covered under warranty.

4.2.2 Connecting the Transformer Power Plugs

- Connect the 9-pin white Molex connector to the matching plug mounted on the back wall of the amplifier
- Connect the 8-pin orange connector to the matching pins on the upper (Mains) PCB.
- Connect the 6-pin yellow connector to the matching pins on the lower (HV) PCB
- Check to ensure that all connector pins on these three connectors engage fully and correctly.

4.2.3 Power Cord Connections

WARNING!

To avoid the hazard of a potentially fatal electric shock and/or severe damage to the ALPHA 8410 and other equipment, always use an AC plug that is appropriate for the primary mains voltage, current rating and configuration.

NEVER use 120V-type plugs and power receptacles for 190-250V circuits.

ALWAYS use grounding type AC connectors which conform to local codes and ensure that the green wire in the Alpha 8410 power cable is wired only to the AC mains safety ground (or to neutral, as may be necessary with a 240V circuit configured 120V-N-120V without a separate ground, commonly found in the US).

The green conductor in the power cord is wired to the ALPHA 8410 chassis. It MUST be connected only to the power source safety ground or neutral. The black and white power cord wires connect to the two “hot” wires of the AC source; either wire may be connected to either side of the line. For best results use a dedicated 200-240 V branch circuit of #10 AWG copper wire or equivalent, rated at 20 A, to feed the amplifier.

4.2.4 Important Information about Operation from 90-130V AC

Electrical power equipment will draw twice as much primary current from 120 V mains as from 240 V mains. Therefore, operating the ALPHA 8410 on a typical 120 V/ 20 Amp household circuit without exceeding the 20 A circuit rating will limit maximum peak power output to about 6001000 W. Maximum possible RF output power for any particular primary AC voltage and current capacity may be estimated as:

$$P_{\text{max}} = (V \times I) / 2.3$$

For example, if the Alpha 8410 operates from a circuit that is capable of delivering 120 V AC at a maximum current of 20A, with no other loads connected to the circuit, maximum peak RF output possible without tripping the 20A breaker (or fuse) is approximately:

$$P_o \text{ max} = (120V \times 20A) / 2.3 = 2400/2.3 = 1043 \text{ W}$$

If the same circuit also supplies a transceiver drawing peak line current of 5A and a lamp drawing 1A, only 20-5-1 = 14A is available for the amplifier and maximum possible output is about:

$$P_o \text{ max} = (120V \times 14A) / 2.3 = 1680/2.3 = 730W$$

Below are some considerations at the high end and the low end of this voltage range that are rarely encountered.

Low Voltage vs. Power Output At the low end of the voltage range, do not expect to be able to get 1,500 watts output if your line voltage is below 120 volts. If your line voltage is between 110 and 130 volts, then 1,500 watts PEP operation (CW or SSB) may be possible if your AC line service has sufficient current capacity (30 amp circuit recommended). However, 1,500 watts continuous should not be expected. If your line voltage is between 90-120 volts, then power outputs above 1,000 watts should not be expected from the amplifier. Tune (adjust) the amplifier for no more than 1,000 watts output, and simultaneously for maximum efficiency.

placed where normal air flow is restricted because the cord could overheat. If other equipment is drawing current from the same circuit as the Alpha 8410, then the considerations in section 4.2.3 should be taken into account.

High Voltage and Tube Life At the high end (sometimes encountered when using poorly regulated generators) the plate voltage and tube heater voltage may be too high. If voltages above 250 volts are applied for any length of time, the lifetime of the tubes may be reduced. If this is your situation, the first line of defense is to contact your utility

company and ask if they can reduce your line voltage. If this is not possible, you may want to consider placing your own step-down transformer in line between the AC outlet and the amplifier. If this is necessary, a transformer with at least 4-kVA rating is required, due to the nature of the current waveform in the primary. Another choice for voltage control, a ferro-resonant voltage regulator, is an expensive solution, but is a good way to stabilize primary voltage.

Note: If you intend to operate the amplifier on any of the 90 - 130V settings, the lower 2 amp fuse on the rear panel will have to be changed to 5 amp. to allow for the increased in-rush current.

FIGURE 4-2-1 Amplifier Interior

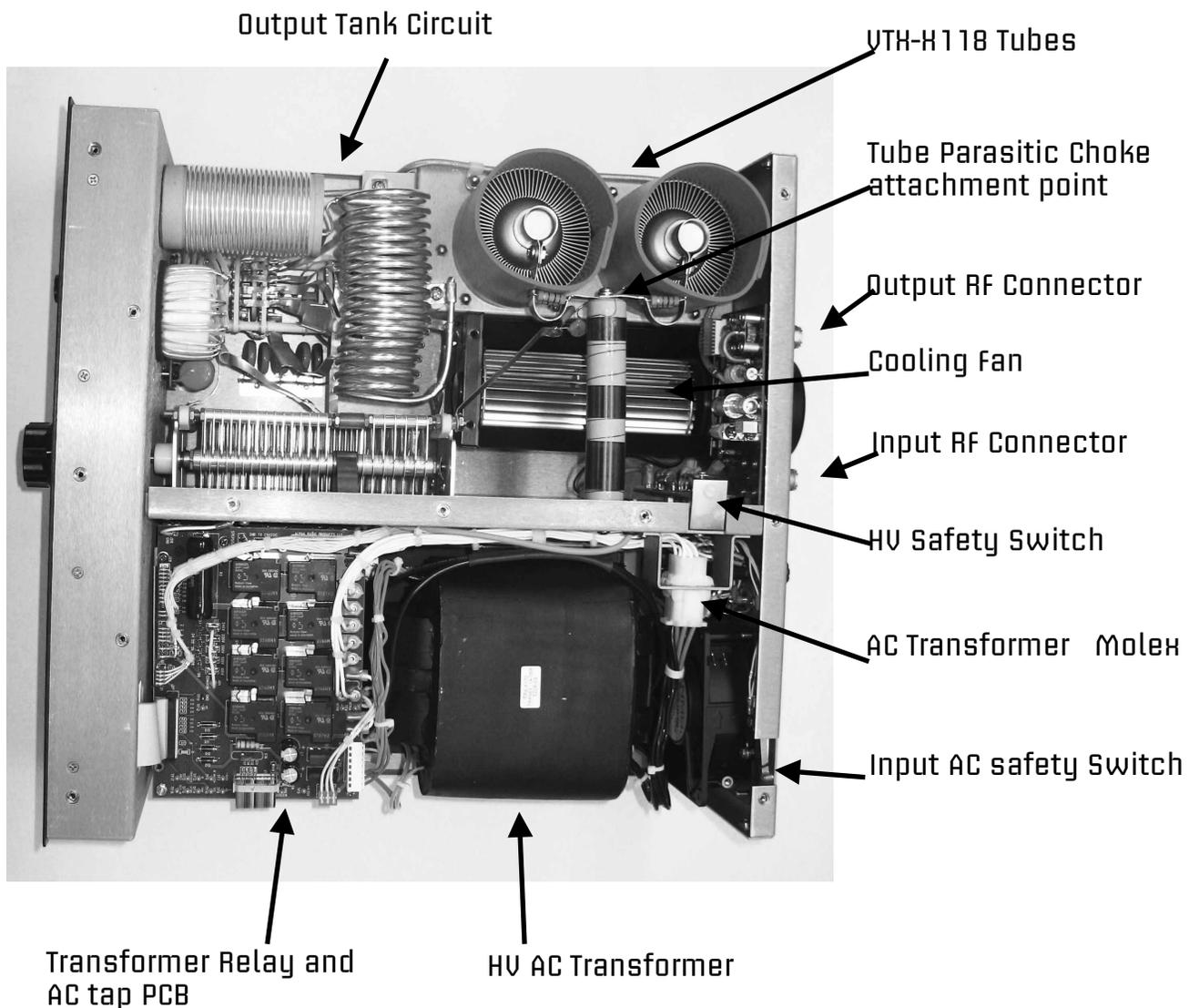
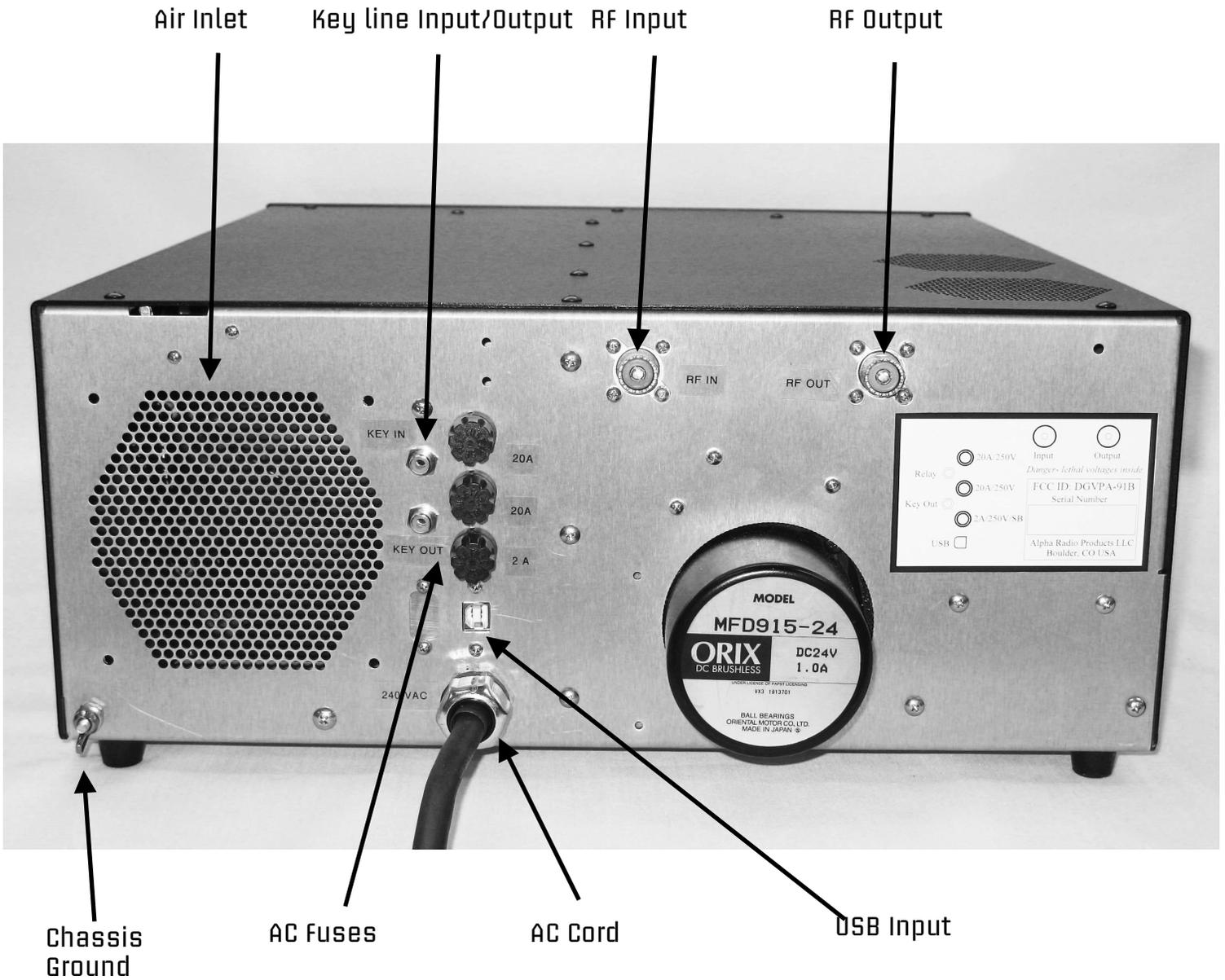
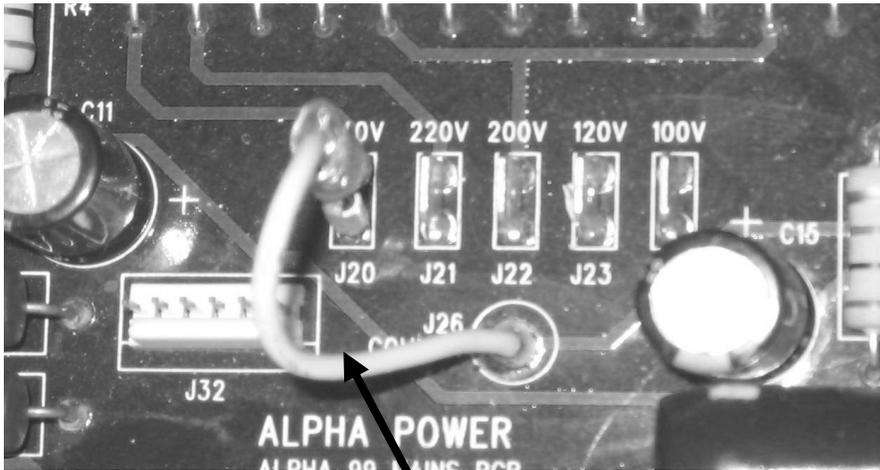


FIGURE 4-2-2 Amplifier Rear





Input AC tap settings can be made by moving the flying lead to the marked AC spade posts marked in the appropriate voltages. The proper taps must be made before the AC power is applied. When making changes make sure the amplifier is unplugged.

Never use a tap other than the proper voltage or damage to the tubes and amplifier will result.

Flying lead attachment points.

Figure 4-3 AC Power Setting

With the top cover removed, the primary voltage taps are located on the top of the Mains Board, which is between the transformer and the front panel. There is a row of 5 “fast on” connectors (J1 through J5) and a “flying” jumper connector which mates with them. See Figure 4-3 above. There are 5 “nominal” primary voltages, which cover all the line voltages normally encountered around the world. Selecting the appropriate tap for your situation will optimize amplifier performance, safety and lifetime. The nominal mid-range voltage for each tap is printed on the Mains Board circuit board. These voltages are 100, 120, 200, 220 and 240 Volts. The acceptable line voltage for each tap is the center voltage plus or minus 10 Volts. One of these taps is suitable for any of the “nominal” line voltages encountered worldwide.

CAUTION:

When using any high power amplifier, failure to connect ALL station equipment to a good common ground may allow RF feedback to leak into the transceiver and cause severe signal distortion.

4.4.2 Replacing the Amplifier Cover

Replace all attachment screws. Use only the 6-32 screws supplied with the amplifier and do not tighten any of the screws until all are started. Do not attempt to operate the amplifier with the cover removed or only placed back on the unit without the attachment screws. This WILL cause damage to the Alpha 8410 and may also lead to injury or death to the operator.

4.5 Amplifier/Station Interconnections

Once the power transformer is installed, properly configured, and the cover replaced, place the amplifier in its operating position. The amplifier with the transformer installed is heavy so you may need assistance to safely move it. Make sure it is placed on a stable surface and that there is sufficient space to the rear, sides, and top to allow good air flow and safe placement of cables.

4.5.1 Coaxial Cable Types & Connectors

Connect the transceiver RF output to the ALPHA 8410 RF INPUT connector with 50-ohm coaxial cable- RG-58C/U or equivalent. Coaxial cable from the 8410 RF OUTPUT connector to the antenna should be RG-8A/U, RG-213/U, or RG8X cable is not interconnection when used with a modern QSK transceiver.

4.5.2 T/R Control Cable

The Alpha 8410 has a full break-in vacuum relay QSK system requiring only the normal interconnection when used with a modern QSK transceiver. The Alpha 8410 requires a contact closure (short circuit) on transmit from its RELAY jack center pin to chassis. This function is supplied by the transceiver, usually from a dedicated relay that is normally open in receive and closed in transmit. Shielded wire should be used for the T/R control cable. The Alpha 8410 end must be fitted with a common phono (RCA-type) plug and the other end with a connector suitable for the transceiver. The T/R relay contact must close before application of RF drive. The Alpha 8410 protection circuitry prevents “hot-switching” with RF drive applied. Modern transceivers have the proper time delay between key up and the start of the transmitted signal to allow the Alpha 8410 to follow the CW keying. If a T/R timing problem is suspected, connect the CW keyer to the RELAY jack on the Alpha 8410, and connect a cable from KEY OUT on the amplifier to the keying input of the transmitter.

4.5.3 ALC

The Alpha 8410 does not generate or use ALC voltages to control an exciter.

For proper operation the exciter transceiver should have its power output set so as not to over drive the amplifier input. Today's modern transceivers have very good power output limiting. As a rule ALC is not needed if the transceiver is less than 15 years old.

Should your transceiver be older then the power output should be reduced so voice peaks will not overdrive the transmitter under any modulation condition.

5 Theory of Operation

5.1 Theory of Operation - Overview

The Alpha 8410 uses tetrode vacuum power grid tubes as the amplifying devices. The main power supply is an unregulated transformer/rectifier/capacitor power supply for the high voltage (HV) and heater circuits. All other power supplies are regulated. The control circuit uses a microprocessor “in the loop” to monitor and control amplifier operation. There are 7 circuit cards in the amplifier. In addition to these, the tubes, tank circuit assembly, and transformer complete the main sections of the amplifier. These major blocks are described below. The 8410 amplifier includes a 5 V power supply that is mounted behind the front panel. Any time the amplifier is plugged into the mains power, this 5 V supply is active and there is power to the micro-controller on the main control board. This feature allows the amplifier to be turned on or off remotely as well as remote monitoring and debugging through a USB cable connected to a computer.

5.2 Tubes

The amplifier is designed to use two VTX-X118 tetrode tubes. The amplifier design uses these tubes well within their ratings. The two tubes are operated in parallel, and the Alpha 8410 is designed with the expectation that a matched pair of tubes will be used in the amplifier. Alpha matches tubes received from the supplier to within 10% for power output and gain when operated in a standardized test fixture. Note that power output, efficiency, tube life and amplifier reliability may be compromised if tubes are used that do not meet Alpha’s matching criteria. Any damage sustained as a result of using unmatched tubes may not be covered under warranty. The tubes are operated in Class AB1, with a plate voltage of 2,800V (nominal, full output, key down), a grid 1 voltage of 50-60 volts, and a grid 2 voltage of 200 volts. The tubes have an inductance resistor in series with their cathodes. This resistor stabilizes the tube bias and provides negative feedback, which improves linearity (and hence IMD performance). Electronic bias switching (EBS) increases the negative grid 1 voltage in pauses in speech or between Morse code elements. This reduces the standing bias on the tubes, resulting in less waste heat, longer tube life and higher overall amplifier efficiency. The artifacts of EBS are not noticeable under normal communications conditions.

5.3 Output Tank Circuit

The output tank circuit of the Alpha 8410 is designed to provide reliable high efficiency, low distortion performance in a very compact volume. The basic topology is “pi-L”, which provides harmonic attenuation adequate to meet the requirements of all countries globally that permit power outputs of 1,500 watts. Band switching is under manual control and is accomplished by a four-wafer band switch. These wafers are used as

multi-function tap selectors, which simultaneously select band taps on the inductors and include varying amounts of capacitance to provide band-spread on the tune and load capacitors. These four wafers are in the RF tank area. A variable resistor inside the front sub-chassis and is used by the control board to determine which band the user has selected.

5.4 Tube Deck

The tube deck is a mechanical assembly built around the tube deck PCB. The tube deck PCB has the tube sockets mounted on it, as well as those critical circuit elements that need to be in close proximity to the tubes. The tube sockets contain integral screen grid (grid 2) RF bypass capacitors. Also on this PCB is the input bypass relay. This relay is under microprocessor control and in one position switches the input RF to the tubes and in the other it switches the input RF to the tube matching circuit. The tubes are operated as a “swamped grid” tetrode design. The tube grids are tied at RF to a 50-ohm swamping resistor, which absorbs most of the input drive power. The RF voltage across this resistor is added to the grid 1 DC bias to provide the net low-impedance tube grid 1 bias. The RF impedance represented by grid 1 and its capacitance is compensated for by a series inductance to provide less than 2:1 SWR on each band at the amplifier’s input. At higher frequencies, a relay switches in a separate matching network. This relay is under microprocessor control and is actuated according to the band switch setting.

5.5 Mains Board

The power supply functions are split between the mains board and the high voltage (HV) board. The mains board mostly deals with the primary side of the transformer. The various taps for the transformer primary are routed through this board and so is the AC line input. Relays on the mains board connect the AC line to the appropriate taps on the primary. One of 5 tap options is selected by using a 5-way jumper field. See section 4.3 for more details on how to set the jumper. Also on the mains board is a step-start circuit. This circuit consists of a relay and a resistor, which are time-sequenced to limit the inrush current into the amplifier when it is first turned on. When initially turned on, the tap relays operate from a voltage derived from resistors from the AC line. They hold via contacts on the trip relay on the HV board. The regulated minus 12 volt and minus 124 volt supplies are also located on this board. Many of the important voltages for the amplifier are brought to test points on this board.

5.5 High Voltage Board

The main high voltage for the amplifier is created on this board using a full-wave bridge rectifier and a bank of capacitors. This power supply has two 10-ohm resistors, one in the positive (B+) lead, and the other in the negative return, which goes to ground. The combination of these two resistors limits the surge current in the case of a B+ arc. The voltage across the resistor in the negative return is used to monitor tube plate current in the control board. This voltage is also used to generate the “hard fault” condition. When the power supply current exceeds about 2 to 2.5 Amps, a relay operates to open the coil circuit of the mains tap relays on the mains board. When these relays release, the amplifier goes to the power-off state. This hard fault circuit operates independently of microprocessor control. The regulated screen supply is also located on this board. All power supply filter capacitors on this board have bleeder resistors which will discharge the capacitors in less than 60 seconds. If it is necessary to work on this board, it is nevertheless recommended that the discharged condition be confirmed with a voltmeter, due to the remote possibility of bleeder resistor failure.

5.6 Control Board

The control board is the heart of the amplifier. It is based around a PIC microcontroller. This microcontroller has a built-in multi-channel analog-to-digital converter, which is used to monitor all the critical voltages and currents in the amplifier, as well as the input power and output forward and reflected power. It uses these converted values to control the amplifier’s operation and to drive the display board on the front panel. A USB port is provided for remote monitoring and is found on the back of the Alpha 8410. The USB driver for the amplifier is provided on the CD shipped with the unit or can be found on the Alpha website at www.alpharadioproducts.com

5.7 Display Board

The display board uses a MAX7219 LED driver chip. It receives data from the controller via an SPI interface. It contains a regulator to drop the +12 V to +5 V for the display.

5.8 T/R Board

The T/R board contains the input and output relays, as well as the input power detection and output directional wattmeter. The voltages from the detector are connected to the control board. There is a trimmer capacitor on this board that is adjusted with the amplifier operating into a good 50-ohm dummy load. The capacitor is rotated to minimize the reflected power voltage. The board also has an 800 V protection device on the RF output. This is located between the PCB and the flange of the output connector.

5.9 Center Partition Board

This contains the RF decoupling circuit on the B+ line as well as the “crowbar” safety circuit. This safety device consists of a piece of spring metal, which shorts out the B+ line when the top cover of the amplifier is removed.

Do not defeat this safety circuit. It is placed there for your protection.

6 Operation & Maintenance

The ALPHA 8410 is extremely easy to operate, but failure to carry out each procedure exactly as described in this manual is likely to lead to amplifier damage, which is not covered under warranty. Damage to other station equipment may also result.

6.1 Before Operating Your Alpha 8410

6.1.1 Setting Input Drive

You must set the transceiver output power properly. Virtually all damage to has resulted directly from severe overdrive. The ALPHA 8410 requires about 50 W drive for full rated output. **Damage caused by applying several times rated drive power to the ALPHA 8410 will not be covered under warranty.** Fortunately, most modern transceivers maintain quite consistent output from band-to-band and mode-to-mode when set up properly.

CAUTION:

Setting only the transceiver POWER or RF PWR control IS NOT SUFFICIENT.

Several popular transceivers can generate RF spikes of 200-300 W. Control of these spikes typically is done with a knob labeled DRIVE (IC-781, FT-1000) or PROCESSOR OUT (TS-940,TS-950). On SSB, when speech processing is not used, adjust the MIC or MIKE controls. See the operator s manual for your particular transceiver.

6.1.2 Dealing with Faults

The ALPHA 8410 “faults” into STBY or OFF when unsafe operating conditions occur. This is shown when the amplifier changes from the OPR LED being ON to the Fault and STBY LED’s If the 8410 encounters unsafe operating conditions, it enters a protective “Fault” mode. When this happens, the tubes are biased off and the relays are placed in the bypass mode, so that RF from the radio goes directly to the antenna. The FAULT LED on the front panel will flash on and off for a period of about 4 seconds, after which the amplifier will attempt to go back into OPERATE mode, unless the

OPER/STBY switch has been placed in the STBY position. This 4 second period can be shortened by toggling the OPER/STBY switch.

While the FAULT LED is flashing, the Ip and HV LED's are used to indicate which of the four fault conditions caused the amplifier to enter fault mode.

Fault type 1

Neither Ip nor HV LED's are lit. Output relay did not close. This fault will rarely be encountered, but if it is, it must be investigated further immediately, as continued operation with this fault could cause additional damage to the amplifier.

Fault type 2

Ip LED is blinking. This indicates that the plate current in the tubes exceeded 1.5 amps. This could be caused by the amplifier being mistuned or by overdriving the amplifier. If neither of the above is the case, then a problem in the bias control circuitry may be indicated.

Fault type 3

Both Ip and HV LED's are blinking. This indicates that the gain of the amplifier has fallen below 10 dB. This is an important safety feature of the amplifier, as many different problems in the amplifier or with its operation can be detected as a drop in gain. To avoid this fault occurring while the amplifier is being tuned up, the gain fault detection is disabled when drive power to the amplifier is below approximately 20 watts. This allows correct initial amplifier tuning to be achieved before going to full power.

Fault type 4

HV LED is blinking. This indicates a reflected power fault. The 8410 is set up to trip when the reflected power exceeds approximately 300 watts. At 1,500 watts output, this would represent an The fault type codes above are also reported in the amplifier telemetry data via the serial or USB ports on the rear of the amplifier.

If the tube current exceeds about 2.5 amps, the amplifier is shut off completely- that is, the AC is shut off. The ON/OFF switch will need to be used to put the amplifier back on line. To avoid problems, wait at least 20 seconds after this occurs before attempting to put the amplifier back on line. If the amplifier trips again immediately, investigate and cure the problem before attempting to turn the amplifier on again.

Repeatedly hitting the ON switch when the amplifier trips out is likely to result in severe damage to components in the amplifier.

If a hard fault trips the amplifier all the way OFF, wait at least 20 seconds before turning the amplifier power on again.

If you are certain that you have taken care of the problem that caused the fault, you may turn the amplifier back to operate and proceed with use.

6.1.3 High SWR Considerations

On any frequency where your antenna VSWR exceeds 1.5:1, it's important to carefully tune the ALPHA 8410 for a proper match. The ALPHA 8410 does not contain an antenna tuner. The SWR can be tuned via the antenna or an external tuner connected to the output of the Alpha 8410. Nevertheless, if the system SWR is below 2:1, the additional RF power loss of an antenna tuner can be avoided by tuning the 8410 into the slight mismatch. There is no advantage to using a tuner to “tweak” the last bit of SWR - in fact you will lose power this way.

6.1.4 Operating at Less Than 1.5 kW Requires Retuning

If you tune the amplifier for maximum power output and then decide to operate the 8410 at a power output much different from 1.5 kW, it must be re-tuned for efficient and RF-clean operation. Under such “lightly loaded” conditions, the green grid LED will probably be fully lit. Note that if you tune the amplifier at 1,500 watts and then simply reduce power to 1,000 watts, the tubes are actually going to run hotter than at 1,500 watts. It is better to tune the amplifier with close to 50 watts of power, but reduce the loading control to get 1,000 watts.

6.1.5 Lightning Protection

Induced energy from nearby electrical storms or other power transients may damage components in the amplifier. **Such damage is not covered under warranty.** It is important to use a good lightning arrestor, **however the only lightning proof solution available is to disconnect antenna feed lines and AC power when the equipment is not in use.**

6.1.6 Operating in Bypass Mode

Whenever the 8410 is in line, either off, in standby (STBY), or in warm-up with the WAIT LED lighted, the amplifier is bypassed and the exciter is connected directly to the antenna. The throughput limit in all cases is 500 watts when operating into a 1:1 SWR. This power level should be reduced accordingly for a higher SWR. Any power level more than this may damage the RF switching relays in the 8410.

6.2 Transceiver Connections

The Alpha 8410 “relay” jack has approximately 12 V on it. When pulled all the way to ground, a current of 10 mA flows. Consult your transceiver manual for additional information on how to connect to an external amplifier.

6.3 Initial Setup and Tuning

6.3.1 Control Functions

The following chart shows the controls that allow you to adjust and monitor the amplifier.

BAND	Used to select amateur band desired (in MHz).
TUNE	Sets output tank circuit to resonance within each band. Higher frequencies tend to tune toward the “0” end of the dial scale, while lower frequencies tend to tune further toward the “100” end.
LOAD	Sets amplifier plate loading and determines the power level at which best efficiency and linearity are achieved. In general, loading is heavier at greater scale settings. Higher frequencies tend to load more toward the “100” end of the dial scale and lower frequencies toward the “0” end.

6.3.2 Tune-Up

The objective of tune-up is to adjust the amplifier (and the drive applied to it) to obtain optimum efficiency and linearity at the desired output power. Any linear amplifier must be adjusted for optimum efficiency and linearity at each specific power level. If operation at higher power is then attempted without appropriate readjustment, the result will be flat topping also known as “splatter,” and (usually) excessive amplifier grid current. If operated at a much lower power level than it has been adjusted for, the amplifier’s efficiency decreases considerably. Recommended practice is to tune first into a dummy load or artificial antenna, then connect the antenna and make any slight final adjustments that may be needed. Alpha Radio Products makes the ALPHA 2100 in-line dummy load which simplifies this process. Using the AP 2100, the operator can switch between the dummy load and the antenna at the flip of a switch.

6.3.3 Grid Current Information

The ALPHA 8410 operates in Class AB1 when delivering maximum output power consistent with excellent linearity. A small amount of grid current flows and the green GRID MIN LED illuminates as drive approaches the optimum level. The green GRID

LED will flicker on SSB voice peaks and illuminate under CW/SSTV/RTTY carrier conditions.

As overdrive approaches, grid current increases rapidly and the red GRID MAX LED illuminates. At maximum output and efficiency, the red LED lights dimly; full illumination of the red LED indicates overdrive and must be avoided. If the red LED lights up before the desired value of plate current and/or against grid current fluctuations.

On SSB, optimum output consistent with good linearity, occurs when the green forward LED's illuminates on most voice peaks and the red LED flickers dimly on only the highest peaks. Excessive grid current results from overdrive and/or inadequate loading. The solution is to restrict drive, and/or increase amplifier loading. The 8410's VTX-X118 tubes are well protected and these adjustments tend to be less critical than in many other amplifiers. Grid bias is stabilized against grid current fluctuations.

6.3.4 ALC

The 8410 grid current limiting circuits provide substantial tube protection against possible damage, therefore no ALC control is necessary. It is only necessary to set the drive power from the radio as detailed in this manual.

6.3.5 Turning On The Amplifier

Please Note: Every time the ALPHA 8410 is powered up, there is a built-in 180 second warm up wait.

1. Place the OPR/STBY switch to STBY (standby).
2. Rotate the multimeter selector switch to HV.
3. Depress the POWER/ON switch. The fan and blower should immediately begin to operate. If there is no air flow from the amplifier and no sound of blower operation, immediately turn the amplifier off and investigate.
4. Within two seconds, the HV display should be all the way to the right, certainly above 2,500 Volts. If it is lower than this, investigate further- perhaps the primary taps are not correctly set.
5. At this time the red LED representing 1800 W output power is illuminated, indicating 180 seconds countdown remaining ($1800/10 = 180$ seconds). As the timer counts down, the remaining time will be indicated by the currently illuminated LED on the power output bar graph moving to the left.
6. Move the multimeter switch to the Ip position. There should be no current indicated, and this should be true during the entire period the amplifier is warming up. Leave the switch in the Ip position during amplifier warm up. The "Wait" LED will be blinking about twice per second, indicating that warm up is still in progress. The FAULT, OPER and STBY LED's should not be

illuminated.

CAUTION:
EXHAUST AIR MUST BE DETECTABLE FROM BOTH TOP VENTS.

If exhaust air is not coming from the top vents, TURN OFF the amplifier immediately and verify that the exhaust chimneys are properly positioned over the tubes. When the warm up delay is complete, the WAIT LED will extinguish and the OPR or STBY lights will stop blinking. Put the OPR/STBY switch to OPR and the Alpha 8410 is now “ready”.

BAND	TUNE	LOAD
10	0	77
12	41	58
15	13	70
17	8	58
20	28	47
30	0	27
40	27	33
80	56	53
160	18	27

*Each ALPHA 8410 shipped from our factory will include an individual table showing the tune and load settings we used to achieve full output power on that amplifier into an AP 2100, a 50-ohm dummy load. These settings usually vary slightly from those in the manual.

CAUTION:
If at any time in the following procedure the amplifier fails to respond as described, remove drive immediately and turn the OPR/STBY switch to STBY! Verify all connections and cables, turn the amplifier switch to OPR and proceed with the tuning procedure.

Alpha Radio Products recommended tune up procedure.

“Dip and Load” Method

Tuning up for Operation at 1,500 W RF Output.

Preset BAND, TUNE, and LOAD controls to the nominal positions given in your amp's specific tune up table or Table 6.3:

Note: Final TUNE and LOAD settings will vary with the operating frequency, antenna characteristics and power level.

1. Please limit the transceiver drive to about 65W for tuning up and operating the amp.
2. Set multimeter to I_p (Plate Current). Set TUNE and LOAD controls to numbers indicated in the tune up sheet originally included with the amplifier.
3. Key radio with 20W drive and adjust TUNE control for a peak in RF out which should be at the same point as a dip in I_p .
4. Increase drive to get 1000W output, going back and forth between the TUNE and LOAD to peak the RF output. If more output is desired, increase drive from radio slightly, increase LOAD for a peak in RF out, then peak RF out with TUNE control.
5. When the amplifier is tuned correctly on 160m thru 40m, the I_p should range between 0.9A and 1.1 A (read on the 0-to-1.5A scale) for 1500W output and input drive should not need to be more than about 60W. On 20m the I_p will usually be about 1.0A for 1500W output.
6. Plate current (I_p) is the most useful parameter to monitor on the multimeter bargraph during normal operation of the amplifier.

Alpha Radio Products alternate tune up procedure. “Nominal Gain” Method

Tuning up for Operation at 1,500 W RF Output.

Preset BAND, TUNE, and LOAF controls to the nominal positions given in your amp's specific tune up table or Table 6.3:

Note: Final TUNE and LOAD settings will vary with the operating frequency, antenna characteristics and power level.

1. Reduce transceiver carrier output control to ZERO.
2. Press OPR (operate) on OPR-STBY switch. OPR LED should illuminate.
3. Select the TUNE function of the multimeter bargraph.
4. Switch transceiver to CW and increase its carrier output to approximately 15 W (8410 output will be approximately 300-500 W).
5. Adjust the TUNE control to deflect the TUNE LED maximum rightward.
6. Adjust the LOAD control to place the illuminated TUNE LED in between the white lines above and below the LED bargraph.
7. Repeat steps 5 and 6 at least twice.
8. Increase the excitation power until the 8410 output is about 1,500 W.
9. Repeat steps 6 and 7 at least twice.
10. Touch up the TUNE control for maximum power output.
11. The ALPHA 8410 is now correctly tuned to deliver 1,500 W RF output on SSB, CW, FSK, SSTV and FM. The TUNE LED normally fluctuates during modulation or keying. Illumination of the first red LED on the RF OUTPUT bargraph indicates output has exceeded 1,500 W. The tune LED may vary during standard operation, especially SSB. This is normal.

6.4 Normal Use

6.4.1 Tubes

The VTX-X118 tubes used in the Alpha 8410 are supplied as a matched pair. They are very rugged and normally operate with a large margin of safety. They should provide outstanding service for many years if not damaged by abuse – such as overdrive or blockage of cooling airflow. Allow at least three to four inches (10 cm) of unobstructed clearance around the air intake and exhaust areas. Stacking equipment on top of the amplifier is not recommended.

Never allow key-down plate current to exceed 1.5 A for more than one or two seconds. If you do, and a plate current trip occurs, it will automatically reset in about 4 seconds if the amplifier is returned to receive (key-up).

Never allow the red GRID LED to stay brightly illuminated for more than a second.

Frequent on-off AC power cycling may shorten the tubes' life. It is less stressful to leave equipment in standby for several hours than to cycle power repeatedly on-off-on-off over the same period.

6.4.2 Interlocks

The ALPHA 8410 is equipped with a cover interlock switch intended to remove primary power from the amplifier, and a crowbar to short-circuit the high voltage to chassis whenever the cover is lifted. These interlocks are designed to protect against dangerous electric shock resulting from accidental contact with the lethal voltages inside the amplifier.

WARNING!

ALWAYS DISCONNECT THE AC LINE CORD FROM THE POWER SOURCE BEFORE REMOVING THE TOP COVER FROM THE 8410 FOR ANY REASON!

Cover interlocks are intended only as back-up protection against accidents. Never depend on them! Always disconnect the power cord from the AC mains before removing the cover! Interlock switches should not be disabled for any reason.

6.4.3 FUSES

Never replace any fuse with one of a different type or greater current rating. Blowing of one or both primary line fuses indicates that the maximum safe average power capability of the amplifier has been substantially exceeded or that an equipment failure has occurred. USE ONLY 20 AMP, 250 VOLT RATED FUSES for 190-220 VAC service. 25 amp fuses may be used with caution for line voltages of 90 – 130 V.

The slow-blow fuses Fe, located below the primary line fuses, may prevent damage to the stop-start resistors and HV rectifiers in the event of abnormal turn-on conditions or HV faults. If the AC interlock is defeated and primary power is applied while the HV crowbar is close, the step-start fuses will normally blow.

CAUTION::

DAMAGE RESULTING FROM USE OF A FUSE OF INCORRECT SIZE OR TYPE WILL NOT BE COVERED UNDER WARRANTY AND MAY VOID THE WARRANTY.

6.4.4 Plate Over Current Relay

This relay will quickly turn off the amplifier in the event of grossly excessive plate current or fault in the high voltage circuitry. The relay will not prevent tube or other damage due to either short or long term overdrive or improper tuning. It is the operator's responsibility to ensure safe tuning, drive, and general operating conditions. Should the over current relay trip, remove AC power from the amplifier, then determine and correct the cause of the trip before turning the 8410 on again. This "hard fault" trip circuit does not rely on the microcontroller for its operation, and will protect the amplifier even if the processor has been damaged or is malfunctioning.

6.4.5 Idling Plate Current and Electronic Bias Control (EBS)

Idling plate current of the ALPHA 8410 is approximately 350 to 400 mA during full power transmission. A detector senses RF drive, and reduces plate current to 30-50 mA during pauses in speech and key-up intervals, thus substantially reducing average power supply loading, heat generation, and wasted energy.

6.4.6 RF and Mistuning Protection

The ALPHA 8410's exclusive circuit senses the beginning of any RF arc in, for example, a TUNE or LOAD variable capacitor and automatically switches the amplifier to standby within a few milliseconds. This system has virtually eliminated RF arc damage in current ALPHA amplifiers. The system similarly detects severe miss-tuning of the 8410, and if

drive exceeds about 25 W switches the amplifier to standby. The 25 watt input trip threshold permits safe tune-up at low power levels without aggravating and unnecessary trip-outs.

6.5 Standard Maintenance Tasks

The amplifier interior, particularly high voltage areas, should be cleaned with a vacuum cleaner and a soft bristle brush frequently enough to prevent visible accumulation of dust. In extremely dusty conditions it may be advisable to secure a thin air filter of the type used for window air conditioners across the air intake on the rear panel.

There are no user-accessible lubrication points in the amplifier. Do not apply oil or grease to any of the components. The exterior of the ALPHA 8410 may be cleaned with a mild household liquid detergent. Do not use chemical solvents, as these may severely damage the front panel or cabinet finish. Never use an abrasive cleaner.

The amplifier should be cleaned at least once a year and all dust should be removed. This include blowing out the cooling fins in the VTH-H118 Tetrodes

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7 Troubleshooting Hints

7.1 Normal Troubleshooting

8410 will not turn on; nothing happens when ON switch is pushed.

Problem	Correction
1) External AC wiring, fuse or circuit breaker may be open.	Check & correct wiring, replace fuse, or reset circuit breaker.
2) Amplifier cover is not in place or properly secured; cover safety interlock is open.	Make sure cover is replaced and all screws securely inserted.
3) Fuse F1-F4 open or missing. Check fuses with an ohmmeter.	Check and replace any blown fuses with fuses of the same size.
4) Step-start resistor open.	Check resistor. If damaged, replace.

Amplifier turns on but no HV is indicated by the multimeter LED bargraph.

Problem	Correction
1) Multimeter selector switch in wrong position, e.g., Ip.	Set Multimeter switch to the correct position.
2) Possible HV circuit fault.	
3) HV sampling resistor in power supply damaged.	
4) Transformer plugged into power supply incorrectly.	Check power supply wiring and connectors to be sure input and output connectors are set properly and the voltage taps have been set properly.

Amplifier turns on but no multimeter indication; other LED bargraphs are operative.

Problem	Correction
1) Low voltage power supply problem.	
2) Defect or damage on control board.	

Amplifier turns on but time delay will not complete; WAIT LED does not turn off.

Problem	Correction
1) Defect or damage in timing circuitry on control board.	Contact Alpha Customer Service.

Amplifier turns on, time delay completes but amplifier will not transmit.

Problem	Correction
1) Open T/R control line from transceiver to RELAY jack.	Contact Alpha Customer Service.

Amplifier transmits but red GRID LED illuminates often.

Problem	Correction
1) Amplifier overdriven or under-loaded.	Reduce transceiver output and /or increase amplifier loading.
2) Load VSWR (reflected power) exceeds 200 W.	Check output cabling and antenna. Correct impedance mismatches.
3) Exciter output poorly controlled.	Consult exciter's User's Manual for assistance on controlling output.

Receive signals disappear or are severely attenuated when switching from

STBY to OPR.

Problem	Correction
1) RELAY (T/R) control cable from transceiver is shorted.	Check T/R control cable to make sure it is switching properly. Replace if needed.
2) Transceiver locked in transmit	Make sure transceiver is properly switching between transmit and receive. See transceiver's User's Manual for assistance.

Plate current indicated when amplifier is in STBY or receive.

Problem	Correction
1) VTX-X118 tube heater-to-cathode leakage or short.	Contact Alpha Customer Support.
2) Tube bias supply or T/R bias switch faulty.	Contact Alpha Customer Support.

Distorted SSB signal; Grid bias is unexpectedly decreasing.

Problem	Correction
1) Excessive RF drive from transceiver and/or insufficient amplifier loading.	Decrease drive from transceiver. Re-check amplifier tuning.
2) Coaxial connector, coax feed line, antenna feed point balun, tuner, or antenna trap arcing on voice peaks.	
3) RF feedback from antenna into transceiver via the transceiver power cord, microphone or key cable, or other unshielded station patch cables.	Make sure all power cords, microphone and key cables, or other cables are properly shielded and grounded.
4) Poor station RF ground.	Be sure the amplifier and transceiver have a proper RF ground. Correct if necessary.

Required drive to maintain 1,500 W is steadily increasing.

Problem	Correction
1) If the amount of drive required to maintain 1,500 watts is steadily increasing, this is an indication that the tubes are probably aging.	Contact Alpha Customer Support to see if tubes need replacing.

8 Glossary

The following terms are used in this manual. Detailed explanations may be found in various publications including the ARRL Handbook.

- AB1**-Modulation class AB1. Provides good linearity in push-pull configuration.
- AC**-Alternating current
- ALC**-Automatic Level Control
- ampere**-Current measurement
- ARRL**-American Radio Relay League
- AWG**-American Wire Gauge
- CW**-Continuous wave
- dB**-Decibel
- EBS**-Electronic bias switching
- Exciter**-The radio that provides RF drive for the 8410 to operate
- FCC**-Federal Communications Commission
- FM**-Frequency modulation
- FSK**-Frequency-shift keying
- HF**-High frequency (3 to 30 MHz)
- HV**-High voltage
- Hz**-Hertz
- Ip**-Idling plate current
- kV**-Kilovolts
- kVA**-Kilovolts/ampere. $kVA * 0.8 = \text{kilowatts}$
- kW**-Kilowatt
- LED**-Light-emitting diode
- LV**-Low voltage
- mA**-milliAmpere
- MHz**-Megahertz
- OPR**-Operate
- PSK**-Phase shift keying. A digital modulation scheme
- QSK** – Quick shift keying. In this CW transmitting mode, the transmitter is only on for the duration of each dot or dash and switches to receive between each
- RCA** - Radio Corporation of America. Also a type of interconnecting plug.
- RTTY** – Radio teletype
- SSB** – single side band
- SSTV** – Slow-scan television
- STBY** – Standby
- SWR** – Standing Wave Ratio. A measure of antenna and feed line efficiency.
- T/R** – Transmit/Receive.
- UHF** – Ultra High Frequency (300 – 3,000 Mhz)

US – United States.
VAC – Volts of alternating current.
VDC – Volts of direct current.
VSWR – Voltage Standing Wave Ratio

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