

# **RKR DESIGNS LLC**

## **Alpha 8410 Linear Amplifier**

### **User Manual**

**RKR Designs LLC**  
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## **Alpha 8410 Linear Amplifier User Manual**

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**[www.rksdesignsllc.com](http://www.rksdesignsllc.com)**.

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# 1 Introduction

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Congratulations on your purchase of a professional-quality Alpha 8410 linear amplifier.

## 1.1 Product Description

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The Alpha 8410 (see [Figure 1-1](#)) is a self-contained manual-tune HF linear power amplifier. It is capable of continuous operation at 1500 W peak power output on single sideband (SSB), keyed continuous wave (CW), slow-scan television (SSTV), radioteletype (RTTY), digital modes or FM, with no time limit.

### CAUTION

**CAUTION!** Study this manual carefully before operating your amplifier for the first time. In particular, it is extremely important that you thoroughly review the installation and operation sections. Failure to do so could result in serious damage not covered under warranty.

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### REMEMBER



Remember

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Amplifier components as photographed for this manual may differ from those in your amplifier, depending on your amplifier vintage.

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Figure 1-1 Alpha 8410



## 1.2 Product Capabilities

Product capabilities include:

- Continuous RF output. The Alpha 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 (other than the 60-meter band).
- Compatibility with popular amateur transceivers and exciters. The Alpha 8410 requires ~50-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.
- Built-in protective functions. 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 goes to standby.
- USB interface allows for remote operations, diagnostics, and firmware upgrades.

## 1.3 Safety Considerations

- Locate the Alpha 8410 where there is good air circulation all around and on top of the cabinet. The unit may become hot during operation.
- When moving the Alpha 8410, use proper lifting techniques and two people. Never transport the amplifier with the transformer in place.

- Although the Alpha 8410 meets international safety standards and FCC regulations, remember that the equipment works with high voltages that can be LETHAL!

This operating manual contains information, cautions, and warnings that you must follow to ensure safe installation and operation. Read Chapter 1 before attempting to unpack or operate the Alpha 8410. Failure to perform procedures properly may result in amplifier damage, fire hazard, or electric shock.

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**IMPORTANT**

- **NEVER open the amplifier case without unplugging the unit from the wall outlet.**
  - **NEVER touch an antenna during transmission.**
  - **NEVER turn on the amplifier without the cover securely in place and all attachment screws inserted.**
  - **NEVER turn on the amplifier without a good ground connection on the rear-panel ground terminal.**
  - **NEVER turn the amplifier back on after a hard fault (that is, a fault to power off) without waiting at least 20 seconds.**
  - **NEVER cover or obscure the exhaust holes in the amplifier cover. Never stick objects into the holes or allow liquids to enter through the holes.**
  - **NEVER allow key-down plate current to exceed 1.5 A for more than 1 or 2 seconds. If you do and a plate current trip occurs, it automatically resets in ~4 seconds if the amplifier is returned to receive (key-up).**
  - **NEVER allow the red GRID LED to stay brightly illuminated for more than 1 second.**
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## 1.4 Related Products

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

- Alpha 2000 full 1500-W-rated 50-ohm dummy loads
- Alpha 4500 series standing-wave-ratio (SWR) meters and wattmeters

For more information, go to [www.rksdesignsllc.com](http://www.rksdesignsllc.com) or call **303-473-9232**.

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## 1.5 Assistance

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Technical assistance from RKR Designs is available from several sources.

- Go to our website at **[www.rksdesignsllc.com](http://www.rksdesignsllc.com)** and click **Support**. On this site you can get the following assistance:
    - Alpha Forum
    - FAQs
    - Legacy equipment information
    - Manuals
    - Repair information
    - Software downloads
    - Tech tips
    - Technical support
  - E-mail us by completing a support request at **[www.rksdesignsllc.com](http://www.rksdesignsllc.com)**.
  - Fax us at **719-428-1919**.
  - Phone us at **303-473-9232**.
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## 2 Amplifier Components and Specifications

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### REMEMBER



Amplifier components as photographed for this manual may differ from those in your amplifier, depending on your amplifier vintage.

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The Alpha 8410 uses ceramic-and-metal forced-air-cooled tetrode vacuum tubes for amplification. 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 seven circuit boards in the amplifier:

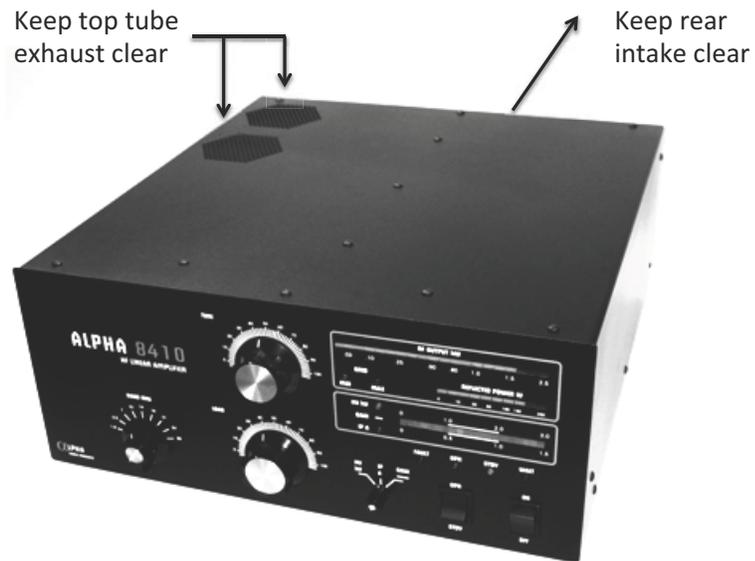
- Center-partition board
- Control board
- Display board
- HV board
- Mains board
- Transmit/receive (T/R) board
- Tube-deck board

In addition to these, the tubes, tank circuit assembly, and transformer complete the main sections of the amplifier. These major blocks are described below.

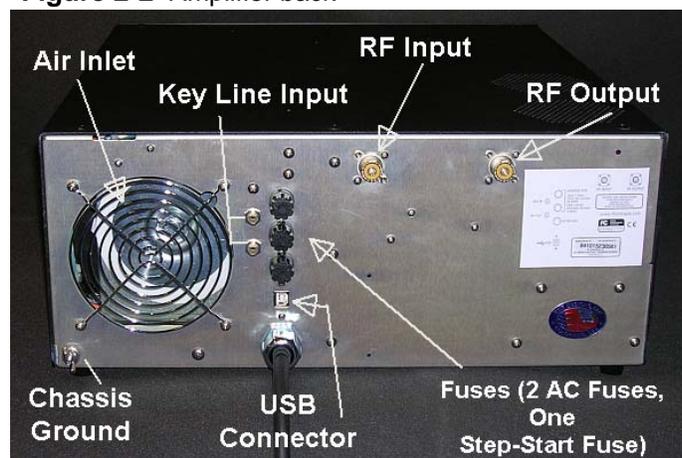
The amplifier includes a 5-V power supply mounted behind the front panel. Whenever the amplifier is plugged into the mains power, this supply is active and there is power to the microcontroller on the main control board. This feature enables the amplifier to be turned on or off remotely. It also enables remote monitoring and debugging via a USB cable connected to a computer.

The amplifier front, back, and interior are shown below (see [Figure 2-1](#), [Figure 2-2](#), and [Figure 2-3](#)). Amplifier components are listed alphabetically and described below.

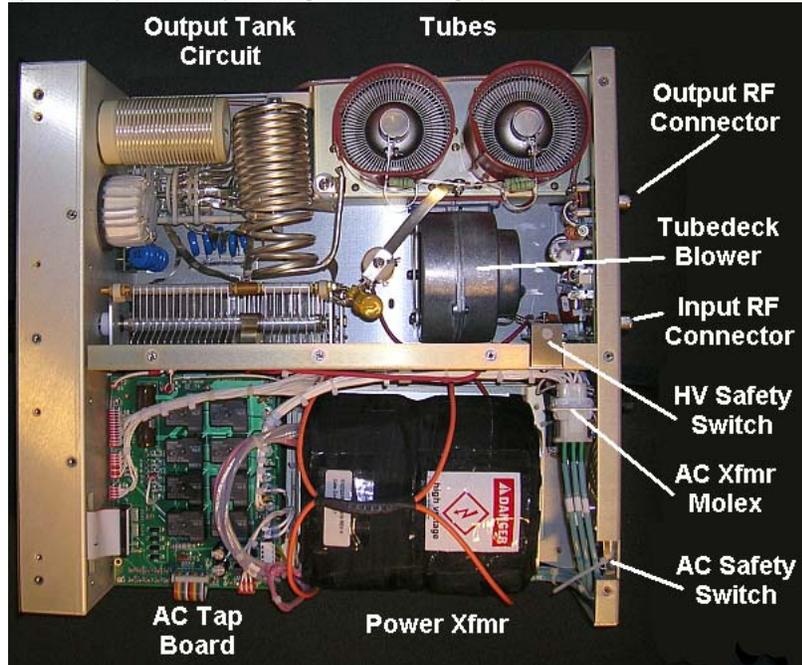
**Figure 2-1** Amplifier front



**Figure 2-2** Amplifier back



**Figure 2-3** Amplifier interior (components may differ from those in your amplifier, depending on its vintage)



## 2.1 Boards

The following amplifier boards are described below in alphabetical order:

- Center-partition board
- Control board
- Display board
- HV board
- Mains board
- Transmit/receive (T/R) board
- Tube-deck board

### Center-Partition Board

The center-partition board contains the RF decoupling circuit on the B+ line as well as the crowbar safety circuit. When you remove the top cover of the amplifier, the spring metal of this safety device shorts out the B+ line.

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**IMPORTANT**



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

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### **Control Board**

The control board is the heart of the amplifier. It is based on a PIC microcontroller. This microcontroller has a built-in multichannel analog-to-digital converter that monitors all 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 on the back of the amplifier is provided for remote monitoring. The USB driver for the amplifier is provided on the CD that ships with the amplifier or is available at [www.rksdesignsllc.com](http://www.rksdesignsllc.com).

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### **Display Board**

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

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### **HV Board**

The main high voltage for the amplifier is created on the HV 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 one in the negative return that goes to ground. This combination of 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. It is also used to generate a hard-fault condition. When the power-supply current exceeds ~2.5 A, a relay opens the coil circuit of the mains tap relays on the mains board, causing the amplifier to go 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 that discharge the capacitors in less than 60 seconds. If you must work on this board, confirm the discharged condition with a voltmeter, due to the remote possibility of bleeder resistor failure.

---

## Mains Board

Power-supply functions are split between the mains board and the HV board. The mains board deals mostly 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 transformer primary.

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 the amplifier is 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  $-12$  and  $-124$ -V supplies are also located on this board. Many of the important voltages for the amplifier are brought to test points on this board.

The primary voltage taps are located on the top of the mains board, between the transformer and the front panel. There is a row of five “fast-on” connectors (J22 through J26) and a flying jumper connector that mates with them.

---

## T/R Board

The transmit/receive (T/R) board contains the RF input and RF output relays as well as the input-power detection and output directional wattmeter. Voltages from the detector are connected to the control board.

A trimmer capacitor on this board has been adjusted at the factory with the amplifier operating into a good 50-ohm dummy load. This capacitor should be adjusted only at the factory.

The board also has an 800-V protection device on the RF output.

---

## Tube-Deck Board

The tube-deck board is located in the tube deck, below the tube sockets. It contains critical circuit elements that need to be in close proximity to the tubes. The tube heater, bias, and screen connections are all located on this board. The tube-deck temperature sensor and the input match for the tubes complete this board.

For more information on the tube deck, see [Section 2.4, “Tubes and Tube Deck,”](#) page 2–6.

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## 2.2 Controls and Display

The Alpha 8410 controls enable you to adjust and monitor the amplifier as needed (see [Table 2-1](#)).

**Table 2-1** Amplifier controls

Control	Purpose
<b>BAND</b>	Selects an amateur band, designated in megahertz (MHz).
<b>LOAD</b>	Controls the load capacitor. Sets the amplifier plate loading and determines the power level at which best efficiency and linearity are achieved. In general, loading is heavier at higher output power.
<b>TUNE</b>	Controls the tune capacitor. Sets the output tank circuit to resonance within each band. Higher frequencies tend to tune toward the 0 end and lower frequencies toward the 100 end of the dial scale.

---

## 2.3 Output-Tank Circuit

The output-tank circuit provides 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 1500 W.

Band switching is under manual control, accomplished by a 4-wafer band switch. These wafers are used as multifunction 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. The wafers are in the RF tank area. A variable resistor inside the front subchassis is used by the control board to determine which band you have selected.

---

## 2.4 Tubes and Tube Deck

The amplifier uses two 4CX1500B (Alpha part number VTX-X120) tetrode tubes, operating well within their ratings and in parallel.

The tubes are very rugged and normally operate with a large margin of safety. They should provide outstanding service for many years if they are not damaged by abuse such as overdrive or blockage of cooling airflow.

The tubes are operated in Class AB1, with a plate voltage of 2800 V (nominal, full output, key down), a grid 1 voltage of –50 to –60 (minus 50 to minus 60) V, and a grid 2 voltage of 200 V. They have a low-inductance resistor in series with their cathodes. This resistor stabilizes the tube bias and provides negative feedback, which improves linearity and hence intermodulation distortion (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.

The tubes are operated as a “swamped grid” tetrode design. The tube grids are tied at RF to a 50-ohm swamping resistor that 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 SWR <2:1 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.

**NOTE**

To prolong tube life, refrain from cycling AC power on-off-on-off repeatedly. It is less stressful to leave equipment in standby for several hours than to cycle it on and off repeatedly.

The tube deck is a mechanical assembly enclosing the tube sockets and the tube-deck board. The tube sockets contain the integral screen grid (grid 2) RF bypass capacitors as well as contacts for the screen, heater, and filament of the tubes.

## 2.5 Specifications

The Alpha 8410 linear amplifier specifications are as follows.

**Table 2-2** Alpha 8410 linear amplifier specifications

Parameter	Value
Frequency coverage	1.8–29.7 KHz
Input-drive level	50 W nominal
Power output	1500 W
SWR tolerance	3:1
Duty cycle	100%
Tubes	2 4CX1500B (Alpha part number VTX-X120)

**Table 2-2** Alpha 8410 linear amplifier specifications (Continued)

<b>Parameter</b>	<b>Value</b>
Intermodulation level	30 dB minimum, two exciter
Harmonics	-50 dBc
Mode of operation	CW, SSB, FM
Input AC voltage	100, 120, 200, 220, 240 selectable
AC current	<15 amps @240 VAC @1500 W
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 lb (31.8 kg)
T/R relay	Vacuum QSK
Tuning/band switching	Manual
Display	Bar-graph LED
Interface	USB
Protection	Against all common faults
RF bypass level	<500 W

## 3 Preparing Your Station

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### 3.1 Prepare Your Station

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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 chapter provides a few important operational considerations. We recommend that you also consult a good source of general information such as the latest Amateur Radio Relay League (ARRL) Handbook for Radio Amateurs, especially if this is the first high-power amplifier that you have used.

---

#### Procedure 3-1 Prepare your station

---

**Step 1** Provide 240 VAC power.

The amplifier runs best when powered by a 200–240 VAC circuit. If you do not have a 240 VAC outlet in your station, have a licensed electrical contractor install one. A minimum of a 20 A capacity is required. A 20-A breaker on your 240-V circuit is sufficient.

Select a location for the outlet as close as possible to where you expect to operate the amplifier. If you are not sure or contemplate moving the amplifier, consider installing two outlets.

The amplifier is shipped with a NEMA 6-20-style plug installed.

Ask the contractor to measure the voltage and record it for reference. If possible, have the contractor measure the line voltage with a 10-A current draw, and use this value for setting the transformer tap.

Although the amplifier can run when connected to a 120-VAC outlet, you MAY NOT achieve full-legal-limit output in this case. Rather, you should not expect more than 1000 W output. For more information on the limitations of operation when connected to a 110 VAC outlet, see [Section 3.2, “Limitations of Operation at Nonstandard Voltage,” page 3–4](#).

**Step 2** Provide proper airflow.

It is critical that airflow around the amplifier remain unimpeded at all times and that the top of the amplifier remain clear of any restrictions.

Maintain at least 3 in. of clearance around the amplifier and at least 4 in. of clearance around the air intake and exhaust areas to allow for unobstructed airflow. Ensure that exhausted air cannot recirculate back into the amplifier air intake. We recommend that you do not stack equipment on top of the amplifier.

If you are mounting the amplifier in a console, ensure that the exhaust air is properly and fully removed from the console. If outlet air is drawn back into the amplifier air intake and recirculated, the amplifier gets hotter and hotter, resulting in degraded performance or even failure. If you are designing your own console, consider putting in additional fans and/or ducting to deal with waste heat.

Minimize the possibility of dust or other contamination getting drawn into or falling on the amplifier. Periodically (at least annually) clean the dust out of the amplifier, paying particular attention to the tube fins. We recommend the use of compressed air for dust removal.

**Step 3** Ready your antenna for 1500 W.

Ensure that all antennas are rated for 1500 W and that they are carefully tuned and installed for minimum voltage SWR.

Many antennas that are suitable for general use are unsuited for operation at full 1500-W power. At this power level in a 50-ohm circuit, the RMS current is 5.5 A and the peak RF voltage is 387 V. For SWR = 2:1, these values double to 11 A and 775 V. 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. 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, take it down for inspection before full-power operation. If any insulators are cracked or show signs of tracking, replace them.

**Step 4** Provide adequate RF cabling.

Use good-quality low-loss coaxial cable.

Use new, clean connectors and install them according to manufacturer recommendations. Clean the connectors after soldering them and before mating them with the amplifier.

Remove any excess solder from the connector; likewise, remove any fragments of braid and the like.

Support the coax frequently using noncompressive clips so that it does not hang or stretch under its own weight. Avoid sharp or kinked bends (most manufacturers specify a minimum bend radius for their product).

Ensure that 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 wind static and lightning strikes, which are not covered under the amplifier warranty.

The importance of a well-constructed feed-line system cannot be overstated. The purpose of the amplifier is to provide approximately 2 S units (12+ dB) of improvement in your radiated signal. Cheap, poor, or underrated coax and connectors can degrade performance by at least one S unit. (This means that you could have bought a 375-W amplifier and achieved the same radiated signal by buying good-quality feed-line components!) Never use old coax, which may have had moisture penetrate under the jacket.

---

**NOTE:** 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. We strongly recommend that you do this for any installation, both fixed and at an expedition or contest site.

If you have any questions regarding engineering your amplifier into your amateur radio station, go to [www.rksdesignsllc.com](http://www.rksdesignsllc.com) and click **Support**.

---

#### **Step 5** Provide surge protection.

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

---

**NOTE:** Whenever the amplifier is online — either off, on standby (STBY), or warming up with the WAIT LED lighted — the amplifier is bypassed and the exciter is connected directly to the antenna. For SWR = 1:1, the throughput limit in all cases is 500 W. For a higher SWR, the power level should be reduced accordingly. Any power level higher than this may damage the RF switching relays in the amplifier.

---

### 3.2 Limitations of Operation at Nonstandard Voltage

Electrical-power equipment draws twice as much primary current from 120-V mains as from 240-V mains. Therefore, if you operate the Alpha 8410 on typical 120-V/20-A household circuit without exceeding the 20-A circuit rating, you limit maximum peak power output to ~600–1000 W. For expected behaviors at nonstandard line voltages, see [Table 3-1](#).

**Table 3-1** Amplifier behavior with nonstandard line voltages

Line voltage	Expected behavior
Low: 90–130 V	<p>For a line voltage of &lt;120 V, do not expect to be able to get 1500 W output. For maximum efficiency, tune the amplifier for no more than 1000-W output.</p> <p>For a line voltage of 110–130 V, 1500 W PEP operation (CW or SSB) may be possible if your AC line service has sufficient current capacity (30-A circuit recommended). However, 1500 W continuous should not be expected.</p>
High: >250 V	<p>Tube lifetimes may be reduced. Ask your utility company if they can reduce your line voltage. If this is not possible, consider placing your own step-down transformer in line between the AC outlet and the amplifier. 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 ferroresonant voltage regulator, is an expensive solution, but is a good way to stabilize primary voltage.</p>

**NOTE**



If you intend to operate the amplifier at ~120 V or if other equipment draws current from the same circuit as the amplifier, the following apply:

1. Ensure that the AC cord is not coiled too tightly or placed where normal air flow is restricted, causing it to overheat.
2. Change the lower 2-A fuse on the rear panel to a 5-A fuse to allow for the increased in-rush current.

## 4 Setting Up the Amplifier

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### IMPORTANT



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The Alpha 8410 is easy to set up, tune, operate, and maintain. However, 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. Proceed slowly throughout these procedures to avoid bumping and damaging adjacent wires, connectors, and components.

---

### 4.1 Unpack the Amplifier and Transformer

---

#### Procedure 4-1 Unpack the amplifier and transformer

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- Step 1** Prepare your station as described in [Chapter 3, “Preparing Your Station.”](#)
  - Step 2** Remove the amplifier and transformer from their cartons.

The Alpha 8410 ships in two heavy-duty double-wall cardboard boxes. The carton containing the amplifier weighs 50 lb (23 kg); the carton containing the transformer weighs 43 lb (20 kg).

    - 2a** Inspect the boxes for shipping damage.
    - 2b** Unpack the boxes and place the contents on a workbench or table.
    - 2c** Retain the boxes and all packing material in case you need to ship the unit later.
  - Step 3** Inspect the amplifier and transformer for shipping damage.

If you find damage, call RKR Designs technical support.
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## 4.2 Connect the Transformer

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### NOTE



- The transformer is very heavy. When moving it, use due caution and handle only by the lifting handle.
  - Do not over-tighten the screws that hold the transformer in place, as doing so may cause excessive vibrations or noise.
  - If you move the amplifier, even if only from one site to another locally, remove the transformer first to avoid the possibility of damage.
- 

---

### Procedure 4-2 Connect the transformer

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- Step 1** Remove the amplifier cover and set it aside.
- Step 2** Position the amplifier on a flat surface, at or near where it is to be used, with plenty of room for you to work.
- The amplifier chassis is designed for the mechanical loads experienced when the amplifier is on a flat surface with the tilt bail up or down. Installing the amplifier on a tilt so far that the transformer is cantilevered or hangs out to any degree can cause the chassis to distort.
- Step 3** Pick the transformer up by the handle and move it onto the lip at the edge of the chassis, about half way into the amplifier.
- Step 4** Connect the transformer:
- 4a** Connect the transformer's 9-pin white Molex connector to the matching 3x3 Molex connector on the back of the amplifier's back wall. Use the handle to move the transformer all the way into the amplifier and push it toward the center.
  - 4b** Connect the transformer's 8-pin orange connector to the matching pins on the amplifier's mains board (the upper of the two boards).
  - 4c** Connect the transformer's 6-pin yellow connector to the matching pins on the amplifier's HV board (the lower of the two boards).
  - 4d** Ensure that all connector pins on these three connectors engage fully and correctly.
- Step 5** Secure the transformer into place from the bottom of the amplifier by inserting the supplied bolts (1/4/20 1/2-inch hex bolts) with 1/4-inch washers through the four clearance holes in the chassis and into the nuts in the transformer base.

 **CAUTION**

**CAUTION!** Do not use the transformer's shipping bolts. They are too long and will damage the transformer!

### 4.3 Check the Tubes and Exhaust Chimney

With the amplifier cover removed, check and, if necessary, adjust the tubes and the exhaust chimney.

#### **Procedure 4-3** Check the tubes and the exhaust chimney

- Step 1** Ensure that the tubes are firmly seated in their sockets.  
The 4CX1500B tubes have bayonet-style bases. Each tube is installed onto a central pin in the tube socket and then rotated clockwise into place so that the flanges on the tube line up with the connectors in the socket. To remove a tube, rotate it counter-clockwise and then pull it up out of the socket.
- Step 2** Ensure that the anode connector is tightly clamped to the tube.
- Step 3** Ensure that the silicon-rubber exhaust chimney is straight and that the bottom is firmly against the tube deck and completely covers the airflow opening in the deck.  
The chimney should be 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.

**IMPORTANT: Damage caused by insufficient cooling airflow is not covered under warranty.**

### 4.4 Connect the Voltage Tap

Selecting the appropriate tap for your situation optimizes amplifier performance, safety, and lifetime.

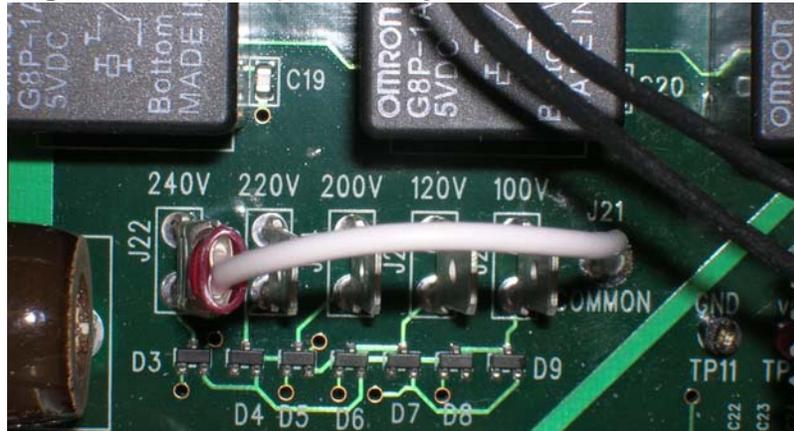
**IMPORTANT**



We strongly recommend that you operate the amplifier on 240 VAC. If you choose to do otherwise, see [Section 3.2, "Limitations of Operation at Nonstandard Voltage,"](#) page 3–4.

The primary voltage taps are located on the top of the mains board, between the transformer and the front panel. There is a row of five “fast-on” connectors (J22 to J26) and a flying jumper connector that mates with them (see [Figure 4-1](#)).

**Figure 4-1** Amplifier power settings



---

**Procedure 4-4** Connect the voltage tap

---

- Step 1** Ensure that the amplifier is unplugged.
- Step 2** Move the flying lead to the AC spade post marked with the appropriate voltage.

These five nominal primary voltages — 100, 120, 200, 220, and 240 V — cover all the line voltages normally encountered around the world. The nominal midrange voltage for each tap is printed on the mains-board circuit board. The acceptable line voltage for each tap is the center voltage plus or minus 10 V. Never use a tap other than the proper voltage, or damage to the tube and amplifier will result.

---

## 4.5 Connect the Cables

---

---

**Procedure 4-5** Connect the cables

---

- Step 1** The amplifier ships from the factory with a power cord and plug. If you ever need to change them, perform this step.

 **WARNING**

**WARNING!** To avoid the hazard of a potentially fatal electric shock and/or severe damage to the amplifier and other equipment:

- **NEVER** operate the amplifier with the cover removed.
- **ALWAYS** use an AC plug that is appropriate for the primary mains voltage, current rating, and configuration.
- **ALWAYS** use grounding-type AC connectors that conform to local codes.
- **NEVER** use 120-VAC plugs to connect to power receptacles for 190–250-V circuits.
- **ALWAYS** connect ALL station equipment to a good common ground. Failure to do so may allow RF feedback to leak into the transceiver and cause severe signal distortion.

**1a** Connect the green wire in the amplifier power cable only to the AC mains safety ground (or to neutral, as may be necessary with a 240-V circuit configured 120V-N-120V without a separate ground, commonly found in the US).

**1b** Connect the black-and-white power cord wires 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.

**Step 2** Replace the amplifier cover and 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.

 **WARNING**

**WARNING!** Do not attempt to operate the amplifier with the cover removed or placed on the unit without the attachment screws. Doing so damages the amplifier and may also cause injury or death to the operator.

**Step 3** Place the amplifier in its operating position on a stable surface with sufficient space to the rear, sides, and top to allow good air flow and safe placement of cables.

**Step 4** Connect the amplifier RF INPUT to the transceiver RF OUTPUT.  
Use 50-ohm coaxial cable-RG-58C/U or equivalent.

The amplifier's relay jack has ~12 V on it. When pulled all the way to ground, a current of 10 mA flows. For information on how to connect to an external amplifier, see your transceiver manual.

**Step 5** Connect the amplifier RF OUTPUT to the antenna.

Be certain to use coax cable that is rated for at least 1500 W.

**Step 6** Connect the transceiver (T/R) control cable to the amplifier's KEY IN input.

The amplifier has a full break-in vacuum relay QSK system that requires only the normal interconnection when used with a modern QSK transceiver. The amplifier requires a contact closure (short circuit) on transmit on the amplifier's KEY IN jack center pin to the chassis. This function is supplied by the transceiver, usually from a dedicated relay that is normally open in receive and closed in transmit.

**6a** Use shielded wire for the T/R control cable. Fit the amplifier end with a common phono (RCA-type) plug and the transceiver end with a suitable connector.

**6b** Ensure that the T/R relay contact closes. Protection circuitry prevents hot-switching when RF drive is applied. Modern transceivers have the proper time delay between key-up and the start of the transmitted signal to allow the amplifier to follow the CW keying.

---

**NOTE:** The Alpha 8410's grid-current-limiting circuits provide substantial tube protection against possible damage. The amplifier does not generate or use Automatic Level Control (ALC) voltages to control an exciter. You need only set the input-drive power as explained in [Section 4.4, page 4-3](#).

For proper operation, set the exciter transceiver's power output so as not to overdrive the amplifier input. If the transceiver is more than 15 years old, reduce the power output so that voice peaks do not overdrive the transmitter under any modulation condition.

---

## 4.6 Set the Input-Drive Power

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You must set the transceiver output power properly. Virtually all damage to date has resulted directly from severe overdrive. The amplifier requires 50-W drive for full rated output.

Damage caused by applying several-times-rated drive power to the amplifier is not covered under warranty. Fortunately, most modern transceivers maintain quite consistent output from band to band and mode to mode when set up properly.

Some transceivers may produce RF spikes upon keying during SSB operations. Do not operate the amplifier with transceiver power controls set at full power output. Do not rely on the mic gain control to set power. Rather, set up the transceiver with proper mic gain and processor levels at normal power level to drive the amplifier (typically 50 W).

 **CAUTION**

**CAUTION!** It is not sufficient to set only the transceiver POWER or RF PWR control.

Several popular transceivers can generate RF spikes of 200–300 W. Control these spikes with a knob labeled **DRIVE** (IC-781, FT-1000) or **PROCESSOR OUT** (TS-940, TS-950). On SSB, when you are not using speech processing, adjust the MIC or MIKE controls. For more information, see the manual for your particular transceiver.

## 4.7 Connect the Transceiver Keying Line

### Procedure 4-6 Connect the transceiver keying line

**Step 1** Connect the transceiver keying line.

The following is a list of popular transceivers and considerations for their connection to the amplifier. For advice on other transceivers, contact RKR Designs as described in [Chapter 1, “Introduction.”](#)

**Table 4-1** Popular transceivers

Transceiver	Connection and keying information
Icom	RF —
	T/R — Connection with the “Send” jack. For information, see the transceiver user manual.
Kenwood	RF —
	T/R — For information on connecting to external amplifiers, see the transceiver user manual.
Yaesu	RF —
	T/R — Connection with the RCA TX GND connector and/or TX GND signal in the DIN Band Data connector. For information, see the transceiver user manual.
Older transceivers	For information on connecting to external amplifiers, see the transceiver user manual.



## 5 Operating the Amplifier

- 
- 5.1 Principles of Operation 5-1
  - 5.2 Start Up the Amplifier 5-2
  - 5.3 Tune the Amplifier 5-3
  - 5.4 Operate the Amplifier 5-7
- 

### 5.1 Principles of Operation

Once your Alpha 8410 linear amplifier is set up as described in the previous chapters, before first use you must tune it for peak RF output and lowest current for the selected antenna port over the range of band segment frequencies to be used. At that point it is ready for use.

The Alpha 8410 can be in one of seven operational states, listed in [Table 5-1](#)

**Table 5-1** Operational states

State	Description
<b>Off</b>	<p>Plugged in but OFF.</p> <p><b>To enter this state:</b> Plug the amplifier into the AC line supply.</p> <p><b>In this state:</b> The front panel is dark. The internal auxiliary 5-V power supply is on. The microprocessor is powered up and communicates via the USB port.</p>
<b>On (warmup)</b>	<p>Tube is warming up and HV is present.</p> <p><b>To enter this state:</b> Press the <b>ON/OFF</b> switch to <b>ON</b>.</p> <p><b>In this state:</b> The AC line is connected to the primary of the transformer and all amplifier voltages are present (including the high voltage for the tubes).</p> <p>A 3-minute warmup countdown begins, with LEDs lighting up sequentially along the RF OUTPUT bargraph. The amplifier cannot be switched to Operate until the countdown timer reaches 0. The number of seconds remaining is displayed in the serial data.</p> <p>During warmup, we recommend that you check the plate voltage by rotating the multimeter selector switch to <b>HV</b>. The LED bargraph should show 3 kV.</p>

**Table 5-1** Operational states (Continued)

State	Description
<b>Standby</b>	<p>Tubes are ready and amplifier is in bypass mode (exciter only).</p> <p><b>To enter this state:</b> Wait for the amplifier to complete its 3-minute warmup.</p> <p><b>In this state:</b> The exciter can use the antenna, but the amplifier does not amplify the signal. Certain faults cause the amplifier to return to this mode.</p>
<b>Operational but unkeyed</b>	<p>Key-in has not been asserted.</p> <p><b>To enter this state:</b> Wait for the amplifier to complete its 3-minute warmup, then press the <b>OPER</b> switch.</p> <p><b>In this state:</b> The amplifier is fully warmed up, but the key-in line has not been activated. The exciter is still connected to the antenna.</p>
<b>Keyed, no RF</b>	<p>Key-in has been asserted, but no RF is sensed.</p> <p><b>To enter this state:</b> Wait for the exciter to short the key-in line to ground.</p> <p><b>In this state:</b> The input and output relays are activated, the tubes are biased on at a very low current, the exciter is connected to the input of tubes, and the antenna is connected to amplifier output.</p>
<b>Power</b>	<p>Amplifier is keyed, RF has been sensed, and amplifier delivers power.</p> <p><b>To enter this state:</b> Wait for the amplifier to sense RF.</p> <p><b>In this state:</b> The tubes are biased to the operational condition. The amplifier is now fully operational and delivering power to the load.</p>

**IMPORTANT**



To clear a fault:

- For a gain fault, wait for the amplifier to reset itself.
- For all other faults, resolve as described in [Chapter 7, “Diagnosing Faults and Troubleshooting.”](#) Then move the amplifier’s **OPR/STBY** switch to **STBY** and finally back to **OPR** to continue.

## 5.2 Start Up the Amplifier

### Procedure 5-1 Start up the amplifier

- Step 1** Install and set up the amplifier as described in the preceding chapters.
- Step 2** Power up the amplifier by moving the **OPR/STBY** switch to **STBY** (standby).
- Step 3** Rotate the multimeter selector switch to **HV**.
- Step 4** Press the **POWER/ON** switch.

The following occur:

- The fan and blower 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.
- Within 2 seconds, the HV display moves all the way to the right, certainly to more than 2500 V. If it is lower than this, investigate further; the primary taps may not be correctly set.
- The red LED representing 1800-W output power lights up, indicating the start of a built-in 180-second countdown ( $1800/10 = 180$  seconds). As the timer counts down, the remaining time is indicated by the currently lit LED on the power-output bargraph.

**Step 5** Move the multimeter selector switch to **Ip** (plate current).

No current should be indicated during the entire warmup period. The WAIT LED blinks about twice per second, indicating that warmup is still in progress. The FAULT, OPER, and STBY LEDs remain unlit.

**Step 6** Ensure that exhaust air is detectable from the exit vent holes above the tubes. If exhaust air is not detectable:

**6a** TURN OFF the amplifier immediately.

**6b** Ensure that the exhaust chimneys are properly positioned over the tubes.

**6c** Power up the amplifier again.

**6d** When the WAIT LED goes out and the OPR or STBY lights stop blinking, indicating that warmup is complete, move the **OPR/STBY** switch to **OPR**.

**Step 7** Proceed to [Section 5.3, “Tune the Amplifier,” page 5–3](#).

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## 5.3 Tune the Amplifier

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Each Alpha 8410 shipped from the factory includes a table showing the tune and load settings that we used to achieve full output power on that particular amplifier into an AP 2100 50-ohm dummy load. These settings usually vary slightly from those in this guide.

Your goal in tuning the amplifier is to maximize output power for a given input power.

Any linear amplifier must be adjusted for optimum efficiency and linearity at each specific power level. Operation at higher or lower power results in the following:

- Operation at higher power without appropriate readjustment results in flat-topping, also known as “splatter,” and (usually) excessive amplifier grid current.
- Operation at lower power results in decreased amplifier efficiency.

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.

For any frequency where antenna VSWR is  $>1.5:1$ , it is important to carefully tune the amplifier 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 amplifier output. Nevertheless, at SWR of  $<2:1$ , the additional RF power loss of an antenna tuner can be avoided by tuning the amplifier into the slight mismatch. There is no advantage to using a tuner to “tweak” the last bit of SWR; in fact, you lose power this way.

The Alpha 8410 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 mistuning and, if drive exceeds  $\sim 25$  W, switches the amplifier to standby. The 25-W input trip threshold permits safe tuning at low power levels without aggravating and unnecessary trip-outs.

## REMEMBER



A properly tuned amplifier has the following properties:

- Full legal power output:
  - For voltage SWR  $<2.0:1$ , normal value is 1500 W (with 40–60 W drive).
  - For SWR  $> 2.0:1$ , full output may not be possible but the other tuning indications are the same.
- Grid-current green LED either lit or unlit.
- Gain indication in right half of bargraph.
- Plate current normal value of 1 A at 1500 W. (The system alarms at values exceeding 1.2 A.)

## CAUTION

**CAUTION!** If, at any time in the following procedure, the amplifier fails to respond as described, do the following:

1. Remove drive immediately.
2. Turn the **OPR/STBY** switch to **STBY**.
3. Verify all connections and cables.

4. Turn the **OPR/STBY** switch to **OPR**.
5. Proceed with the tuning procedure.

### Tuning by the Recommended Dip-and-Load Method

This is our recommended way to tune the amplifier.

#### **Procedure 5-2** Tune by the recommended dip-and-load method

- Step 1** Start up the amplifier as described in [“Start Up the Amplifier,” page 5–2](#).
- Step 2** Set the BAND, TUNE, and LOAD controls to the values given in your amplifier’s specific tuneup table. Note that final TUNE and LOAD settings will vary with operating frequency, antenna characteristics, and power level.
- Step 3** Please limit the transceiver drive to ~65 W for tuning and operating the amplifier.
- Step 4** Move the multimeter selector switch to **Ip** (plate current).
- Step 5** Set the TUNE and LOAD controls to the values given in your amplifier’s specific tuneup table.
- Step 6** Key the amplifier with 20 W drive and adjust the TUNE control for a peak in RF out that should be at the same point as a dip in Ip.
- Step 7** Increase the drive to get 1000 W output, going back and forth between TUNE and LOAD to peak the RF output. If more output is desired, increase drive from the amplifier slightly, increase LOAD for a peak in RF out, then peak RF out with TUNE control.

When the amplifier is tuned correctly on 160 through 40 m, the following should be the case:

- The Ip should range between 0.9A and 1.1 A (read on the 0–1.5-A scale) for 1500 W output.
- The input-drive power should not be more than ~60 W.
- On 20 m, the Ip is usually ~1.0 A for 1500-W output.

Plate current (Ip) is the most useful parameter to monitor on the multimeter bargraph during normal operation.

- Step 8** Proceed to [“Operate the Amplifier,” page 5–7](#).

### Tuning by the Alternate Nominal-Gain Method

This is an alternative way to tune the amplifier.

#### **Procedure 5-3** Tune by the alternate nominal-gain method

- Step 1** Start up the amplifier as described in [“Start Up the Amplifier,” page 5–2](#).

- 
- Step 2** Set the BAND, TUNE, and LOAD controls to the values given in your amplifier's specific tuneup table. Note that final TUNE and LOAD settings will vary with operating frequency, antenna characteristics, and power level.
- Step 3** Reduce the transceiver carrier output control to 0.
- Step 4** Move the **OPR/STBY** switch to **OPR** (operate).  
The OPR LED lights up.
- Step 5** On the multimeter selector-switch bargraph, select the GAIN function.
- Step 6** Switch the transceiver to CW and increase its carrier output to ~15 W (the amplifier output will be ~300–500 W).
- Step 7** Do the following:
- 7a** Adjust the TUNE control to deflect the GAIN LED maximum rightward.
  - 7b** Adjust the LOAD control to place the illuminated GAIN LED between the white lines above and below the LED bargraph.  
Repeat this step at least twice.
- Step 8** Increase the excitation power until the amplifier output is ~1500 W.
- Step 9** Do the following:
- 9a** Adjust the TUNE control to deflect the GAIN LED maximum rightward.
  - 9b** Adjust the LOAD control to place the illuminated GAIN LED between the white lines above and below the LED bargraph.
- Step 10** Touch up the TUNE control for maximum power output.  
The amplifier is now correctly tuned to deliver 1500 W RF output on SSB, CW, FSK, SSTV, and FM.  
The GAIN LED normally fluctuates during modulation or keying. If the first red LED on the RF OUTPUT bargraph lights, output exceeds 1500 W. It is normal for the GAIN LED to vary during standard operation, especially for SSB.
- Step 11** Proceed to [“Operate the Amplifier,” page 5–7.](#)
-

## 5.4 Operate the Amplifier

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### Procedure 5-4 Operate the amplifier

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**Step 1** Start up and tune the amplifier as described in “Start Up the Amplifier,” page 5–2 and “Tune the Amplifier,” page 5–3.

**Step 2** Apply RF.

The amplifier requires only ~50 W for full output.

**Step 3** Ensure that exhaust air is detectable from the exit vent holes above the tube. If exhaust air is not detectable:

**3a** TURN OFF the amplifier immediately.

**3b** Ensure that the exhaust chimneys are properly positioned over the tubes.

**3c** Power up the amplifier again.

**3d** When the WAIT LED goes out and the OPR or STBY lights stop blinking, indicating that warmup is complete, move the **OPR/STBY** switch to **OPR**.

**Step 4** Monitor grid current.

The amplifier operates in Class AB1 when delivering maximum output power consistent with excellent linearity. A small amount of grid current flows, which you can monitor as follows:

- The GRID MIN LED lights up green as drive approaches the optimum level.
- The GRID LED flickers green on SSB voice peaks and lights up under CW/SSTV/RTTY carrier conditions.
- The GRID MAX LED does the following:
  - Lights dim red at maximum output and efficiency
  - Lights full red as overdrive approaches

For SSB operation, optimum output consistent with good linearity occurs when the GRID LED lights up green on most voice peaks and the GRID MAX LED flickers dim red 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 amplifier’s VTX-X120 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.

**Step 5** Monitor plate current.

In the event of grossly excessive plate current or fault in the high-voltage circuitry, the plate-current relay quickly turns the amplifier off. However, the relay does not prevent tube or other damage due to either short-term or long-term overdrive or improper tuning. It is your responsibility to ensure safe tuning, drive, and general operating conditions.

If the overcurrent relay trips, remove AC power from the amplifier, then determine and correct the cause of the trip before turning the amplifier back on. This hard-fault trip circuit does not rely on the microcontroller for its operation, and protects the amplifier under all conditions, even if the processor is damaged or malfunctioning.

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

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**NOTE**



If the amplifier faults, it usually resets itself after 4 seconds. For information about faults, see [Chapter 7, “Diagnosing Faults and Troubleshooting.”](#)

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## 6 Maintaining the Amplifier

- 
- 6.1 Clean the Amplifier Chassis 6-1
  - 6.2 Replace Tubes and/or Fuses 6-2
  - 6.3 Retune the Amplifier 6-3
- 

### IMPORTANT



- The Alpha 8410 is extremely easy to set up, operate, and maintain. However, 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.
- Do not apply oil or grease to any amplifier components. There are no user-accessible lubrication points in the amplifier.
- The amplifier is equipped with a cover interlock switch that removes primary power from the amplifier and a crowbar that short-circuits high voltage to the chassis when the cover is lifted. These interlocks protect against electric shock resulting from accidental contact with the lethal voltages inside the amplifier.

The cover interlock is intended only as backup protection against accidents. Never depend on it! Always disconnect the power cord from the AC mains before removing the cover.

**IMPORTANT: Do not disable the interlock switch for any reason.**

---

### 6.1 Clean the Amplifier Chassis

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Perform this procedure at least once a year.

---

#### **Procedure 6-1** Clean the amplifier chassis

---

- Step 1** Power down the amplifier.
- Step 2** Clean the exterior with a mild liquid detergent. Do not use chemical solvents, as these may severely damage the front panel or cabinet finish. Never use an abrasive cleaner.

 **WARNING**

**WARNING!** Do not allow any liquids to enter the cover's tube-exhaust holes.

**Step 3** Disconnect the AC line cord from the power source and lift the cover.

 **WARNING**

**WARNING!** Disconnect the AC line cord from the power source before lifting the cover for any reason.

**Step 4** Clean the interior, particularly high-voltage areas, with a vacuum cleaner and a soft bristle brush frequently enough to prevent visible accumulation of dust. Optimally, remove the plate under the tube deck (attached with 4 screws) and use compressed air to blow out the cooling fins in the tubes.

**Step 5** If conditions are extremely dusty, secure a thin air filter of the type used for window air conditioners across the air intake on the rear panel.

**Step 6** Replace the cover and reconnect the AC line cord to the power source.

## 6.2 Replace Tubes and/or Fuses

Perform this procedure only as needed.

### Procedure 6-2 Replace tubes and/or fuses

**Step 1** Power down the amplifier.

**Step 2** Disconnect the AC line cord from the power source and lift the cover.

 **WARNING**

**WARNING!** Before lifting the cover for any reason, disconnect the AC line cord from the power source.

**Step 3** Replace tubes as needed. Ensure that cooling airflow to the tubes is sufficient.

Use a matched pair of high-quality VTX-X120 tubes.

**Step 4** Replace fuses as needed.

For 190–220-VAC service, use only 20-A, 250-V-rated fuses. For 90–130-VAC service, you may optionally use 25-A fuses with caution.

**IMPORTANT:** Never replace a fuse with one of a different type or greater current rating. Damage resulting from

**use of a fuse of incorrect size or type is not covered under and may void the warranty.**

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.

The slow-blow fuse (F3), located below the primary-line fuses, may prevent damage to the step-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 closed, the step-start fuse normally blows.

**Step 5** Replace the cover and reconnect the AC line cord to the power source.

---

### 6.3 Retune the Amplifier

---

Normally you need to retune the amplifier only if you change radios, antennas, or some other aspect of your shack.

Your objective in tuning the amplifier (and the drive applied to it) is to obtain optimum efficiency and linearity at the desired output power. You must adjust the amplifier for optimum efficiency and linearity at each specific power level. If you attempt to operate at higher or lower power levels than those for which you have adjusted, the following happens:

- At higher power, the amplifier flattops, splatters, and (usually) produces excessive amplifier grid current.
- At lower power, the amplifier decreases efficiency considerably.

For instructions on retuning the amplifier, see [Section 5.3, “Tune the Amplifier,”](#) page 5–3.

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## 7 Diagnosing Faults and Troubleshooting

7.1 Diagnose Faults 7-1

7.2 Troubleshoot Problems 7-4

### 7.1 Diagnose Faults

If the amplifier encounters unsafe operating conditions, it enters a protective fault mode and faults into STBY or OFF. The OPR LED goes off and the FAULT and STBY LEDs go on.

When this happens, the tubes are biased off and the relays are placed in bypass mode, causing RF from the radio to go directly to the antenna. The FAULT LED on the front panel flashes on and off for ~4 seconds. After this period, unless the OPER/STBY switch has been placed in the STBY position, the amplifier attempts to return to OPERATE mode. You can shorten this 4-s period by toggling the OPER/STBY switch.

While the FAULT LED is flashing, the Ip and HV LEDs indicate which fault type caused the amplifier to enter fault mode. Fault-type codes are also reported in the amplifier telemetry data via the USB port on the rear of the amplifier. These fault types are summarized in [Table 7-1](#) and described in the following text.

**Table 7-1** Fault types

Fault type	LED behavior		Cause
	Ip LED	HV LED	
1	Blinking	Blinking	Amplifier gain is below 10 dB.
2		Dark	Plate current in the tube exceeds 1.5 A.
3	Dark	Blinking	Reflected power is too high.
4		Dark	Input-drive power is too high.
5*			Plate current exceeds 2.5 A.
6*			Plate current was detected during warmup.

\* Faults 5 and 6 do not display on the front panel. Rather, they indicate only through telemetry via the USB port.

---

### Fault type 1

<b>LED behavior</b>	Both Ip and HV LEDs are blinking.
<b>Cause</b>	Amplifier gain has fallen to <10 dB.  This is an important safety feature of the amplifier, as many different problems can be detected as a drop in gain. So that this fault does not occur while the amplifier is being tuned, gain fault detection is disabled when drive power to the amplifier is below ~20 W. This allows correct initial amplifier tuning to be achieved before going to full power.
<b>Resolution</b>	<ol style="list-style-type: none"><li>1. Reduce the input-drive power.</li><li>2. Retune the amplifier.</li></ol>

---

### Fault type 2

<b>LED behavior</b>	Ip LED is blinking.
<b>Cause</b>	Plate current in the tube has exceeded 1.5 A. If the current exceeds ~2.5 A, AC select relays are de-energized and the amplifier shuts off completely.
<b>Resolution</b>	<ol style="list-style-type: none"><li>1. Retune the amplifier.</li><li>2. Ensure that the amplifier is not overdriven.</li><li>3. Fix any problems in the bias-control circuitry.</li><li>4. If the amplifier has shut off, wait at least 20 seconds, then use the <b>ON/OFF</b> switch to turn the amplifier back on.</li><li>5. If the amplifier trips again immediately, investigate and resolve the problem before attempting to turn the amplifier on again.  DO NOT repeatedly hit the ON switch when the amplifier trips out. Doing so is likely to result in severe damage to amplifier components.  When you are certain that you have taken care of the problem that caused the fault, you may turn the amplifier back on.</li></ol>

---

### Fault type 3

<b>LED behavior</b>	HV LED is blinking.
<b>Cause</b>	Reflected power is too high.  The amplifier trips when reflected power exceeds ~250 W. At 1500-W output, this represents a voltage standing-wave ratio (VSWR) fault exceeding 3:1.

- Resolution**
1. Check the output coaxial cable and connectors; replace or reconnect as needed.
  2. Check the antenna SWR using an external wattmeter or by putting the amplifier in standby mode and using the SWR meter on your transceiver. Make adjustments as needed.
- 

#### Fault type 4

- LED behavior** Neither Ip nor HV LED is blinking; both are dark.
- Cause** Input-drive power is too high.  
The amplifier behaves as follows at various input-drive power levels:
- When power is below 75 W, the amplifier operates normally.
  - When power spikes above 75 W, a 500-ms timer starts, during which time the power threshold is reduced from 75 to 65 W. If you do not reduce the power to below the threshold at the end of 500 ms, Fault 4 results.
  - When power exceeds 100 W (the absolute maximum value at which the amplifier can operate), an immediate Fault 4 results.
- Resolution** Decrease the input-drive power.
- 

#### Fault type 5

- LED behavior** The amplifier shuts off and goes to State 0.
- Cause** A hard fault has occurred because input-drive power exceeded 125 W, causing plate current to exceed 2.5 A ( $I_p > 2.5$  A).
- Resolution** Decrease the input-drive power or retune the amplifier.
- 

#### Fault type 6

- LED behavior** The amplifier shuts off and goes to State 0.
- Cause** A hard fault has occurred because significant plate current was detected when the amplifier was warming up or was unkeyed (States 1–3). The threshold for this fault is one-third of the value for a “soft” Ip trip, or 533 mA.
- Resolution**
1. After the amplifier shuts off, wait at least 20 seconds, then use the **ON/OFF** switch to turn the amplifier back on.
- IMPORTANT: When the amplifier trips out, DO NOT repeatedly press the ON/OFF switch to attempt to turn**

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**the amplifier back on. Doing so is likely to result in severe damage to amplifier components.**

2. If the plate current again starts to rise while the amplifier is warming up, investigate and resolve the problem before attempting to turn the amplifier on again.
3. Fix any problems in the bias-control circuitry.
4. When you are certain that you have taken care of the problem that caused the fault, turn the amplifier back on.

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## 7.2 Troubleshoot Problems

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**Amplifier does not turn on; nothing happens when the ON switch is pushed**

1. External AC wiring, a fuse, or a circuit breaker may be open. Check and correct wiring, replace fuse, or reset circuit breaker.
2. The amplifier cover may not be in place or properly secured or the cover safety interlock may be open. Ensure that the cover is in place and all screws are securely inserted.
3. One or more connectors may be loose. Check that all of the transformer connectors are securely attached, that the 3x3 molex connector at the back of the amplifier is fully engaged, and that the two connectors between the transformer and the HV power supply boards are firmly inserted.
4. Fuse F1–F3 may be open or missing. Check fuses with an ohmmeter. Replace any blown fuses with fuses of the same size.
5. The step-start resistor may be open. Check the resistor. If it is damaged, replace it.

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

1. The multimeter selector switch may be in the wrong position (example: Ip). Set the switch to the correct position.
  2. The transformer may be plugged into the power supply incorrectly. Check the power-supply wiring and connectors to ensure that the input and output connectors and the voltage taps are set properly.
  3. An HV circuit fault may exist. Check the line voltage.
  4. The HV sampling resistor in the power supply may be damaged. Contact RKR Designs technical support.
-

**Amplifier turns on but HV reading is low as indicated on the multimeter bargraph**

The plate voltage to the power supply may be too low. Check the line voltage and confirm that the tap is set correctly.

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**Amplifier turns on but time delay does not complete and WAIT LED does not turn off**

The timing circuitry on the control board may be damaged or defective. Contact RKR Designs technical support.

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**Amplifier turns on and time delay completes but amplifier does not transmit**

The T/R control-line (key-line) connection to the amplifier may be faulty.

1. Confirm that the key line is inserted into the correct jack on the back of the amplifier.
  2. Confirm that the key line is connected to the correct port on the transceiver and that amplifier-keying is enabled.
  3. If the tube current has exceeded 2.5 A, follow the resolution instructions for [“Fault type 2,” page 7–2](#) and [“Fault type 5,” page 7–3](#).
  4. Confirm that the cable is good.
  5. Confirm, with the multimeter switch in the Ip position and the amplifier keyed with no RF, that plate current is drawn.
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**Amplifier operates properly, then turns off completely**

The tube current may exceed ~2.5 A. See the resolution instructions for [“Fault type 4,” page 7–3](#).

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**Amplifier transmits but red GRID LED lights often**

The amplifier may be overdriven or incorrectly tuned; most likely the load control is set too low. Reduce the transceiver output and adjust the tune and load controls to maximize efficiency with minimum grid lights.

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**When switching from STBY to OPR mode, receive signals disappear or are severely attenuated**

1. The RELAY (T/R) control cable from the transceiver may be shorted. Check the cable to ensure that it is switching properly. Replace it if needed.

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2. The transceiver may be locked in transmit. Ensure that the transceiver is properly switching between TRANSMIT and RECEIVE modes. For assistance, see the transceiver manual.
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**When amplifier is in STBY or RECEIVE mode, plate current is indicated**

The tube bias supply or T/R bias switch may be faulty. Contact RKR Designs technical support.

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**Distorted SSB signal; grid bias is unexpectedly decreasing**

1. The RF drive from the transceiver may be excessive and/or amplifier loading may be insufficient. Decrease drive from the transceiver. Recheck the amplifier tuning.
  2. The coaxial connector, coax feed line, antenna feed point balun, tuner, or antenna trap may be arcing on voice peaks. Replace the faulty components.
  3. RF feedback may exist from the antenna into the transceiver via the transceiver power cord, microphone or key cable, or other unshielded station patch cables. Ensure that all power cords, microphone and key cables, and other cables are properly shielded and grounded.
  4. The station RF ground may be poor. Ensure that the amplifier and transceiver have a proper RF ground.
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**Required drive to maintain 1500 W is steadily increasing**

The tubes may be aging. Contact RKR Designs technical support to determine whether the tubes need to be replaced.

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## Terminology

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**NOTE:** For detailed explanations of the following terms, see various publications including the latest *American Radio Relay League (ARRL) Handbook*.

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### A

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**AB1** — Modulation class AB1. Class that provides good linearity in a push-pull configuration.

**AC** — Alternating current. Electric current whose magnitude and direction vary with time.

**ALC** — Automatic Level Control. Technology that automatically controls output power.

**ampere** — Unit of electric current.

**ARRL** — American Radio Relay League. US national organization of amateur radio operators. For more information, go to [www.arrl.org](http://www.arrl.org).

**AWG** — American wire gauge. Standard method of denoting wire diameter.

### B

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**B1** — Modulation class AB1. Amplifier-circuit class that provides good linearity in push-pull configuration.

### C

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**CW** — Continuous wave. Electromagnetic wave of constant amplitude and frequency.

### D

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**dB** — Decibel. Logarithmic unit of measure of the power of sound relative to a reference level.

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## E

**EBS** — Electronic bias switching. A form of switching that increases negative grid 1 voltage in pauses in speech or between Morse code elements, resulting in reduced standing bias on the tubes.

**exciter** — Radio that provides RF drive for the amplifier to operate. The transmitter portion of the transceiver.

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## F

**FCC** — Federal Communications Commission. For more information, go to [www.fcc.gov](http://www.fcc.gov).

**FM** — Frequency modulation. Modulation scheme in which information is conveyed over a carrier wave by variations in frequency.

**FSK** — Frequency-shift keying. Type of frequency modulation in which information is conveyed by shifts in the output frequency between predetermined values.

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## H

**HF** — High frequency. Radio frequency within the range 3–30 MHz.

**HV** — High voltage. Electrical circuit in which the voltage used presents risk of both electric shock and electrical arcing.

**Hz** — Hertz. One periodic event per second.

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## I

**I<sub>p</sub>** — Idling plate current. Plate current measured when the amplifier is keyed and RF is not present.

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## K

**key** — Signal from the radio to the amplifier that instructs the amplifier to switch from receive to transmit mode because the radio is ready to generate RF power. The (programmable) delay between keydown and RF out is generally 8–12 ms. When the amplifier is keyed, it is in State 5.

**kV** — Kilovolt. 1000 V.

**kVA** — Kilovolt-ampere. 1000-W capability.  
kVA \* 0.8 = kilowatts.

**kW** — Kilowatt. 1000 W.

**L**

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**LED** — Light-emitting diode. Semiconductor diode that emits incoherent narrow-spectrum light, providing a form of electroluminescence.

**LV** — Low voltage. Electrical circuit in which the voltage used presents risk of electric shock but only minor risk of electrical arcing.

**M**

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**mA** — Milliamperere.  $10^{-6}$  A.

**MHz** — Megahertz.  $10^6$  Hz.

**O**

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**OPR** — Operate.

**PCB** — Printed circuit board. Board that mechanically supports and electrically connects electronic components.

**P**

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**PSK** — Phase-shift keying. Digital modulation scheme in which information is conveyed by

changes, or modulations, in the phase of a reference signal.

**Q**

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**QSK** — Quadrature-shift keying. Digital modulation scheme in which the transmitter is on only for the duration of each dot or dash and

switches to receive between each dot or dash, allowing the operator to hear any signal being sent.

**R**

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**RCA** — Radio Corporation of America. Also a type of interconnecting plug.

**RMS** — Root mean square. Statistical measure of the magnitude of a varying quantity such as a wave.

**RF** — Radio frequency. Frequency within the range 3 Hz–300 GHz.

**RTTY** — Radio teletype. Telecommunications system consisting of two or more teleprinters using radio as the transmission medium.

**RG-x/x** — Coaxial cable type.

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## S

**SSB** — Single sideband. Modulation scheme that refines upon amplitude modulation.

**SSTV** — Slow-scan television. Picture-transmission method for transmitting and receiving static pictures via radio.

**STBY** — Standby. Mode in which an electronic appliance is turned off but under power and ready to activate on command.

**SWR** — Standing-wave ratio. Ratio of the amplitude of a partial standing wave at an antinode (maximum) to the amplitude at an adjacent node (minimum). Measure of antenna and feedline efficiency.

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## T

**T/R** — Transmit /receive.

**transceiver** — Device that has both a transmitter and a receiver within the same circuitry or chassis.

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## U

**UHF** — Ultra-high frequency. Radio frequency within the range 300–3000 MHz (3 GHz).

**US** — United States.

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## V

**VAC** — Volts of alternating current.

**VDC** — Volts of direct current.

**VSWR** — Voltage standing-wave ratio. Example: If  $VSWR = 1.2:1$ , the maximum standing-wave amplitude is 1.2 times greater than the minimum standing-wave amplitude.

## Schematics

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**NOTE:** The following pages contain detailed schematics for the Alpha 8410 linear amplifier.

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