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AETECHRON



8504

Operator's Manual

Wide-Bandwidth, High-Power Digital Amplifier

Three-Year, No-Fault Warranty

SUMMARY OF WARRANTY

AE TECHRON INC., of Elkhart, Indiana (Warrantor) warrants to you, the ORIGINAL COMMERCIAL PURCHASER and ANY SUBSEQUENT OWNER of each NEW **AE TECHRON INC. product, for a period of three (3) years from the date of purchase, by the original purchaser (warranty period) that the product is free of defects in materials and workmanship and will meet or exceed all advertised specifications for such a product. We further warrant the new AE Techron product regardless of the reason for failure, except as excluded in the Warranty.**

ITEMS EXCLUDED FROM WARRANTY

This AE Techron Warranty is in effect only for failure of a new AE Techron product which occurred within the Warranty Period. It does not cover any product which has been damaged because of any intentional misuse, accident, negligence, or loss which is covered under any of your insurance contracts. This warranty does not extend to any product on which the serial number has been defaced, altered, or removed. It does not cover damage to loads or any other products or accessories resulting from **AE TECHRON INC.** product failure. It does not cover defects or damage caused by the use of unauthorized modifications, accessories, parts, or service.

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We will remedy any defect, regardless of the reason for failure (except as excluded), by repair, replacement, or refund, at our sole discretion. We may not elect refund unless you agree, or unless we are unable to provide replacement, and repair is not practical or cannot be timely made. If a refund is elected, you must make the defective or malfunctioning product or component available to us free and clear of all liens or other encumbrances. The refund will be equal to the actual purchase price, not including interest, insurance, closing costs, and other finance charges less a reasonable depreciation on the product from the date of original purchase. Warranty work can only be performed at our authorized service centers or at our factory.

Expenses in remedying the defect will be borne by **AE TECHRON INC.**, including one-way surface freight shipping costs within the United States. (Purchaser must bear the expense of shipping the product between any foreign country and the port of entry in the United States and all taxes, duties, and other customs fees for such foreign shipments.)

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When you notify us or one of our authorized service centers of your need for warranty service, you will receive an authorization to return the product for service. All components must be shipped in a factory pack or equivalent which, if needed, may be obtained from us for a nominal charge. We will take corrective actions and return the product to you within three weeks of the date of receipt of the defective product, or will make available to you a product of equal or better performance on temporary loan until your product can be repaired or replaced and returned to you. If the repairs made by us are not satisfactory, notify us immediately.

DISCLAIMER OF CONSEQUENTIAL AND INCIDENTAL DAMAGES

You are not entitled to recover from us any consequential or incidental damages resulting from any defect in our product. This includes any damage to another product or products resulting from such a defect.

WARRANTY ALTERATIONS

No person has the authority to enlarge, amend, or modify this warranty. The warranty is not extended by the length of time for which you are deprived of the use of this product. Repairs and replacement parts provided under the terms of this warranty shall carry only the unexpired portion of this warranty.

DESIGN CHANGES

We reserve the right to change the design of any product from time to time without notice and with no obligation to make corresponding changes in products previously manufactured.

LEGAL REMEDIES OF PURCHASER

There is no warranty that extends beyond the terms hereof. This written warranty is given in lieu of any oral or implied warranties not contained herein. We disclaim all implied warranties, including, without limitation, any warranties of merchantability or fitness for a particular purpose. No action to enforce this Warranty shall be commenced later than ninety (90) days after expiration of the warranty period. This statement of warranty supersedes any others contained in this manual for AE Techron products.

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Contents

1	Introduction	5
1.1	Features	5
1.2	Configuration Options.....	5
2	Amplifier Unpacking and Installation	6
2.1	Safety First	6
2.2	Unpacking	6
2.3	Installation	6
3	Connections and Startup	6
3.1	Connecting the Load	7
3.2	Connecting the Input Signal	7
3.3	Other DIP Switch Settings.....	8
3.4	Monitor and Sense Ports.....	8
3.5	Connecting the AC Supply	8
3.6	Start-up Procedure.....	8
4	Amplifier Operation	9
4.1	Front-Panel Controls and Indicators.....	9
4.2	Back-Panel Controls & Connectors.....	10
5	Advanced Configuration	12
5.1	DIP Switch Configurations.....	13
5.2	Internal Configuration.....	15
6	Applications	18
6.1	Parallel Multi-amp Systems for Increased Current.....	18
6.2	Safety Interlock.....	22
6.3	Controlled-Voltage vs. Controlled-Current Modes of Operation	22
7	Maintenance	28
7.1	Clean Amplifier Filter and Grills.....	28
8	Troubleshooting	29
8.1	Introduction & Precautions	29
8.2	Visual Inspection	29
8.3	No Signal.....	29
8.4	No LEDs Illuminated.....	29
8.5	Over/Under Line LED Lit	29
8.6	Run/Standby LED Remains Amber	29
8.7	Amplifier Overheats (Over Temp Fault Condition).....	30
8.8	Fault LED is Illuminated	30
8.9	Factory Service	31



Figure 1.1 – 8504 Front Panel

1 Introduction

Congratulations on your purchase of the 8504 digital power amplifier. 8500 Series amplifiers are the first wide-bandwidth, high-power digital amplifiers available from any manufacturer. They are fast enough for DC automotive dropout testing and capable of AC voltages required for ISO 61000 and Aviation testing. Plus, they have low enough noise and distortion specifications to be the reference power source in power quality measurements.

1.1 Features

Wide Bandwidth and Flexible

The 8504 amplifier is capable of reproducing AC, DC and AC+DC waveforms into loads from a dead short to high impedance. It can be used to simulate a battery at 13.5 VDC or be an AC source with a L-N potential of up to 250 VAC. Rated current, for a given voltage, is available for all waveform types (AC, DC or AC+DC) at frequencies from DC to 50 kHz. Voltages from 0 to 250 VRMS are available with no changes in configuration.

Reuses Energy from Reactive Loads

The 8504 excels when it comes to driving reactive loads. As frequencies increase, the effective-impedance of the load becomes a much larger part of the total load to be driven (especially with inductive loads like coils).

However, when driving reactive loads, the 8504 is capable of receiving, reprocessing and returning to the load up to 5X its rated power. The result is a bench top system capable of 20 kVA+ output while drawing less than 4 kW of AC mains power!

Performance Overview	
Bandwidth	DC - 50 kHz
Voltage	0 to 250 VRMS; 0 to 350 VDC
Current	100 ARMS
Distortion	0.1%
Power	4 kW
Apparent Power	20 kVA

1.2 Configuration Options

A key to everyday product usability is quick and easy product (re)configuration. The 8504 provides all key configuration controls on either the front or back panels of the unit. Configuration options available include:

- **Gain:** Fixed or variable gain (0 to 40)
- **Current Limit:** From 5% to rated limit (to protect fragile DUTs or where specified in the Standard)
- **DC Control:** DC enabled or DC blocked and DC Servo (for driving transformer-coupled loads, coils)
- **Input:** Balanced and/or unbalanced
- **Mode:** Voltage source or current source
- **Output Impedance:** Variable from 0 to 1 ohm (Voltage mode)
- **Sense:** Sense line with correction of up to 4 volts

2 Amplifier Unpacking and Installation

The 8504 amplifier is a precision instrument that can be dangerous if not handled properly. Lethal voltages are present in both the AC input supply and the output of the amplifier. For this reason, safety should be your primary concern when you setup and operate this amplifier.

2.1 Safety First

Throughout this manual special emphasis is placed on good safety practices. The following graphics are used to highlight certain topics that require extra precaution.



2.2 Unpacking

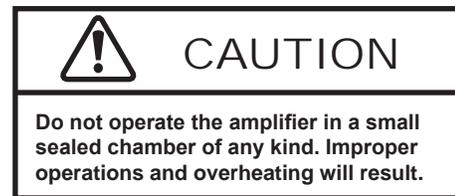
All amplifiers are tested and inspected for damage before leaving the factory. Carefully unpack and inspect the amplifier for damage. **Please note any damage for future reference and notify the shipping company immediately if damage is found.** Also, please save the shipping carton and materials as evidence of damage and/or for returning the amplifier for repair.

2.3 Installation

The 8504 amplifiers are packaged in a rugged powder-coated chassis. This chassis is 3U (rack units) tall, and has rack “ears” on each side of the front panel for mounting to a standard EIA (Electronic Industries Association) rack. Use standard rack mounting hardware to mount the amplifier. Use nylon washers if you wish to protect the powder-coat finish on the front of the amplifier.

Optionally, the amplifier can be placed on a bench top; please keep in mind that the protective powder-coating can be scratched when placed on other equipment or on a bench top, especially when there is dirt present. To protect the finish, a set of rubber feet is included in the toolkit that can be installed on the bottom of the amplifier.

Allow ample space on the sides and especially the back of the amplifier for heated air to escape. The amplifier should be mounted in a rack that is adequately ventilated and not sealed. Likewise, the front of the amplifier should be unobstructed to allow cool air to enter the amplifier.



3 Connections and Startup

This section details the wiring and startup procedures for an 8504 amplifier operating in Controlled-Voltage mode (factory default). Before connecting the amplifier inputs and outputs, make sure the AC power cord is unplugged.

Testing Before Controlled-Current Operation

IMPORTANT: If your application requires Controlled Current operation, the 8504 amplifier first should be wired and tested in Controlled-Voltage mode to verify that the amplifier and input signal



Figure 3.1 – 8504 Back Panel

are operating correctly. Once proper operation is confirmed, refer to the **Applications** section of this manual for instructions on configuring and operating your amplifier in Controlled-Current mode.

3.1 Connecting the Load

3.1.1 Preparation and Cautions

Before connecting the amplifier, make sure the AC power is disconnected.

Always use the appropriate wire size and insulation for the maximum current and voltage expected at the output. Never connect the output of the amplifier to any other model amplifier, power supply, signal source, or other inappropriate load; fire can result.

3.1.2 Output Connections

Connection to the output of the amplifier is to a pair of high-current output terminals. Wires terminated with 3/8-inch ring terminals are recommended when connecting to the output terminals. Connect the load across the terminals marked “OUTPUT” (positive) and “GND” (ground). The GND terminal also can be connected to an external ground point such as the rack chassis, if desired. See **Figure 3.2**.

3.2 Connecting the Input Signal

Both an unbalanced Input BNC jack and a balanced Input “WECO” terminal block connector are provided on the amplifier back panel for signal input. Connect your input signal source to the unbalanced or balanced input connector as shown in **Figure 3.3**. Use cables that are high quality and shielded to minimize noise and to guard against possible feedback.

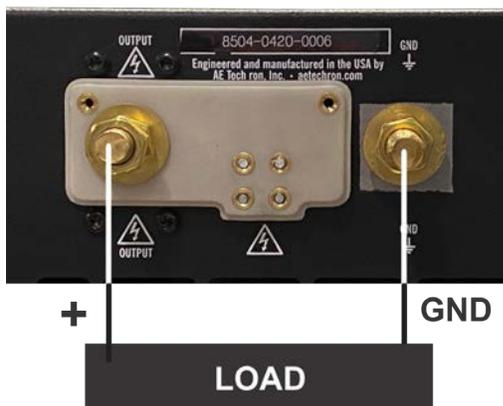


Figure 3.2 – Connecting the Load

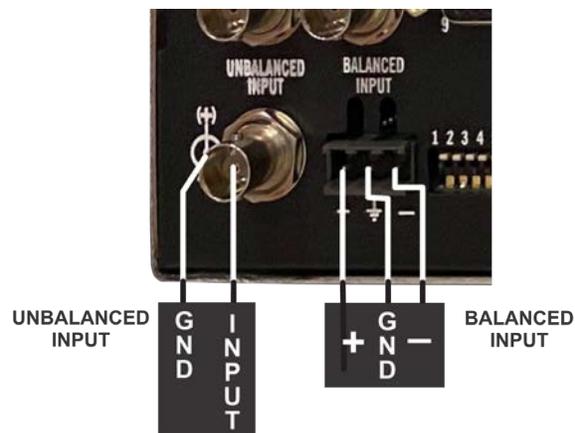


Figure 3.3 – Wiring for Unbalanced or Balanced Input Connector

The back-panel DIP switch #1 can be used to enable/disable the unbalanced input connector, and DIP switch #2 can be used to enable/disable the balanced input connector.

When these two DIP switches are placed in the UP position (factory default), the input connectors are enabled. When the DIP switches are placed in the DOWN position, the input connectors are disabled. See **Figure 3.4** for DIP switch locations.

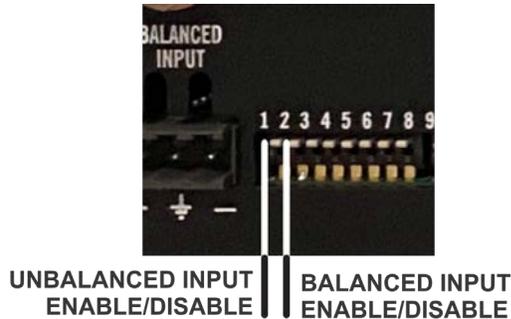


Figure 3.4 – DIP Switch Locations for Input Connector Enable/Disable

3.3 Other DIP Switch Settings

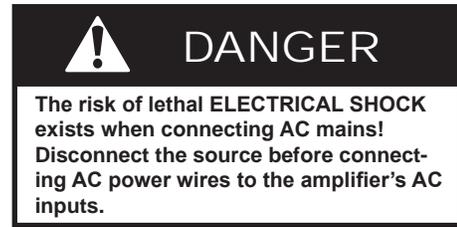
Other DIP switches can be used to enable features or configure the amplifier for special applications. See the **Advanced Configuration** section of this manual for more information. Before operating the amplifier, check to make sure all DIP switches are set as intended. The factory default setting for all DIP switches is the UP position.

3.4 Monitor and Sense Ports

The amplifier provides five additional back-panel ports:

- Current Monitor (BNC connector)
- Voltage Monitor (BNC connector)
- Multi-amp Connectors (9-pin dSub connectors, two total)
- Remote Sense Port (2-pin terminal block connector).

See the **Applications** section of this manual for information on using these ports



3.5 Connecting the AC Supply

Always operate the amplifier from the proper AC mains. The 8504 amplifier requires single-phase, 50-60 Hz, 230/240 VAC with no more than 10% variance above or below the line voltage. The amplifier will not operate properly outside these limits.

Connect the AC supply to the three-terminal barrier strip located on the amplifier back panel (see **Figure 3.5**).

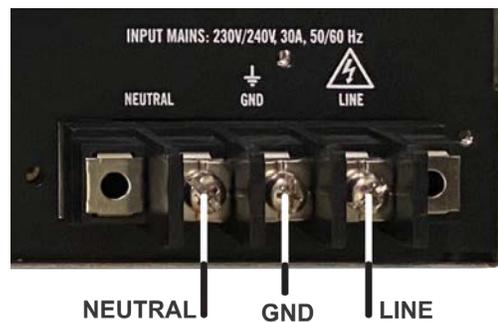


Figure 3.5 – Closeup of AC Mains Barrier Strip

3.6 Start-up Procedure

1. Turn down the level of your signal source.
2. Place the back-panel breaker switch in the ON position.
3. Press the front-panel POWER switch to turn the amplifier ON.
4. Wait until the Run/Standby indicator turns solid green.
5. Adjust your input signal level to achieve the desired output level.

4 Amplifier Operation

4.1 Front-Panel Controls and Indicators

This section provides an overview of Front-Panel controls and indicators found on the 8504. Refer to **Figure 4.1** for component locations.

4.1.1 Power Switch

The Power switch controls the power to the amplifier's high-voltage transformers. Switch to the ON position (I) to energize the amplifier. Switch to the OFF position to remove power from the high-voltage transformers and place the amplifier in Standby mode.

4.1.2 Run/Standby Indicator

Run mode: The indicator will be lit solid green. The amplifier's high-voltage transformers are energized and the unit will amplify the input signal.

Standby mode: The indicator will be lit solid amber. The amplifier will be placed in Standby when one of the following conditions occurs:

1. High/Low Line error
2. Overtemp condition
3. Fault condition
4. The user presses the front-panel power switch to the OFF (O) position.

In Standby mode, the amplifier's low-voltage transformer is energized but the high-voltage transformers are not.

To release the amplifier from Standby mode:

1. **High/Low Line error:** Clear the over- or under-voltage condition. The amplifier will resume operation when the input voltage is brought within the operating range of the amplifier.
2. **Overtemp condition:** Leave the amplifier in Standby mode with the fans operating to cool the amplifier. When the amplifier's internal temperature drops to less than 100°C, the amplifier will resume operation.
3. **Fault condition:** Press the front-panel power switch to reset the amplifier. If the fault condition recurs or does not clear, the amplifier may require servicing. See the **Troubleshooting** section for more information.
4. **Power switch pressed:** When the amplifier is operating (Run mode), pressing the front-panel power switch will place the amplifier in Standby mode. Press the power switch again to release the amplifier from Standby and return the amplifier to Run mode.

4.1.3 Signal/Overload Indicator

Signal Presence: When an input signal is presented at an active signal input on the amplifier at a level greater than 0.5V, the Signal/Overload indicator will light solid green.

Overload (clipping): The indicator will flash amber intermittently. When the indicator flashes amber, this indicates that the output of the system

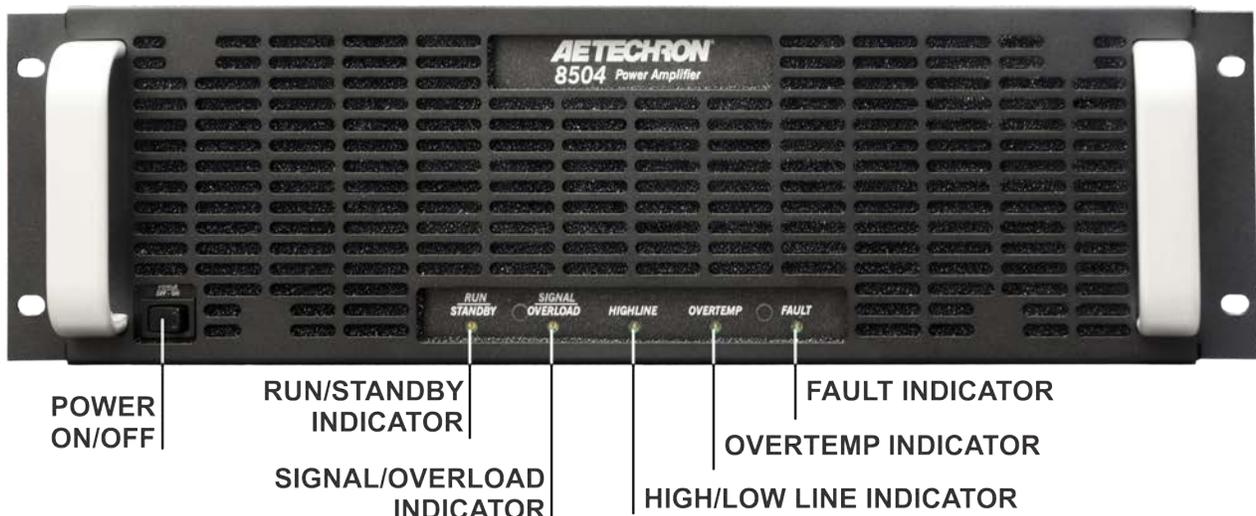


Figure 4.1 – Front Panel Controls and Indicators

could not follow the input signal due to voltage or current limits. The amber Overload indicator will begin flashing when distortion is greater than 0.1%.

4.1.4 High/Low Line Indicator

This amber indicator will illuminate and the amplifier will be placed in Standby if the detected AC mains voltage is outside of the operable range of the amplifier ($\pm 10\%$).

To remove the amplifier from Standby, the AC mains must be brought to within the optimal range. Once the fault condition has been cleared, the amplifier will return automatically to Run mode. If the High/Low Line indicator does not turn off or if the amplifier does not return from Standby, the amplifier may require servicing. See the **Troubleshooting** section for more information.

4.1.5 Overtemp Indicator

The amplifier monitors the temperature inside the high-voltage transformers and in the output stage heat sinks. The amber Overtemp indicator will light and the amplifier will be placed in Standby mode when the temperature sensors detect a condition that would damage the amplifier. If the Overtemp pulse is extremely short, as in the case of defective wiring or switches, this indicator may be lit too briefly to observe.

To remove the amplifier from Standby and return it to normal operation after an Overtemp fault has occurred, make sure the amplifier fans are running and then remove the input signal from the amplifier. Allow the fans to run until the amplifier automatically returns to Run mode. See the **Troubleshooting** section for information on identifying and correcting the cause of an Overtemp fault condition.

4.1.6 Fault Indicator

The red Fault indicator will light and the amplifier will be placed in Standby under two conditions:

1. High frequency oscillation is causing high shoot-through current.
2. An output transistor has shorted, causing the output fault condition.

Cycle the front-panel power switch (off, then on) to reset the amplifier. If the fault condition recurs or does not clear, the amplifier may require servicing. See the **Troubleshooting** section for more information.

4.2 Back-Panel Controls & Connectors

This section provides an overview of Back-Panel controls and connectors found on the 8504. Please refer to **Figure 4.2** for component locations.

AC Power Input – Three-terminal barrier strip connector.

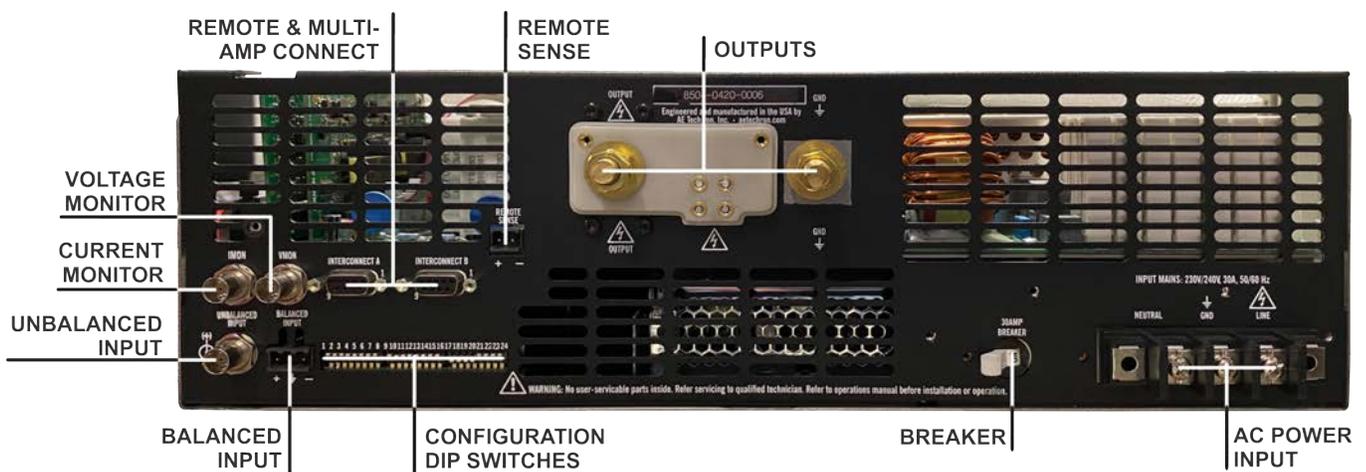


Figure 4.2 – Back Panel Controls and Connectors

Output Terminals – Connect output lines from the load to this pair of high-current output terminals using 3/8-inch ring terminals.

Unbalanced BNC Input Connector – This input option provides a standard unbalanced input.

Balanced WECO Input Connector – This input option provides a balanced input.

DIP Switches – This bank of 24 DIP switches provides various functions and allows the amplifier to be configured for special applications. See the **“Advanced Configuration”** section for more information.

Current Monitor Connector – This unbalanced BNC port allows for connection to current monitoring equipment. The current monitor output is 1V = 20A.

Voltage Monitor Connector – This unbalanced BNC port allows for connection to voltage monitor-

ing equipment. The voltage monitor output is 1V = 40V.

Multi-amp Connectors – These two 9-pin D-sub connectors, labeled Interconnect A and Interconnect B, can be used to connect two or more 8504 amplifiers in a parallel configuration. They can also be used to set up a Safety Interlock circuit to automatically place the amplifier in Standby mode when tripped. See the **“Applications”** section for more information.

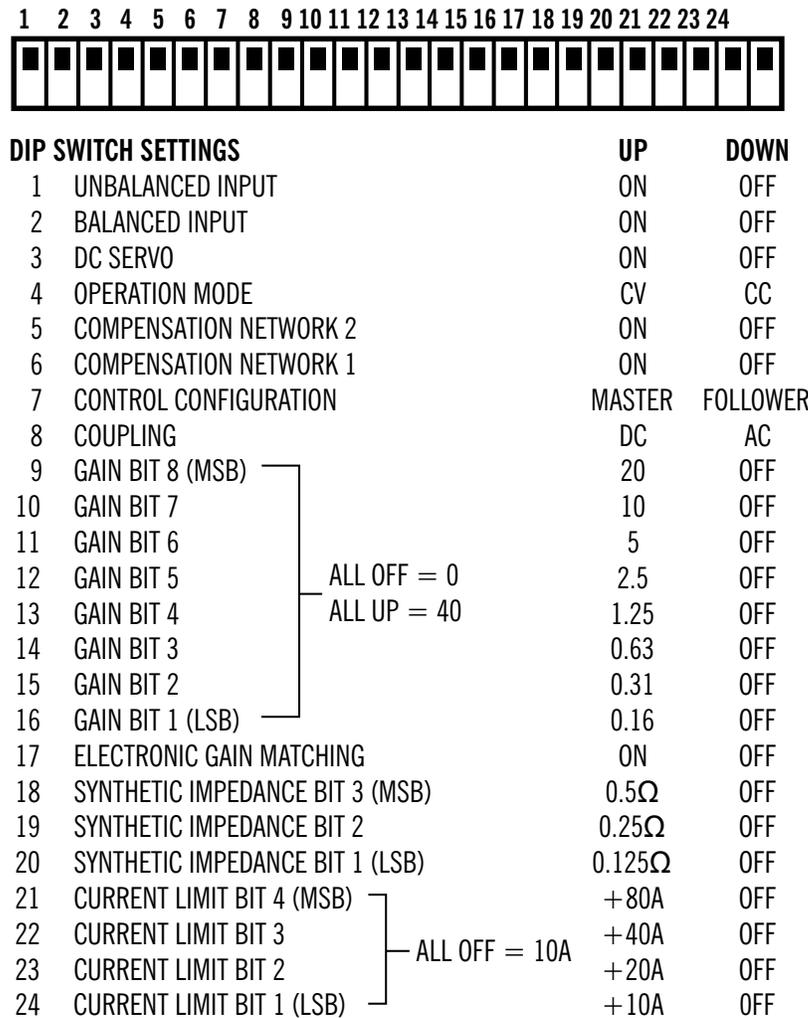
Remote Sense Port – This 2-pin terminal block connector provides a sense line with up to 4V of correction. The Remote Sense port can be useful when the voltage at the load must be precise. If the cables connecting the amplifier and the load are very long or under-sized, the voltage drop between the amplifier and load can be corrected up to 4V.

The benefits of this feature is limited to frequencies below 10kHz

5 Advanced Configuration

The 8504 amplifier was designed to offer exceptional versatility in operation. You can choose from a range of field-configurable options, including:

- Enable the unbalanced or balanced signal input connections, or use both inputs.
- Select DC-coupled or AC-coupled operation.
- Enable DC Servo to ensure DC offset remains at zero and safely drive coils and transformers.
- Select Controlled-Current or Controlled-Voltage modes of operation.
- Enable a custom compensation network for Controlled Current operation.
- Limit current output via programmable current limits.
- Adjust the amplifier gain from 0.16 to 40 in increments of 0.16.
- Configure two or more 8504 amplifiers for operation as a parallel system.
- Enable electronic gain matching to optimize parallel operation of two or more 8504 amplifiers.
- Select and enable a synthetic impedance from 0.125 ohms to 0.875 ohms.



NOTE: ALL BIT SWITCHES ARE ADDITIVE. UP = ON.

Figure 5.1 – DIP Switch Settings and Descriptions

5.1 DIP Switch Configurations

The 8504 amplifier provides 24 DIP switches located on the amplifier back panel. Most configuration settings can be made using these DIP switches. See **Figure 5.1** for DIP switch settings and descriptions.

SW#1: Unbalanced Input

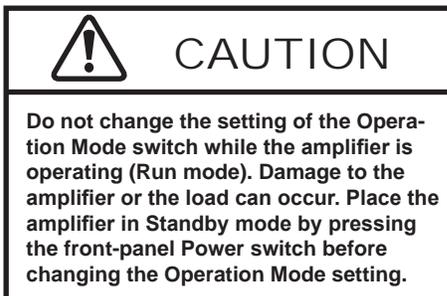
When this switch is in the UP position (default), the unbalanced BNC input connector is enabled and can be used to send an input signal to the amplifier. When this switch is in the DOWN position, this connector is disabled. Note that disabling an unused input connector can help to minimize noise going into the amplifier.

SW#2: Balanced Input

When this switch is in the UP position (default), the balanced WECO input connector is enabled and can be used to send an input signal to the amplifier. When this switch is in the DOWN position, this connector is disabled. Note that disabling an unused input connector can help to minimize noise going into the amplifier.

SW#3: DC Servo

The DC Servo function ensures that no DC offset is present at the signal output (-3 dB at 3 Hz). Select DC Servo when driving transformers or other coils. When the DC Servo DIP switch is in the UP position (default), the DC Servo function is enabled. When this switch is in the DOWN position, the DC Servo function is disabled.



SW#4: Operation Mode

When the Operation Mode DIP switch is in the UP position (default), the amplifier will operate in Controlled-Voltage mode, and the amplifier's output voltage will be controlled by its input voltage

CAUTION

In Controlled-Current Mode, the load is part of the amplifier circuit, and the relationship of the load to the amplifier is critical. For proper and safe operation in Controlled-Current mode, you must observe the following guidelines:

1. **Properly attach a load before operating the amplifier.**
2. **Make sure a compensation network is enabled.** Set switch #6 ON unless you are using a custom compensation network.
3. **DO NOT use a blocking capacitor.** The load must have a DC path.
4. **Never leave the load open.** If you feel the load must be fused, which could lead to a potential open circuit, please contact AE Techron Application Engineering department.
5. **Check to make sure the load has some inductive component.**
6. **Provide appropriate Compensation for the load.**
7. **Turn off the amplifier immediately if oscillation occurs.**

Failure to follow these guidelines may result in **damage to the amplifier or load.**

signal. When this switch is in the DOWN position, the amplifier will operate in Controlled-Current mode, and the amplifier's output current will be controlled by its input voltage signal.

IMPORTANT: Controlled-Current operation requires the use of a compensation network, and the 8504's default compensation network may not be suitable for your application. For more information on Controlled-Current operation, including how to determine and configure a custom compensation network, see the **Applications** section.

SW#5: Compensation Network 2

When the 8504 amplifier is used in Controlled-Current mode, the current control loop is tuned with an RC network. The factory default network (Compensation Network 1) provides 75k ohm resistance and 47 nF capacitance. If this default network is not adequate for your application and load, The Compensation Network 2 switch can be used to enable a custom RC network that can be installed by the user.

NOTE: Enable ONLY Compensation Network 2 (SW#5) or Compensation Network 1 (SW#6). Both compensation networks should NOT be enabled simultaneously.

For more information on Controlled-Current operation and installing a custom RC network, see the “**Applications**” section of this manual.

SW#6: Compensation Network 1

When the 8504 amplifier is used in Controlled-Current mode, the current control loop is tuned with an RC network. The Compensation Network 1 switch enables the factory default RC network. This provides 75k ohm resistance and 47 nF capacitance. If this default network is not adequate for your application and load, The Compensation Network 1 switch can be turned off and the Compensation Network 2 switch can be used to enable a custom RC network that can be installed by the user.

NOTE: Enable ONLY Compensation Network 2 (SW#5) or Compensation Network 1 (SW#6). Both compensation networks should NOT be enabled simultaneously.

For more information on Controlled-Current operation and installing a custom RC network, see the “**Applications**” section of this manual.

SW#7: Control Configuration

When this switch is in the UP position (default), the amplifier will function as a stand-alone amplifier or as a Master amplifier in a multi-amp system. When this switch is in the DOWN position, the amplifier will function as a Follower amplifier in a Parallel multi-amp system.

For more information on multi-amplifier system configuration and operation, see the **Applications** section.

SW#8: Coupling

When the Coupling DIP switch is in the UP position (default), the amplifier can receive and amplify both DC and AC signal. When this switch is in the DOWN position, a 30-Hz high-pass filter on the inputs prevents the transmission of DC signal.

SW#9 – SW#16: Gain

The amplifier gain can be adjusted from 0.16 to 40 in increments of 0.16 using switches 9 through 16.

All switches are additive and provide the following values toward the total Gain amount.

- SW#9 = 20.00 SW#13 = 1.25
- SW#10 = 10.00 SW#14 = 0.63
- SW#11 = 5.00 SW#15 = 0.31
- SW#12 = 2.50 SW#16 = 0.16

Refer to the chart in **Appendix A** to quickly determine the switch settings for your desired amplifier gain.

SW#17: Electronic Gain Matching

The Electronic Gain Matching function serves to minimize circulating currents when multiple amplifiers are used in a parallel configuration. When enabled, the Electronic Gain Matching function progressively increases impedance from the voltage gain as current increases, up to a maximum 0.20-ohm increase. This allows the amplifiers to operate in parallel without the use of separate ballast resistors. For more information on multi-amplifier system configuration and operation, see the **Applications** section.

When the Electronic Gain Matching DIP switch is in the DOWN position (default), the function is disabled. When this switch is in the UP position, Gain Matching is enabled.

SW#18 - SW#20: Synthetic Impedance

These three switches allow the addition of a synthetic impedance on the output of the ampli-

ON = DIP Switch UP OFF = DIP Switch DOWN			
SW#18	SW#19	SW#20	Synthetic Impedance
ON	ON	ON	0.875Ω
ON	ON	OFF	0.750Ω
ON	OFF	ON	0.625Ω
ON	OFF	OFF	0.500Ω
OFF	ON	ON	0.375Ω
OFF	ON	OFF	0.250Ω
OFF	OFF	ON	0.125Ω
OFF	OFF	OFF	0.00Ω

Figure 5.2 – Synthetic Impedance Switch Configurations

ON = DIP Switch UP OFF = DIP Switch DOWN				
SW#21	SW#22	SW#23	SW#24	Current Limit
ON	ON	ON	ON	160A
ON	ON	ON	OFF	150A
ON	ON	OFF	ON	140A
ON	ON	OFF	OFF	130A
ON	OFF	ON	ON	120A
ON	OFF	ON	OFF	110A
ON	OFF	OFF	ON	100A
ON	OFF	OFF	OFF	90A
OFF	ON	ON	ON	80A
OFF	ON	ON	OFF	70A
OFF	ON	OFF	ON	60A
OFF	ON	OFF	OFF	50A
OFF	OFF	ON	ON	40A
OFF	OFF	ON	OFF	30A
OFF	OFF	OFF	ON	20A
OFF	OFF	OFF	OFF	10A

Figure 5.3 – Current Limit Switch Configurations

fier. Synthetic Impedance can be used to increase stability when driving capacitive loads. It can also be used in testing where the effect of long power lines needs to be simulated (such as for power utility applications).

When all four switches are in the DOWN position, Synthetic Impedance is disabled. The synthetic impedance can be added in increments of 0.125 ohms by setting one or more of the synthetic impedance switches in the UP position. Refer to **Figure 5.2** for all available synthetic impedance switch settings.

SW#21 - #24: Current Limit

These four switches control the current-limit settings for the amplifier. When all four switches are in the UP position (default), the amplifier's output current is limited to 160A. The current-limit can be lowered in 10A increments by setting one or more of the current limit switches in the DOWN position. Refer to **Figure 5.3** for all available current-limit switch settings.

NOTE: If all four current-limit DIP switches are set

in the DOWN position, the amplifier's output current will be limited to 10A.

5.2 Internal Configuration

The 8504 amplifier contains a circuit board with circuitry that can be used to install and enable a custom compensation network for use in Controlled-Current operation. A custom network may be required if the default compensation network (enabled by placing DIP switch #6 in the UP position) does not provide adequate compensation for your application.

DANGER

Uninsulated terminals with AC mains potential are exposed when the top cover is removed. Do not proceed until the amplifier has been turned off and the AC Mains has been disconnected.

CAUTION

After turning the amplifier off, let the unit sit for 3-5 minutes before removing the top cover. This will allow the electrical charge in the power supply capacitors to discharge.

CAUTION

ESD and Safety Precautions
Electronic equipment is susceptible to damage by static electricity. Use a grounded antistatic wriststrap, foot-strap, or equivalent safety equipment to prevent ESD when you install a custom compensation network.

Caution - System damage possible – Take the following ESD precautions to protect electronic components from electrostatic damage, which can permanently disable the system or require repair by service technicians.

Place the component on an antistatic surface, such as an antistatic discharge mat, an antistatic bag, or a disposable antistatic mat.

Wear an antistatic grounding strap connected to a metal surface on the chassis when you work on system components.

Failure to follow these guidelines may result in **damage to the amplifier**

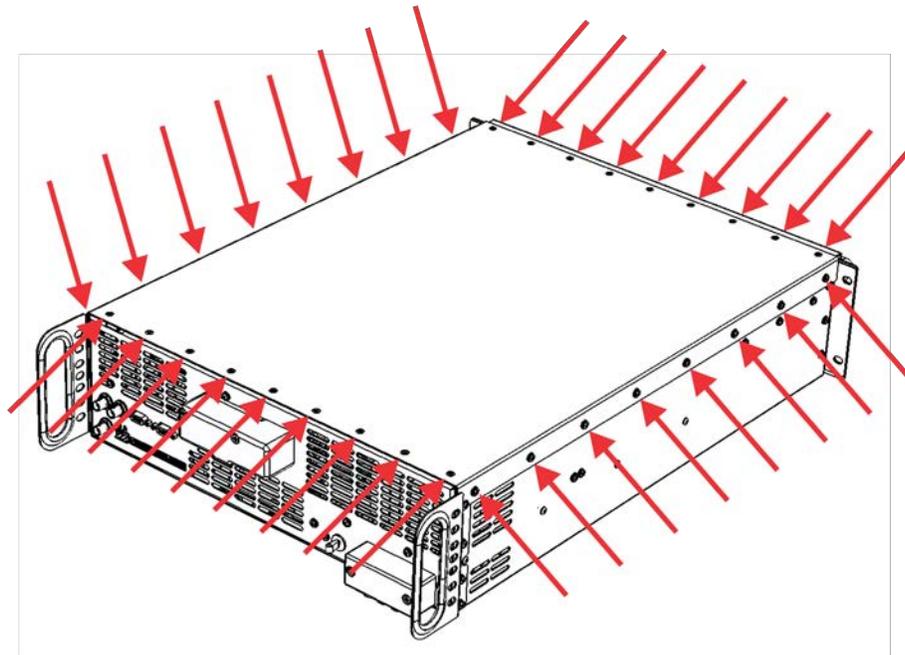


Figure 5.4 – Removing the amplifier top cover

To install a custom compensation network, the amplifier top cover must be removed and the front-end board must be removed from the amplifier. Complete the following steps to install a custom compensation network.

Tool Required

#2 Phillips screwdriver

Procedure

1. Remove power from the amplifier and disconnect any load from the amplifier outputs. Wait a minimum of three minutes to allow the amplifier's capacitors to discharge.
2. Use the #2 Phillips screwdriver to remove the 34 screws securing the top cover, as shown in **Figure 5.4**.
3. Lift the cover straight up to remove and set aside.
4. Locate the screw just above the voltage and current monitor BNC connectors on the amplifier back panel. Use the Phillips screwdriver to remove the screw. See **Figure 5.5**.
5. Locate the front-end board inside the amplifier chassis, as show in **Figure 5.6**. Gently rock the board back and forth in the board socket while pulling up on the board to release the board from the socket.

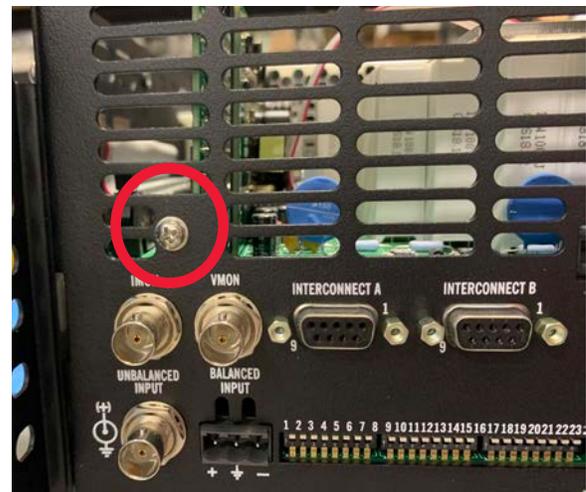


Figure 5.5 – Front-end board screw location



Figure 5.6 – Front-end board location



Figure 5.7 – Location of Installation Area for Compensation Network 2

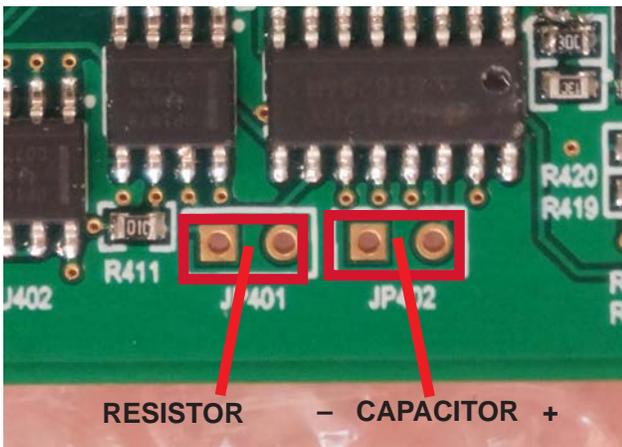


Figure 5.8 – Compensation Network 2 component locations on front end board



Figure 5.9 – Connectors location for front-end board replacement

6. Locate the installation area for the custom compensation network (see **Figure 5.7**). Install the resistor and capacitor in the areas shown in **Figure 5.8**. Note: For instructions for selecting the best RC components for your network, see the topic “Controlled Current Operation” in the **Applications** section of this manual.
7. Replace the front-end board in the connectors by positioning the board above the connectors and making sure the front-end board and the adjacent board are both vertical. Press gently but firmly down on the front-end board until it is completely seated in the connectors. See **Figure 5.9** for connectors location.
8. Replace the screw securing the front-end board to the back panel. Make sure the screw hole in the back panel lines up with the screw hole in the front-end board, then hold the board to secure it in the vertical position while you tighten the screw into place. Do not over-tighten.
9. To replace the top cover, place the cover on the amplifier and replace the 34 screws. First screw in all screws loosely, then tighten all screws until secure (torque to 12-14 lbs/in).

6 Applications

6.1 Parallel Multi-amp Systems for Increased Current

The 8504 amplifier may be used with other 8504 amplifiers to increase current by creating a paralleled multi-amp system.

Up to five 8504 amplifiers may be configured in parallel; each 8504 amplifier added in parallel will increase the continuous current output. See **Figure 6.1** for the approximate output levels you can expect from each multi-amp system.

While it is possible to operate a multi-amp system in either Controlled Voltage or Controlled Current modes of operation, multi-amp operation in Controlled Current mode requires additional configuration of the equipment. Please contact **AE Techron Tech Support** for assistance with configuring a multi-amp system for Controlled Current operation.

For routine, Controlled-Voltage applications, Parallel amplifier systems can be configured using standard 8504 amplifiers and the following accessory available from AE Techron:

8500 series Multi-amp Cable

Please contact AE Techron's **Sales Department** for more information.

6.1.1 Multiamp Safety Principles

Following these basic principles will help to ensure the safety of your equipment and personnel.

One Master Amplifier

Multi-amp configurations require one amplifier configured as a Master amplifier, and all other amplifiers in the system configured as Follower amplifiers.

Use Only 8504 Amplifiers

Use only AE Techron 8504 amplifiers to construct a 8504 multiamp system. Do not combine different models of AE Techron amplifiers in the same system or use amplifiers made by another manufacturer in a 8504 multiamp system. Such improper

CONFIGURATION	CONTINUOUS OUTPUT (100% Duty Cycle)
Two in Parallel	200 Ap
Three in Parallel	300 Ap
Four in Parallel	400 Ap
Five in Parallel	500 Ap

Figure 6.1 – Typical Output Levels for 8504 Multiamp Systems

connections could damage the amplifiers.

Use Proper Output Wiring

IMPORTANT: In a paralleled system, it is important to control the lengths of output cables. Output cables should be between 2.5 and 4.0 feet in length, and the lengths of each leg of the output cables should match within $\pm 1/4$ -inch. Refer to **Figure 6.2** for information on critical cable lengths for paralleled systems.

Select wire appropriate for your application, load and expected output. Parallel systems with a high-impedance load running high-current, continuous-duty applications may require 1/0 AWG or more. Please refer to an AWG wire sizes chart or the equivalent to determine the appropriate wire for your application.

Never directly connect one amplifier's OUTPUT terminal to another amplifier's OUTPUT terminal, unless the Electronic Gain Matching option has been selected (see the **Advanced Configuration** section of this manual for more information). The resulting circulating currents will waste power and may damage the amplifiers. The OUTPUT terminal of one amplifier should only be directly connected to the load.

Operate with Safety in Mind

Potentially lethal voltages and currents are present within the 8504 amplifiers. While the amplifiers' chassis are earth-grounded, **all internal grounds are floating.**

6.1.2 Multi-amp Configuration

To configure and connect two or more amplifiers for operation in a parallel configuration, begin by

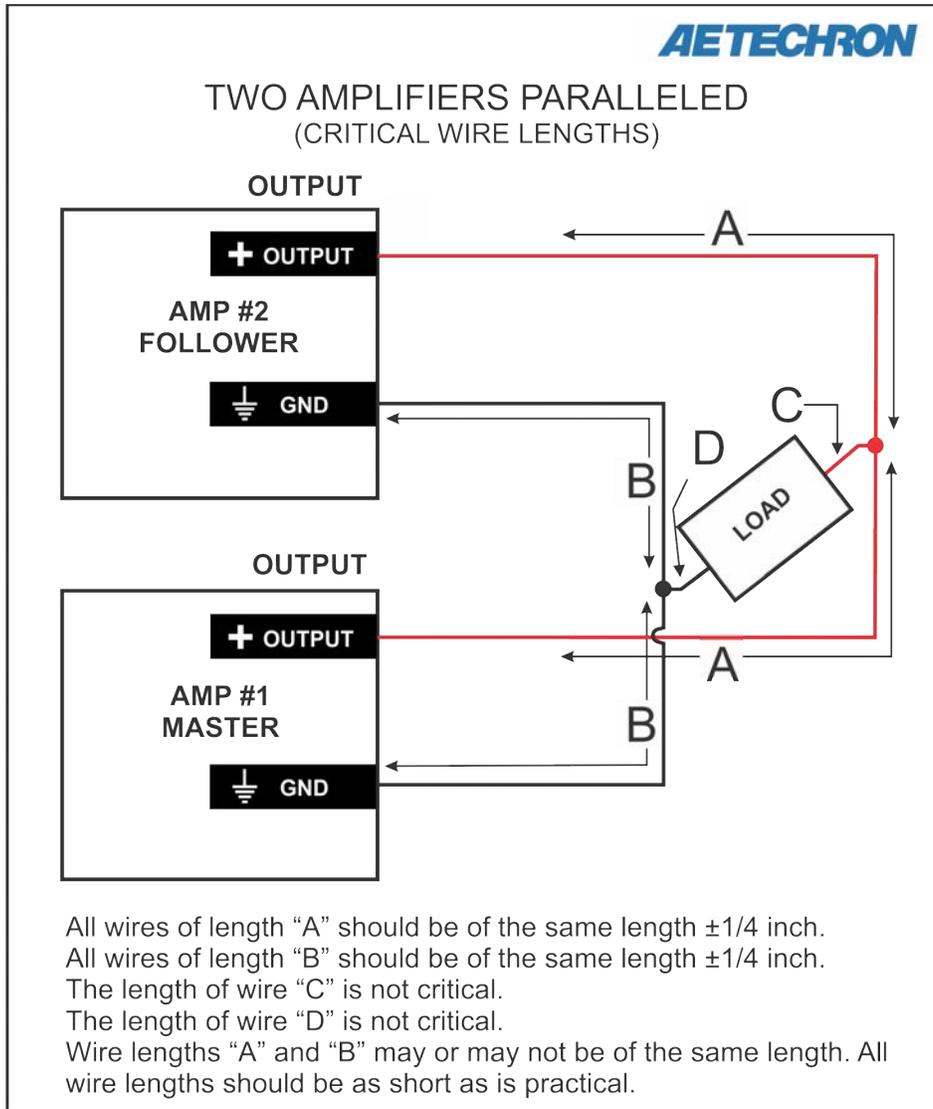


Figure 6.2 – Critical Wire Lengths in Parallel Systems



WARNING

ELECTRIC SHOCK HAZARD.
 Output potentials can be lethal. Make connections only with AC Power OFF and input signals removed.

designating one amplifier as the Master amplifier, and all of the other amplifiers as Follower amplifiers. Consider placing a "Master" or "Follower" label on each amplifier's back panel to clarify the amplifier designation during setup and operation.

Make sure all amplifiers are disconnected from AC power.

DIP Switch Settings

On each amplifier designated as Follower, **set DIP switch #7 in the DOWN (Follower) position.**

On all amplifiers, **set DIP switch #17 in the UP (Electronic Gain Matching ON) position**

Amplifier Wiring

Refer to **Figure 6.3** and make the following connections to the Master and Follower amplifiers.

1. Connect the 9-pin D-sub cable (8500 series Multi-amp Cable,) from the back-panel Interconnect B port on the Master amplifier to the Interconnect A port on the first Follower amplifier.

2. Connect another 9-pin D-sub cable from the Interconnect B port on the first Follower amplifier to the Interconnect A port on the second Follower amplifier.
3. Continue to connect from the Interconnect B port of each additional Follower amplifier to the Interconnect A port of the next Follower amplifier until all amplifiers for the system have been connected.
4. Connect from a signal generator to the BNC signal input connector on the Master amplifier's back panel.
5. Build your output cables:
 - A. Build two cables for output wiring. Each cable should contain one leg for each amplifier in your system. Color-code the

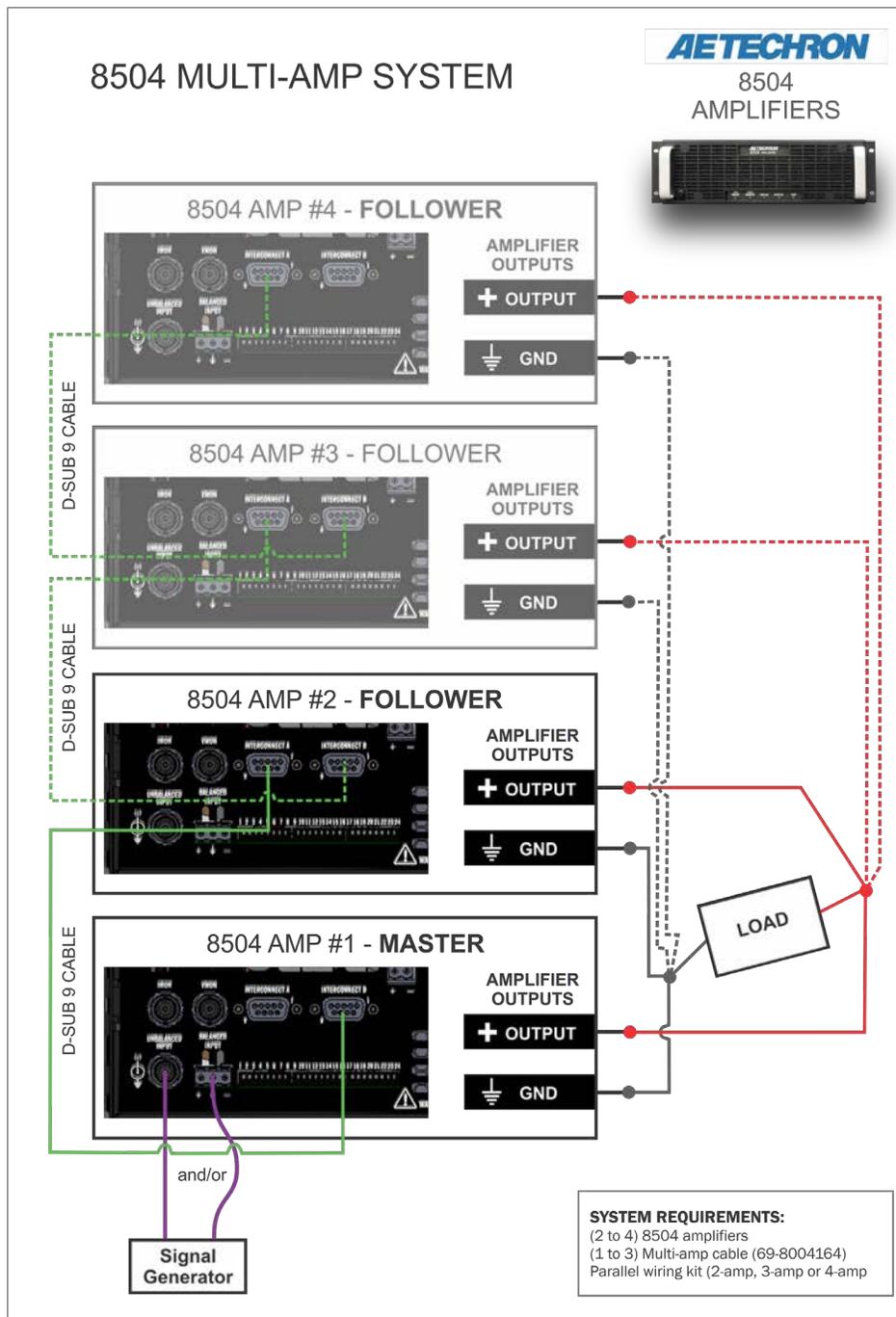


Figure 6.3 – Multi-amp System Configuration (Parallel System)

cables using RED for the cable to connect to the positive terminal of the load; use BLACK for the cable to connect to the ground terminal of the load.

- B. The wires should be terminated at one end into a spade lug, ring terminal or other terminal suitable for the system output and adaptable to the connectors on the load.
 - C. Terminate each of the legs of the cable with 3/8-inch ring terminal ends to facilitate connection to each amplifier's output connectors.
4. Connect one cable leg of the black (ground) output cable to each of the amplifier's back-panel GND connectors, and then connect the cable's terminated end to the ground terminal of your load. Next, connect one cable leg of the red (positive) output cable to each of the amplifier's back-panel OUTPUT connectors, and then connect the cable's terminated end to the positive terminal of your load.

6.1.3 Multiamp System Start-up Procedure

1. Turn down the level of your signal source.
2. Press the POWER switches on both the Master and the Follower amplifiers to turn the power ON. Powering on the Master amplifier first is recommended, although not absolutely required.
3. Wait for the green RUN LEDs to illuminate on both amplifiers.
4. Adjust the input signal level to achieve the desired output level.

6.1.4 Multiamp System Operation

In multiamp systems, the Master amplifier controls several operating functions for all amplifiers included in the system, so Follower amplifiers are said to be "interlocked" with the Master amplifier. The functions controlled by the Master amplifier include input signal, operating status, mode of operation (controlled-voltage or controlled-current operation) and amplifier compensation.

Because the amplifiers in a multiamp system are interlocked, the main and fault status indicators of

all amplifiers in the system must be considered to determine the current status and the necessary remedies to return the system to operational status when a fault condition occurs.

Run/Standby Indicators

When each amplifier in a multi-amp system is powered on, the amplifier will be placed in Standby mode (Run/Standby LED solid amber) and remain in Standby mode until all amplifiers in the system have been powered on. The system will automatically proceed to Run mode when all amplifiers in the system are powered on and achieve Standby mode.

Switching the Power switch on any amplifier in the system to the OFF position will place all the amplifiers in the system in Standby mode.

Signal/Overload Indicators

When an input signal is presented to the Master amplifier at a level greater than 0.5V, the Signal/Overload indicators on all of the amplifiers in the system will light solid green. When signal distortion greater than 0.1% is sensed by the Master amplifier, the Signal/Overload indicators on all of the amplifiers in the system will flash amber.

Fault Status Indicators

The three Fault Status indicators located on each amplifier's front panel are used to monitor the internal conditions of the amplifier and will illuminate when a fault condition occurs. All amplifiers in the system will be placed in Standby mode when a fault condition occurs.

Over/Under Line: This fault condition will occur when the detected AC mains voltage is outside of the operable range of the amplifier ($\pm 10\%$).

To remove the system from Standby, the AC mains must be brought to within the optimal range. Once the fault condition has been cleared, all amplifiers in the system will return automatically to Run mode. If the High/Low Line indicator does not turn off or if the system does not return from Standby, one or more amplifiers may require servicing. See the **Troubleshooting** section for more information.

Overtemp: Each amplifier in the system monitors the temperature inside its high-voltage transformers and in the output stage heat sinks. The amber Overtemp indicator will light and the system will be placed in Standby mode when the temperature sensors in any amplifier detect a condition that would damage the amplifier. If the Overtemp pulse is extremely short, as in the case of defective wiring or switches, this indicator may be lit too briefly to observe.

To remove the system from Standby, make sure the fans in all of the amplifiers are running and then remove the input signal from the system. Allow the fans to run until the system automatically returns to Run mode. See the **Troubleshooting** section for information on identifying and correcting the cause of an Overtemp fault condition.

Fault: If the red Fault indicator lights on one or more amplifiers in the system, the system will be placed in Standby. An amplifier may report a Fault status under two conditions:

1. High frequency oscillation is causing high shoot-through current.
2. An output transistor has shorted, causing the output fault condition.

Cycle the front-panel power switch (off, then on) on the amplifier(s) reporting the Fault condition to reset each amplifier. When all amplifiers reporting a fault have been reset, cycle the power switches on any other amplifiers in the system to return the system to Run mode.

On any amplifier in the system, if the fault condition recurs or does not clear, the amplifier may require servicing. See the **Troubleshooting** section for more information. Repair or replace the faulty amplifier to re-enable the system.

6.1.5 Multi-amp Accessories

9-pin D-sub Multi-amp Cables

The 8500 series multi-amp cable is available from AE Techron. For installation instructions, refer to the topic “Multiamp Systems for Increased Current.”

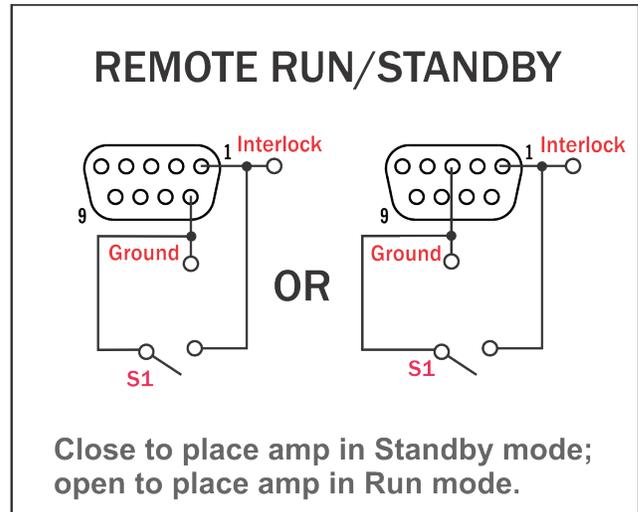


Figure 6.4 – Using the Interlock A or Interlock B connector to wire a safety interlock switch

6.2 Safety Interlock

The two 9-pin D-Sub connectors on the amplifier back panel (Interlock A and Interlock B) can be used to remotely place the amplifier in Standby mode. This can provide a valuable safety feature, such as in creating a safety interlock for a cabinet in which one or more 8504 amplifiers are installed.

To use this function, wire a switch using Pin1 (Interlock) and either Pin 3 or Pin 6 (Ground), as shown in Figure 6.4. Note that either the Interlock A connector or the Interlock B connector can be used.

In multi-amp systems, the unused Interlock A connector on the Master amplifier or the unused Interlock B connector on the last Follower amplifier can be used to wire the safety interlock.

6.3 Controlled-Voltage vs. Controlled-Current Modes of Operation

AE Techron 8504 amplifiers can be field-configured to operate as **Voltage Amplifiers** (Voltage-Controlled Voltage Source) or as **Transconductance Amplifiers** (Voltage-Controlled Current Source). The mode selection is made via the back-panel DIP switch #4. See the **Advanced Configuration** section for more information.

When configured as a **Controlled-Voltage** source (voltage amplifier), the amplifier will provide an output voltage that is constant and proportional to the control (input) voltage. If the load's impedance changes, the amplifier will seek to maintain this ratio of input to output voltage by increasing or decreasing the current it produces, as long as it is within the amplifier's ability to create the required current. Use this mode if you want the output voltage waveform to be like the input waveform (see **Figure 6.5**).

Conversely, when configured as a **Controlled-Current** source (transconductance amplifier), the amplifier will provide an output current that is constant and proportional to the control (input) voltage. If the load's impedance changes, the amplifier will seek to maintain this transconductance (ratio of input voltage to output current) by increasing or decreasing the voltage it produces, as long as it is within the amplifier's ability to create the required voltage. Use this mode if you want the output current waveform to be like the input waveform (see **Figure 6.6**).

6.3.1 Safety and Operation Considerations for Controlled Current Operation

When an AE Techron amplifier is configured as a Controlled-Current source, care needs to be exercised in its operation. **Any voltage controlled current source should never be turned on without a load, (with some impedance, real or effective) connected to its output terminals.** When asked to operate in this way, any current source (including an AE Techron amplifier) will increase its output voltage in an attempt to drive the requested current into the load. In an open-circuit condition, creating current flow will be impossible. The current source will increase its output voltage until it reaches its voltage limit. This is a potentially dangerous condition for both the AE Techron amplifier and for any user who might come in contact with the amplifier output terminals.

Likewise, operation in Controlled Current mode into a load that is completely resistive is **NOT rec-**

CONTROLLED-VOLTAGE MODE

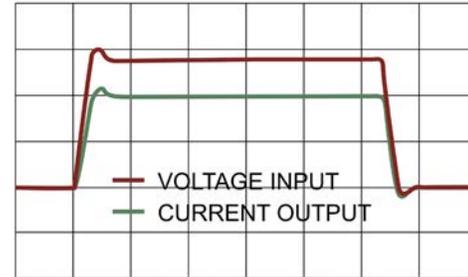


Figure 6.5 – Input to Output Comparison, Controlled-Voltage Operation

CONTROLLED-CURRENT MODE

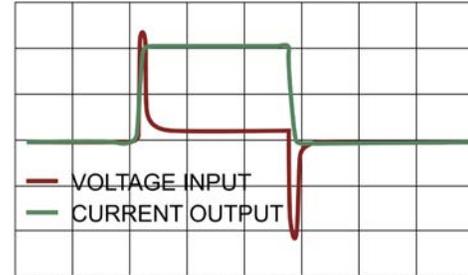


Figure 6.6 – Input to Output Comparison, Controlled-Current Operation

ommended. The load must have some inductance for Controlled Current mode to operate correctly.

When operating in Controlled-Current (CC) mode, a compensation circuit is required to ensure accurate output current. Since the load is a critical circuit component in CC mode, the inductive and resistive values of the load will determine the required compensation values. While the factory-default compensation setting will be sufficient for some applications, the compensation setting may also be adjusted in the field. The following section describes methods for determining and setting proper compensation when operating in Controlled-Current mode.

6.3.2 Controlling Compensation for CC Operation

AE Techron 8504 amplifiers can be configured for either Controlled Voltage (CV) or Controlled Current (CC) mode of operation. When operating the amplifier in Controlled Voltage (CV) mode, com-

compensation is not required. However, when operating in Controlled Current (CC) mode, the amplifier load becomes an integral part of the system. In order to ensure system stability and to control

available bandwidth, compensation via an RC network is required for CC operation. The following steps will allow you to compensate your amplifier for operation in CC mode safely and effectively.

STEP 1: Check Amplifier Operation in CV mode.

We recommend that you power-up and enable the amplifier in Controlled Voltage mode without attaching a load before configuring your amplifier for Controlled Current operation. This will allow you to verify that the input signal and the amplifier are operating correctly.

Once this initial check is completed, power down the amplifier, attach your load, and move the back-

panel Operation Mode DIP switch (SW#4) to the DOWN position to place the amplifier in CC mode. **IMPORTANT:** Before switching to CC mode, check that the Compensation Network 1 is enabled by making sure the back panel DIP switch #6 is in the UP position. (Refer to the **Advanced Configuration** section for more information.)

STEP 2: Determine Required Compensation.

When operating an amplifier in Controlled-Current mode, the load becomes an integral part of the system. In order to determine the required compensation for your load, begin by consulting the following table to determine the approximate

compensation capacitance (C) required based on the inductance of your load. Note that these calculations are based on empirical measurements and are approximent.

	Load Inductance (L)		
	<200 μ H	<>200 μ H – <1 mH	>1 mH
Compensation Capacitance (CC)	0.001 μ F	0.01 μ F	0.1 μ F

NOTE: Load Resistance (R) is assumed to be <5 ohms.

STEP 3: Determine if Default or Custom Compensation is Required.

If your load inductance is between 200 microHenries and 1 milliHenry, and your load resistance is less than 5 ohms, then you can likely use the default compensation provided by the amplifier's factory-installed RC network (see **Figure 6.7**). This compensation network is enabled when the Compensation Network 1 DIP switch (SW#7) is set to the ON (UP) position

If your load inductance falls outside of the mid-range, or if your load resistance is greater than 5 ohms, then you must calculate your required compensation. If, after calculating your required compensation, you determine that the default com-

penensation will be insufficient for your load, then you will need to calculate and then enable and install a custom RC network. See **STEP 5**.

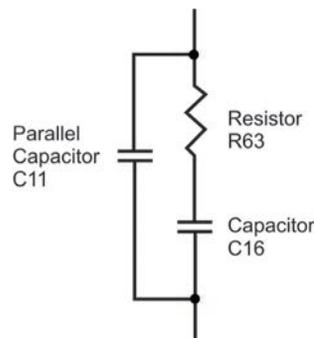


Figure 6.7 – Factory-installed Default RC Network

STEP 4: (Optional) Verify Suitability of Default Compensation (CC1)

If desired, the following values of the components contained in the default RC network can be used with the formulas provided in **STEP 5** to verify the suitability of the default compensation for your

uses.

- Compensation Resistor:** 75k ohms
- Compensation Capacitor:** 47 nF
- Parallel Capacitor:** 100 pF

STEP 5: Calculating Values for an RC Network for Custom Compensation

If the default RC network does not provide suitable compensation for your intended load, you will need to install a custom RC network that is matched to your load. This network will require two components (a resistor (R) and a capacitor (C)) to be installed on the amplifier's front-end board. To calculate the approximate values required for each component, use the following fomulas.

COMPENSATION FORMULAS:

To find the value for the resistor (Rc) in the RC network: $R_c = 20,000 \times 3.14 \times L \times BW$
 where:

- Rc** is compensation resistance in ohms.
- L** is load inductance in henries.
- BW** is bandwidth in hertz.

To find the value for the capacitor (Cc) in the RC network: $C_c = L / (R \times R_c)$

where:

- Cc** is compensation capacitance in farads.
- L** is load inductance in henries.
- R** is resistance of load in ohms.
- Rc** is compensation resistance in ohms.

STEP 6: Installing and Enabling the Custom RC Network

Once an approximate Rc and Cc have been computed, these values will need to be evaluated. To do this, you will need to install the custom components in the amplifier and enable the alternate compenation network (Compensation Network 2).

Refer to the topic "**Internal Configuration**" in the **Advanced Configuration** section of this manual for instructions on accessing the front-end board in the amplifier.

Next, install components with the required values in the front-end board at locations R5 and C2 as shown in Figure 6.8.

Finally, place the Compensation Network 2 DIP switch (SW#5) in the UP (ON) position and place the Compensation Network 1 DIP switch (SW#6) in the DOWN (OFF) position.

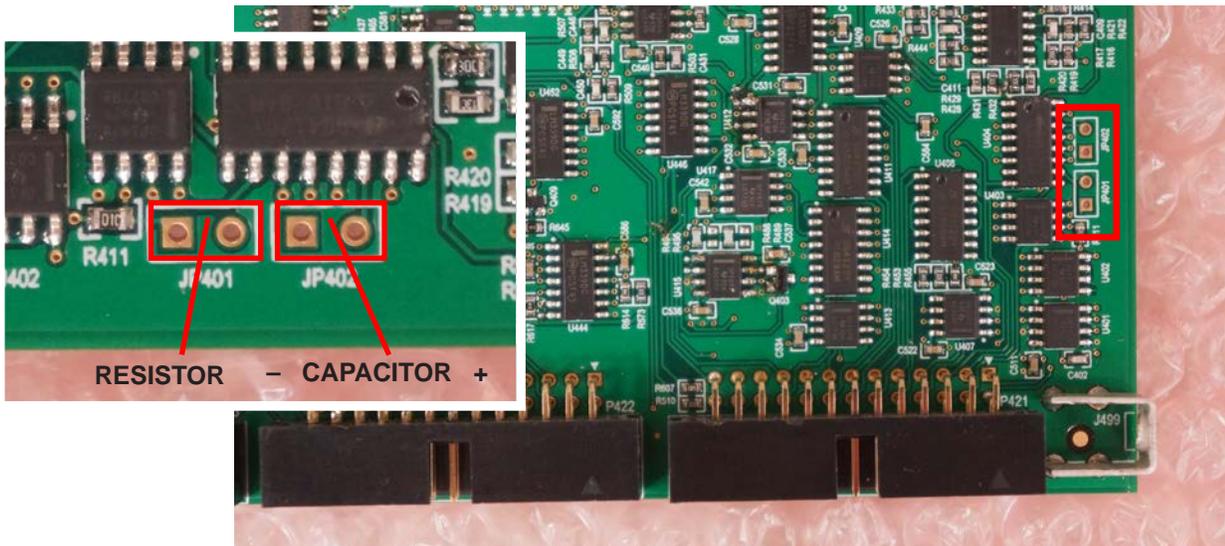


Figure 6.8 – Custom Compensation Component Locations

STEP 7: Optimizing the Compensation Values.

Remember the load you are connecting is a part of the system and the amplifier should not be turned on without the load being connected.

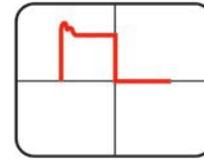
After installing the components, check to ensure that the Operation Mode DIP switch is set to CC (DOWN), then power up the amplifier without signal input.

To begin testing, input a square wave with a frequency of 100 Hz to 1 kHz, or a squared pulse at a low level (typically 0.25 to 2.0 volts). A limited-rise-time, repetitive pulse of low duty cycle is preferred.

Observe the output current through a current monitor or current probe. Look for clean transition edges. The presence of ringing or rounding on the transition edges indicates compensation problems. (See **Figure 6.9.**)

If a change in compensation is necessary, an adjustment to the resistor component of the Compensation circuit is probably required.

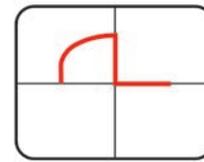
If the output current waveform is ringing, the circuit is underdamped: You have too much compensation and should lower the resistance (see **Figure 6.10.**)



Decrease R

Figure 6.10 – Square Wave Showing a Decrease in R is Required

If the output current waveform is rounded, the circuit is overdamped: You have too little compensation and should increase resistance (see **Figure 6.11.**)



Increase R

Figure 6.11 – Square Wave Showing an Increase in R is Required

If the output current waveform is neither underdamped or overdamped, but the top of the squarewave is not level, then you should instead decrease the capacitor value (see **Figure 6.12.**)

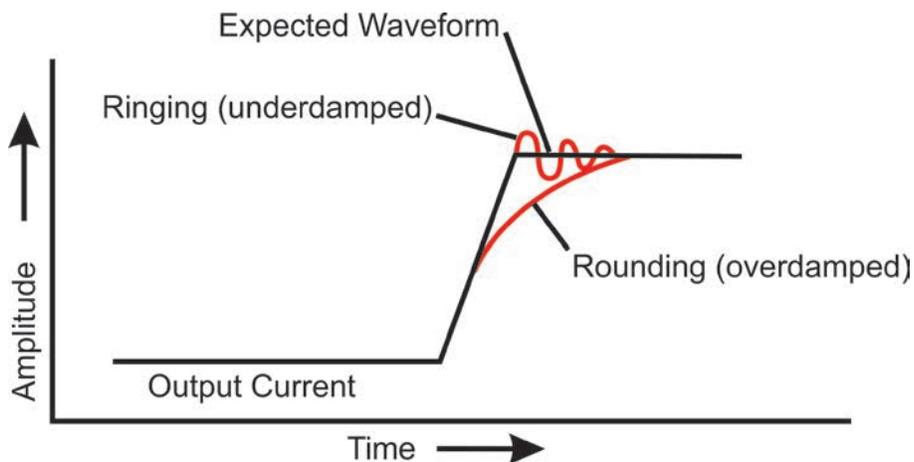


Figure 6.9 – Compensation Effects on Waveform

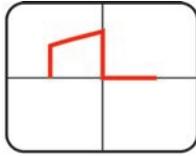
**Decrease C**

Figure 6.12 – Square Wave Showing a Decrease in C is Required

When making adjustments:

Resistor: Increase or decrease resistance values in increments of +/- 10%.

Capacitor: Incrementally decrease capacitor values by a factor of 2 or 3.

After final adjustments have been made to the circuit, the final waveform for your planned appli-

cation should be tested to confirm the amplifier's compensation setting.

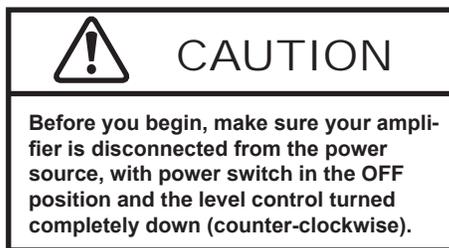
NOTE:

- If possible, use 1% metal film resistors. AE Techron discourages installation of potentiometers in the resistor location of the compensation circuit because this can decrease stability and may increase inductance.
- The parallel capacitor in the RC network serves to increase stability but can be removed, if it is not required for system stability. If the parallel capacitor is used, it will usually decrease the value of resistance needed.
- In multiple amplifier systems, expect to decrease the value of R5 in series systems by 1/2.

7 Maintenance

Simple maintenance can be performed by the user to help keep the equipment operational. The following routine maintenance is designed to prevent problems before they occur. See the **Troubleshooting** section, for recommendations for restoring the equipment to operation after an error condition has occurred.

Preventative maintenance is recommended after the first 250 hours of operation, and every three months or 250 hours thereafter. If the equipment environment is dirty or dusty, preventative maintenance should be performed more frequently.



7.1 Clean Amplifier Filter and Grills

7.1.1 Tools Required

The recommended equipment and supplies needed to perform the functions required for this task are described as follows.

- Vacuum cleaner
- Damp cloth (use water only or a mild soap diluted in water)

To ensure adequate cooling and maximum efficiency of the internal cooling fans, the amplifier's front and rear grills should be cleaned periodically. To clean the amplifier grills and filter, complete the following steps:

1. Turn the amplifier OFF. Disconnect the amplifier from its power source.
2. The front grill is secured to the amplifier front panel by magnets. Pull out on the grill to release it from the front panel.
3. Remove the filter located behind the front grill.
4. Using a vacuum cleaner, vacuum the front ventilation grill, the grill filter, and the back ventilation exit grill.
5. Using a damp cloth, clean the amplifier front panel and the rear ventilation grills. Also use the damp cloth to clean the front grill and filter. If necessary, these can be immersed in warm, soapy water.
6. Dry the front panel, filter, and grills with a clean cloth or allow to air dry. **IMPORTANT: All parts should be completely dry before plugging in or restarting the amplifier.**

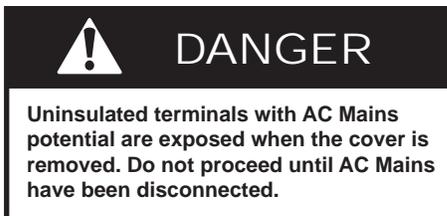
8 Troubleshooting

8.1 Introduction & Precautions

This section provides a set of procedures for identifying and correcting problems with the 8504 amplifier. Rather than providing an exhaustive and detailed list of troubleshooting specifications, this section aims to provide a set of shortcuts intended to get an inoperative amplifier back in service as quickly as possible.

The procedures outlined in this section are directed toward an experienced electronic technician; it assumes that the technician has knowledge of typical electronic repair and test procedures.

Please be aware that the 8504 will undergo frequent engineering updates. As a result, modules and electronic assemblies may not be interchangeable between units. Particularly, the circuit boards undergo periodic engineering modifications that may make interchangeability between units impossible.



8.2 Visual Inspection

Before attempting to troubleshoot the amplifier while it is operating, please take time to complete a visual inspection of the internal components of the amplifier.

1. To perform a Visual Inspection, first turn the Power switch to the Off (O) position.
2. Disconnect the AC mains from the amplifier.
3. Wait three to five minutes for the Power Supply capacitors to discharge.
4. Remove the cover and Inspect the amplifier's internal components. Check the following:
 - Inspect modules for charring, breaks, deformation or other signs of physical damage.
 - Look for any foreign objects lodged inside the unit.

- Inspect the entire lengths of wires and ribbon cables for breaks or other physical damage.
5. If there is any physical damage to the amplifier, please return it to AE Techron for repair.

8.3 No Signal

Missing Output signal may be caused by one of the following:

1. The Control Configuration DIP switch (#7) is set to the Follower (down) position. The amplifier should only be configured for Follower operation if it is in a multi-amplifier system; otherwise this DIP switch should be set to the Master (up) position. See the **Advanced Configuration** section in this manual for more information.
2. A signal source is not connected to either inputs on the amplifier. See the **Amplifier Setup** section in this manual for more information.

8.4 No LEDs Illuminated

If none of the LEDs on the Display Panel are illuminated, check the following:

1. The AC mains are not connected or not on (see the **Amplifier Setup** section for more information).

8.5 Over/Under Line LED Lit

The amplifier will protect itself from AC mains voltage that is 10% above or below the voltage indicated on the back panel. If the AC mains voltage is more than 10% outside the range of the operating voltage, increase or reduce the AC mains voltage to the proper level. When the line voltage condition is corrected, the amplifier will automatically return to Run mode. If the amplifier does not reset, the amplifier's internal transformers may need to be replaced. Please see the **Factory Service** information at the end of this section.

8.6 Run/Standby LED Remains Amber

When the Run/Standby LED is lit solid amber, the

amplifier is in Standby mode. Press the Power switch to the ON position to place the amplifier in Run mode.

If the amplifier does not return to run mode, check to see if the High/Low Line, Overtemp, or Fault LEDs are lit, and then follow the instructions in this section for remedying the fault condition and returning the amplifier to Run mode.

If the remedies given fail to restart the amplifier, the amplifier may require servicing. See the Factory Service Information at the end of this section.

8.7 Amplifier Overheats (Over Temp Fault Condition)

There are two possible reasons why the 8504 amplifier is overheating: Excessive power requirements or inadequate airflow.

8.7.1 Excessive Power Requirements

An amplifier will overheat if the required power exceeds the amplifier's capabilities. High duty cycles and low-impedance loads are especially prone to cause overheating. To see if excess power requirements are causing overheating, check the following:

1. The application's power requirements fall within the specifications of the amplifier. See the **Specifications** section.
2. Faulty output connections and load.
3. Undesired DC offset at the Output and Input signal.

If the amplifier chronically overheats with suitable power/load conditions, then the amplifier may not be receiving adequate airflow. To check for adequate airflow, proceed with the following steps:

8.7.2 Check for Inadequate Airflow

1. Check air filters. Over time they can become dirty and worn out. It is a good idea to clean the air filters periodically with a mild detergent and water.
2. Visually inspect fans to assure correct operation while amplifier is On (I). When an OverTemp fault occurs, the amplifier fans will automatically be placed in continuous high-

speed operation. Any inoperative, visibly slow, or reverse-spinning fan should be replaced.

Please see the Factory Service information at the end of this section.

An OverTemp condition places the amplifier in Standby mode. If the OverTemp pulse is extremely short, as in the case of defective wiring or switches, the OverTemp pulse may be too brief to observe.

8.7.3 Resetting After OverTemp

To reset the amplifier after an OverTemp has occurred, make sure fans are running (the amplifier fans should switch to high-speed operation when an OverTemp fault occurs). Remove the input signal from the amplifier and allow the fans to run until the amplifier has cooled sufficiently and the amplifier automatically returns to Run mode..

NOTE: Typically, overheating that occurs in the amplifier outputs due to inadequate airflow or very low impedance loads will clear within 5 minutes. Overheating in the amplifier transformers due to excessive power requirements will take from 5 to 15 minutes to clear. Timing the cool-down period for the amplifier may help to determine the cause of the overheating.

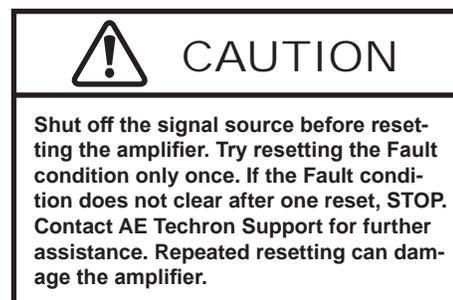
If the fault condition does not clear, return the amplifier for Factory Service.

8.8 Fault LED is Illuminated

The 8504 contains protection circuitry that disables the amplifier if an output stage is behaving abnormally. This usually indicates an output transistor has shorted.

To clear the Fault condition, follow these steps:

1. Turn off the signal source.



2. Turn off the AC mains.
3. Turn AC mains power back on. If the Fault LED doesn't illuminate again, press the Power switch to place the amplifier in Run mode and turn the signal source on.
4. If the Fault LED is still illuminated and the Fault condition doesn't clear, return the amplifier for Factory Service. See the Factory Service information at the end of this section.

8.9 Factory Service

If the troubleshooting procedures are unsuccessful, the amplifier may need to be returned for Factory Service. All units under warranty will be serviced free of charge (customer is responsible for one-way shipping charges as well as any custom fees, duties, and/or taxes). Please review the Warranty at the beginning of this manual for more information.

All service units must be given Return Authorization by AE Techron, Inc. before being returned. Return Authorizations can be requested on our website or by contacting our Customer Service Department.

Please take extra care when packaging your amplifier for repair. It should be returned in its original packaging or a suitable alternative. Replacement packaging materials can be purchased for a nominal fee.

Please send all service units to the following address and be sure to include your Return Authorization Number on the box.

**AE Techron, Inc.
Attn: Service Department / RMA#
2507 Warren Street
Elkhart, IN 46516**

Appendix A: Gain DIP Switch Settings

Use this chart to determine the required settings for DIP switches 9 through 16 to achieve the amplifier gain you need for your application. Note: All

switches ON = Gain of 39.85, all switches OFF = gain of 0 (signal will not be amplified).

ON = DIP Switch UP OFF = DIP Switch DOWN								Gain
SW#9	SW#10	SW#11	SW#12	SW#13	SW#14	SW#15	SW#16	Gain
ON	ON	ON	ON	ON	ON	ON	ON	39.85
ON	ON	ON	ON	ON	ON	ON	OFF	39.69
ON	ON	ON	ON	ON	ON	OFF	ON	39.54
ON	ON	ON	ON	ON	ON	OFF	OFF	39.38
ON	ON	ON	ON	ON	OFF	ON	ON	39.22
ON	ON	ON	ON	ON	OFF	ON	OFF	39.06
ON	ON	ON	ON	ON	OFF	OFF	ON	38.91
ON	ON	ON	ON	ON	OFF	OFF	OFF	38.75
ON	ON	ON	ON	OFF	ON	ON	ON	38.60
ON	ON	ON	ON	OFF	ON	ON	OFF	38.44
ON	ON	ON	ON	OFF	ON	OFF	ON	38.29
ON	ON	ON	ON	OFF	ON	OFF	OFF	38.13
ON	ON	ON	ON	OFF	OFF	ON	ON	37.97
ON	ON	ON	ON	OFF	OFF	ON	OFF	37.81
ON	ON	ON	ON	OFF	OFF	OFF	ON	37.66
ON	ON	ON	ON	OFF	OFF	OFF	OFF	37.50
ON	ON	ON	OFF	ON	ON	ON	ON	37.35
ON	ON	ON	OFF	ON	ON	ON		37.19
ON	ON	ON	OFF	ON	ON		ON	37.04
ON	ON	ON	OFF	ON	ON			36.88
ON	ON	ON	OFF	ON	OFF	ON	ON	36.72
ON	ON	ON	OFF	ON	OFF	ON		36.56
ON	ON	ON	OFF	ON	OFF	OFF	ON	36.41
ON	ON	ON	OFF	ON	OFF	OFF	OFF	36.25
ON	ON	ON	OFF	OFF	ON	ON	ON	36.10
ON	ON	ON	OFF	OFF	ON	ON		35.94
ON	ON	ON	OFF	OFF	ON		ON	35.79
ON	ON	ON	OFF	OFF	ON			35.63
ON	ON	ON	OFF	OFF	OFF	ON	ON	35.47
ON	ON	ON	OFF	OFF	OFF	ON		35.31
ON	ON	ON	OFF	OFF	OFF	OFF	ON	35.16
ON	ON	ON	OFF	OFF	OFF	OFF	OFF	35.00
ON	ON	OFF	ON	ON	ON	ON	ON	34.85
ON	ON	OFF	ON	ON	ON	ON	OFF	34.69
ON	ON	OFF	ON	ON	ON	OFF	ON	34.54
ON	ON	OFF	ON	ON	ON	OFF	OFF	34.38
ON	ON	OFF	ON	ON	OFF	ON	ON	34.22
ON	ON	OFF	ON	ON	OFF	ON	OFF	34.06
ON	ON	OFF	ON	ON	OFF	OFF	ON	33.91
ON	ON	OFF	ON	ON	OFF	OFF	OFF	33.75
ON	ON	OFF	ON	OFF	ON	ON	ON	33.60
ON	ON	OFF	ON	OFF	ON	ON	OFF	33.44

ON = DIP Switch UP OFF = DIP Switch DOWN								
SW#9	SW#10	SW#11	SW#12	SW#13	SW#14	SW#15	SW#16	Gain
ON	ON	OFF	ON	OFF	ON	OFF	ON	33.29
ON	ON	OFF	ON	OFF	ON	OFF	OFF	33.13
ON	ON	OFF	ON	OFF	OFF	ON	ON	32.97
ON	ON	OFF	ON	OFF	OFF	ON	OFF	32.81
ON	ON	OFF	ON	OFF	OFF	OFF	ON	32.66
ON	ON	OFF	ON	OFF	OFF	OFF	OFF	32.50
ON	ON	OFF	OFF	ON	ON	ON	ON	32.35
ON	ON	OFF	OFF	ON	ON	ON		32.19
ON	ON	OFF	OFF	ON	ON		ON	32.04
ON	ON	OFF	OFF	ON	ON			31.88
ON	ON	OFF	OFF	ON	OFF	ON	ON	31.72
ON	ON	OFF	OFF	ON	OFF	ON		31.56
ON	ON	OFF	OFF	ON	OFF	OFF	ON	31.41
ON	ON	OFF	OFF	ON	OFF	OFF	OFF	31.25
ON	ON	OFF	OFF	OFF	ON	ON	ON	31.10
ON	ON	OFF	OFF	OFF	ON	ON		30.94
ON	ON	OFF	OFF	OFF	ON		ON	30.79
ON	ON	OFF	OFF	OFF	ON			30.63
ON	ON	OFF	OFF	OFF	OFF	ON	ON	30.47
ON	ON	OFF	OFF	OFF	OFF	ON		30.31
ON	ON	OFF	OFF	OFF	OFF	OFF	ON	30.16
ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	30.00
ON	OFF	ON	ON	ON	ON	ON	ON	29.85
ON	OFF	ON	ON	ON	ON	ON	OFF	29.69
ON	OFF	ON	ON	ON	ON	OFF	ON	29.54
ON	OFF	ON	ON	ON	ON	OFF	OFF	29.38
ON	OFF	ON	ON	ON	OFF	ON	ON	29.22
ON	OFF	ON	ON	ON	OFF	ON	OFF	29.06
ON	OFF	ON	ON	ON	OFF	OFF	ON	28.91
ON	OFF	ON	ON	ON	OFF	OFF	OFF	28.75
ON	OFF	ON	ON	OFF	ON	ON	ON	28.60
ON	OFF	ON	ON	OFF	ON	ON	OFF	28.44
ON	OFF	ON	ON	OFF	ON	OFF	ON	28.29
ON	OFF	ON	ON	OFF	ON	OFF	OFF	28.13
ON	OFF	ON	ON	OFF	OFF	ON	ON	27.97
ON	OFF	ON	ON	OFF	OFF	ON	OFF	27.81
ON	OFF	ON	ON	OFF	OFF	OFF	ON	27.66
ON	OFF	ON	ON	OFF	OFF	OFF	OFF	27.50
ON	OFF	ON	OFF	ON	ON	ON	ON	27.35
ON	OFF	ON	OFF	ON	ON	ON	OFF	27.19
ON	OFF	ON	OFF	ON	ON	OFF	ON	27.04
ON	OFF	ON	OFF	ON	ON	OFF	OFF	26.88
ON	OFF	ON	OFF	ON	OFF	ON	ON	26.72
ON	OFF	ON	OFF	ON	OFF	ON	OFF	26.56
ON	OFF	ON	OFF	ON	OFF	OFF	ON	26.41
ON	OFF	ON	OFF	ON	OFF	OFF	OFF	26.25
ON	OFF	ON	OFF	OFF	ON	ON	ON	26.10
ON	OFF	ON	OFF	OFF	ON	ON	OFF	25.94
ON	OFF	ON	OFF	OFF	ON	OFF	ON	25.79

ON = DIP Switch UP OFF = DIP Switch DOWN								
SW#9	SW#10	SW#11	SW#12	SW#13	SW#14	SW#15	SW#16	Gain
ON	OFF	ON	OFF	OFF	ON	OFF	OFF	25.63
ON	OFF	ON	OFF	OFF	OFF	ON	ON	25.47
ON	OFF	ON	OFF	OFF	OFF	ON	OFF	25.31
ON	OFF	ON	OFF	OFF	OFF	OFF	ON	25.16
ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	25.00
ON	OFF	OFF	ON	ON	ON	ON	ON	24.85
ON	OFF	OFF	ON	ON	ON	ON	OFF	24.69
ON	OFF	OFF	ON	ON	ON	OFF	ON	24.54
ON	OFF	OFF	ON	ON	ON	OFF	OFF	24.38
ON	OFF	OFF	ON	ON	OFF	ON	ON	24.22
ON	OFF	OFF	ON	ON	OFF	ON	OFF	24.06
ON	OFF	OFF	ON	ON	OFF	OFF	ON	23.91
ON	OFF	OFF	ON	ON	OFF	OFF	OFF	23.75
ON	OFF	OFF	ON	OFF	ON	ON	ON	23.60
ON	OFF	OFF	ON	OFF	ON	ON	OFF	23.44
ON	OFF	OFF	ON	OFF	ON	OFF	ON	23.29
ON	OFF	OFF	ON	OFF	ON	OFF	OFF	23.13
ON	OFF	OFF	ON	OFF	OFF	ON	ON	22.97
ON	OFF	OFF	ON	OFF	OFF	ON	OFF	22.81
ON	OFF	OFF	ON	OFF	OFF	OFF	ON	22.66
ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	22.50
ON	OFF	OFF	OFF	ON	ON	ON	ON	22.35
ON	OFF	OFF	OFF	ON	ON	ON		22.19
ON	OFF	OFF	OFF	ON	ON		ON	22.04
ON	OFF	OFF	OFF	ON	ON			21.88
ON	OFF	OFF	OFF	ON	OFF	ON	ON	21.72
ON	OFF	OFF	OFF	ON	OFF	ON		21.56
ON	OFF	OFF	OFF	ON	OFF	OFF	ON	21.41
ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	21.25
ON	OFF	OFF	OFF	OFF	ON	ON	ON	21.10
ON	OFF	OFF	OFF	OFF	ON	ON		20.94
ON	OFF	OFF	OFF	OFF	ON		ON	20.79
ON	OFF	OFF	OFF	OFF	ON			20.63
ON	OFF	OFF	OFF	OFF	OFF	ON	ON	20.47
ON	OFF	OFF	OFF	OFF	OFF	ON		20.31
ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	20.16
ON	OFF	20.00						
OFF	ON	19.85						
OFF	ON	ON	ON	ON	ON	ON	OFF	19.69
OFF	ON	ON	ON	ON	ON	OFF	ON	19.54
OFF	ON	ON	ON	ON	ON	OFF	OFF	19.38
OFF	ON	ON	ON	ON	OFF	ON	ON	19.22
OFF	ON	ON	ON	ON	OFF	ON	OFF	19.06
OFF	ON	ON	ON	ON	OFF	OFF	ON	18.91
OFF	ON	ON	ON	ON	OFF	OFF	OFF	18.75
OFF	ON	ON	ON	OFF	ON	ON	ON	18.60
OFF	ON	ON	ON	OFF	ON	ON	OFF	18.44
OFF	ON	ON	ON	OFF	ON	OFF	ON	18.29
OFF	ON	ON	ON	OFF	ON	OFF	OFF	18.13

ON = DIP Switch UP OFF = DIP Switch DOWN								
SW#9	SW#10	SW#11	SW#12	SW#13	SW#14	SW#15	SW#16	Gain
OFF	ON	ON	ON	OFF	OFF	ON	ON	17.97
OFF	ON	ON	ON	OFF	OFF	ON	OFF	17.81
OFF	ON	ON	ON	OFF	OFF	OFF	ON	17.66
OFF	ON	ON	ON	OFF	OFF	OFF	OFF	17.50
OFF	ON	ON	OFF	ON	ON	ON	ON	17.35
OFF	ON	ON	OFF	ON	ON	ON	OFF	17.19
OFF	ON	ON	OFF	ON	ON	OFF	ON	17.04
OFF	ON	ON	OFF	ON	ON	OFF	OFF	16.88
OFF	ON	ON	OFF	ON	OFF	ON	ON	16.72
OFF	ON	ON	OFF	ON	OFF	ON	OFF	16.56
OFF	ON	ON	OFF	ON	OFF	OFF	ON	16.41
OFF	ON	ON	OFF	ON	OFF	OFF	OFF	16.25
OFF	ON	ON	OFF	OFF	ON	ON	ON	16.10
OFF	ON	ON	OFF	OFF	ON	ON	OFF	15.94
OFF	ON	ON	OFF	OFF	ON	OFF	ON	15.79
OFF	ON	ON	OFF	OFF	ON	OFF	OFF	15.63
OFF	ON	ON	OFF	OFF	OFF	ON	ON	15.47
OFF	ON	ON	OFF	OFF	OFF	ON	OFF	15.31
OFF	ON	ON	OFF	OFF	OFF	OFF	ON	15.16
OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	15.00
OFF	ON	OFF	ON	ON	ON	ON	ON	14.85
OFF	ON	OFF	ON	ON	ON	ON	OFF	14.69
OFF	ON	OFF	ON	ON	ON	OFF	ON	14.54
OFF	ON	OFF	ON	ON	ON	OFF	OFF	14.38
OFF	ON	OFF	ON	ON	OFF	ON	ON	14.22
OFF	ON	OFF	ON	ON	OFF	ON	OFF	14.06
OFF	ON	OFF	ON	ON	OFF	OFF	ON	13.91
OFF	ON	OFF	ON	ON	OFF	OFF	OFF	13.75
OFF	ON	OFF	ON	OFF	ON	ON	ON	13.60
OFF	ON	OFF	ON	OFF	ON	ON	OFF	13.44
OFF	ON	OFF	ON	OFF	ON	OFF	ON	13.29
OFF	ON	OFF	ON	OFF	ON	OFF	OFF	13.13
OFF	ON	OFF	ON	OFF	OFF	ON	ON	12.97
OFF	ON	OFF	ON	OFF	OFF	ON	OFF	12.81
OFF	ON	OFF	ON	OFF	OFF	OFF	ON	12.66
OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	12.50
OFF	ON	OFF	ON	ON	ON	ON	ON	12.35
OFF	ON	OFF	OFF	ON	ON	ON	OFF	12.19
OFF	ON	OFF	OFF	ON	ON	OFF	ON	12.04
OFF	ON	OFF	OFF	ON	ON	OFF	OFF	11.88
OFF	ON	OFF	OFF	ON	OFF	ON	ON	11.72
OFF	ON	OFF	OFF	ON	OFF	ON	OFF	11.56
OFF	ON	OFF	OFF	ON	OFF	OFF	ON	11.41
OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	11.25
OFF	ON	OFF	OFF	OFF	ON	ON	ON	11.10
OFF	ON	OFF	OFF	OFF	ON	ON	OFF	10.94
OFF	ON	OFF	OFF	OFF	ON	OFF	ON	10.79
OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	10.63
OFF	ON	OFF	OFF	OFF	OFF	ON	ON	10.47

ON = DIP Switch UP OFF = DIP Switch DOWN								
SW#9	SW#10	SW#11	SW#12	SW#13	SW#14	SW#15	SW#16	Gain
OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	10.31
OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	10.16
OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	10.00
OFF	OFF	ON	ON	ON	ON	ON	ON	9.85
OFF	OFF	ON	ON	ON	ON	ON	OFF	9.69
OFF	OFF	ON	ON	ON	ON	OFF	ON	9.54
OFF	OFF	ON	ON	ON	ON	OFF	OFF	9.38
OFF	OFF	ON	ON	ON	OFF	ON	ON	9.22
OFF	OFF	ON	ON	ON	OFF	ON	OFF	9.06
OFF	OFF	ON	ON	ON	OFF	OFF	ON	8.91
OFF	OFF	ON	ON	ON	OFF	OFF	OFF	8.75
OFF	OFF	ON	ON	OFF	ON	ON	ON	8.60
OFF	OFF	ON	ON	OFF	ON	ON	OFF	8.44
OFF	OFF	ON	ON	OFF	ON	OFF	ON	8.29
OFF	OFF	ON	ON	OFF	ON	OFF	OFF	8.13
OFF	OFF	ON	ON	OFF	OFF	ON	ON	7.97
OFF	OFF	ON	ON	OFF	OFF	ON	OFF	7.81
OFF	OFF	ON	ON	OFF	OFF	OFF	ON	7.66
OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	7.50
OFF	OFF	ON	OFF	ON	ON	ON	ON	7.35
OFF	OFF	ON	OFF	ON	ON	ON	OFF	7.19
OFF	OFF	ON	OFF	ON	ON	OFF	ON	7.04
OFF	OFF	ON	OFF	ON	ON	OFF	OFF	6.88
OFF	OFF	ON	OFF	ON	OFF	ON	ON	6.72
OFF	OFF	ON	OFF	ON	OFF	ON	OFF	6.56
OFF	OFF	ON	OFF	ON	OFF	OFF	ON	6.41
OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	6.25
OFF	OFF	ON	OFF	OFF	ON	ON	ON	6.10
OFF	OFF	ON	OFF	OFF	ON	ON	OFF	5.94
OFF	OFF	ON	OFF	OFF	ON	OFF	ON	5.79
OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	5.63
OFF	OFF	ON	OFF	OFF	OFF	ON	ON	5.47
OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	5.31
OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	5.16
OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	5.00
OFF	OFF	OFF	ON	ON	ON	ON	ON	4.85
OFF	OFF	OFF	ON	ON	ON	ON	OFF	4.69
OFF	OFF	OFF	ON	ON	ON	OFF	ON	4.54
OFF	OFF	OFF	ON	ON	ON	OFF	OFF	4.38
OFF	OFF	OFF	ON	ON	OFF	ON	ON	4.22
OFF	OFF	OFF	ON	ON	OFF	ON	OFF	4.06
OFF	OFF	OFF	ON	ON	OFF	OFF	ON	3.91
OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	3.75
OFF	OFF	OFF	ON	OFF	ON	ON	ON	3.60
OFF	OFF	OFF	ON	OFF	ON	ON	OFF	3.44
OFF	OFF	OFF	ON	OFF	ON	OFF	ON	3.29
OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	3.13
OFF	OFF	OFF	ON	OFF	OFF	ON	ON	2.97
OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	2.81

ON = DIP Switch UP OFF = DIP Switch DOWN								
SW#9	SW#10	SW#11	SW#12	SW#13	SW#14	SW#15	SW#16	Gain
OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	2.66
OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	2.50
OFF	OFF	OFF	OFF	ON	ON	ON	ON	2.35
OFF	OFF	OFF	OFF	ON	ON	ON	OFF	2.19
OFF	OFF	OFF	OFF	ON	ON	OFF	ON	2.04
OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	1.88
OFF	OFF	OFF	OFF	ON	OFF	ON	ON	1.72
OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	1.56
OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	1.41
OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	1.25
OFF	OFF	OFF	OFF	OFF	ON	ON	ON	1.10
OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	0.94
OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	0.79
OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	0.63
OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	0.47
OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	0.31
OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	0.16
OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	0