# QSC SERIES THREE OWNER'S MANUAL

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QSC AUDIO PRODUCTS
1028 PLACENTIA WY., COSTA MESA, CALIFORNIA 92627
(714) 645-2140
PP-000015-OH, 1984
1.1 Welcome. Thank you for selecting a QSC Series Three power amplifier for your audio system. Our goal is to be sure you remain happy with your amplifier for many years to come. Please do not hesitate to call your QSC Dealer or QSC Audio Products if you have any service problems or questions not answered in this manual.

QSC Series Three power amplifiers are designed to be readily operated by anyone familiar with pro-audio systems. However, there are certain characteristics which the industry has not yet standardized. In addition, these amplifiers contain certain features not found on competitive amps. For these reasons, we recommend that experienced as well as the first time users review the contents of this manual.

Please consult the Table of Contents for fast guidance to the sections of interest. We recommend that all users read the sections under Basic Instructions—Unpacking and Inspection (2.1), Important Cautions (2.2), and Quick Instructions (2.3).

1.2 Warranty

QSC AUDIO PRODUCTS 2 YEAR LIMITED WARRANTY

QSC Audio Products guarantees all Series Three products to be free from defective material and/or workmanship for a period of three years from date of sale, and will replace defective parts and repair malfunctioning products under this warranty when the defect occurs under normal installation and use—provided the unit is returned to our factory or one of our Authorized Service Stations via prepaid transportation. This warranty provides that examination of the returned product must disclose, in our judgment, a manufacturing defect. This warranty does not extend to any product which has been subject to misuse, neglect, accident, improper installation, or where the serial number has been removed or defaced. Manufacturer shall not be liable for consequential damages resulting from defects in materials and/or workmanship.

1.3 Overview of Amplifier, Series Three power amplifiers use a basic circuit design which is the result of years of QSC product development, combined with a new high efficiency output stage for more power and increased headroom. The result is superb audio performance, and a modern low-profile design, combined with a host of operational features. As with our earlier power amplifiers, we have used the minimum number of amplifying stages required to deliver the intended power. This ensures minimum signal degradation and maximum reliability and consistency. A balanced bipolar power supply gives direct output coupling and proper dynamic response during program peaks, and a superior series of complementary power transistors combine high power handling with outstanding audio performance. A high-performance op-amp assures balanced or unbalanced input signals, and provides the high internal gain needed for low overall distortion and wide frequency response. Because our circuit design only requires two additional stages of power transistors, after the op-amp, class AB operation (slight idle current to eliminate crossover distortion) is easy to maintain over the entire temperature range of the amplifier. The, combined with the two-level, high efficiency output circuit, results in minimum temperature rise under both low power and high power conditions. This enables us to offer about twice the power normally possible in this chassis size without decreased reliability due to excessive heat.

In order to ensure that users get the full benefit of the high performance, we have included many operational and protective features. Since professional amps may be exposed to many hazards, as well as heavy use, complete protection is provided for open-circuit, short-circuit, and mismatched loads; the amplifier will shut down temporarily if it overloads, and AC circuit breakers protect against excessive power levels. Our protection circuits are designed to ensure a minimum of false triggering and unwanted interruptions, and except for the AC breaker (which replaces the usual AC fuse), all protection systems will reset automatically as soon as it's safe. An equally important system protects the users loudspeakers from unexpected damage, by muting the amp during turn-on and turn-off, and by quickly disconnecting the speakers in case of DC fault (uncontrolled power breakthrough) in the amplifier or any
SECTION ONE: OVERVIEW

preceding component. In addition, the Octal Module accessory plugs allow the user to connect a series of plug-in modules, for frequency filtering, power limited, and other special functions.

From panel indicators have been designed to present all essential operating information and are released to prevent damage. The 31-step detented Scan control allows precise level adjustments; multi-color LED’s show power/protect status, signal level, distortion, and thermal warning before thermal shutdown. In addition, AC switches and circuit breakers are mounted up front for fast access.

The amplifier uses true “dual monaural” construction. This means that all functions, except the chassis itself and AC cord, are separate for both channels. This maintains complete isolation in normal use, permits either channel to be powered up or down independently, and isolates any possible breakdown. This, combined with the formidable shielding channels, ensures against total loss of the program, and allows fast rectification in case of breakdown in the field.

In order to interface properly to a variety of pro-audio systems, we have included all of the popular input and speaker connectors. Balanced or unbalanced inputs can be made with 1/4-inch (ring-up/sleeve for balanced) plugs, XLR “Cannon” plugs, or with screw-lugs to the barrier strip. Please see Section 2.36 for important note on input polarity. Speaker connectors are made with the 5-way binding posts or to the barrier strip screw terminals.

Users will note that the chassis has rear mounting supports as well as the usual rack-mounting ears. This ensures that the deep, low-profile chassis can be fully supported in portable systems which are subject to road abuse.

All of these points are more fully explained in the following Sections.

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#### DYNAMIC HEADROOM

- 8 ohms: 30 dB
- 4 ohms: 30 dB
- 4 ohms: 30 dB

#### DISTORTION

- THD: 20-20 kHz, from 250 mWatts to rated power; more than 0.1% SWRTE/MD less than 0.02% more than 0.4%

#### FREQUENCY RESPONSE

- 20-20 kHz, +/- -0.1 dB
- 8-200 kHz, +/- -0.5 dB

#### NOISE

- Greater than 0 dB

#### SENSITIVITY

- TV RMS for rated power (8 ohms)

#### INPUT IMPEDANCE

- 20k, balanced or unbalanced

#### CROSSFALK

- 75k, 20-20kHz

#### CONTROLS

- Front
- Rear

#### INDICATORS

- Bi-color LED indicating DC power-OK/Protect mode LED clip indicator - 30dBV and -6dBV signal level indicators Flashing over-temp indicators

#### CONNECTORS

- XLR, 1/4" (ring, tip, sleeve) and 3 terminal barrier strip inputs wired in parallel, 2 terminal barrier strip and 5-way binding post outputs wired in parallel. Octal input sockets provided for input transformers or active accessories. Ground 1/2 terminal block. Switchable XLR polarity (see Section 2.36)

#### COOLING

- Passive-combined with high efficiency output stage for reduced operating temperatures. Unique circuit configuration allows direct metal mounting of output devices for reduced thermal stress from short-term peaks.
**SECTION ONE: SPECIFICATIONS**

**AMPLIFIER PROTECTION**
Individually short circuit-, overvoltage-, over-current-, over-temp., ultrasonic and RFI protection. Stable into reactive and mismatched loads. Inputs protected from overload. All protection completely independent on each channel.

**LOAD PROTECTION**
Individual channel Load Grounding output relays provide DC fault, 3 second delayed turn-on (transient protection), and excessive low frequency protection. Instant turn-off and fast suppression is also provided.

**OUTPUT CIRCUIT TYPE**
Full complementary two-level high efficiency.

**OUTPUT DEVICES (Total)**
- 3200: 8
- 3300: 15
- 3500: 24
- 3600: 40

**POWER SUPPLY**
Two completely separate power supplies including AC switches and AC circuit breakers.

**POWER REQUIREMENTS**
- 3200: 44A @ 120 Volts, 60Hz
- 3300: 8A @ 120 Volts, 60Hz
- 3500: 10A @ 120 Volts, 60Hz
- 3600: 20A @ 120 Volts (10A per AC cord)

**DIMENSIONS**
- Faceplate: 19" x 1.75" depth (with rear support) 15.5"
- Depth (chassis): 14.5"
- Faceplate: 19" x 3.25" depth (with rear support) 19.75"
- Depth (chassis): 15.25"
- Faceplate: 19" x 3.25" depth (with rear support) 17.5"
- Depth (chassis): 15.25"
- Faceplate: 19" x 3.25" depth (with rear support) 15.5"
- Depth (chassis): 15.25"

**WEIGHT**
- 3200: Shipping (lbs): 31, Net (lbs): 26
- 3300: Shipping (lbs): 46, Net (lbs): 41
- 3500: Shipping (lbs): 55, Net (lbs): 50
- 3600: Shipping (lbs): 83, Net (lbs): 75

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**SECTION ONE: PERFORMANCE GRAPHS**

1.51 **POWER vs. FREQUENCY** at 0.1% Clipping

1.52 **DISTORTION vs. FREQUENCY** THD Plus Noise: 8 Ohms
SECTION ONE: PERFORMANCE GRAPHS

1.53 AC CURRENT vs. POWER

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<th>Current (A)</th>
<th>Percent of Output Power, Sine Wave</th>
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STANDARD CIRCUIT

1.54 HEAT LOSS vs. POWER

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<th>Percent of Output Power</th>
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<td>45</td>
<td>45%</td>
</tr>
<tr>
<td>50</td>
<td>50%</td>
</tr>
</tbody>
</table>

STANDARD CIRCUIT

SECTION TWO: UNPACKING, PRECAUTIONS

2.1 Unpacking and Inspection. QSC triple-checks the Series Three amplifiers before they leave the factory, and they are shipped in good condition. Despite the protective carton and rugged amplifier design, it is possible for shipping abuse to damage the amplifier. Check for obvious carton damage while unpacking the unit. After removing the amp from the box, inspect it in all directions to check for loose parts inside. The side-out channel modules may rattle slightly in the tracks if shaken vigorously, but no parts should rattle around inside.

Please save the carton for return shipment, if required. QSC does not warranty against damage caused by sending amplifiers back in the wrong carton. If shipping damage is evident, notify the transportation company immediately. Only the consignee can file a claim with the carrier for shipping damage. QSC will co-operate fully in such an event. Be sure to save the carton for the shipment to inspect.

2.2 Important Precautions

2.21 Be sure to have power OFF when making all connections. Especially in dry environments, static sparks can cause loud pops which can damage speakers; defective cables could cause disastrous hums.

2.22 When first powering up the amp, have the amplifier Gain controls all the way off. This will block abnormal sounds from defective cables or hookups; turn the Gains up gradually until normal operation is verified. Series Three amps have enough power to blow most speakers if not kept under control.

2.23 Check the AC voltage before connecting the AC plug. Amps shipped in the USA are designed for 120V, 60Hz operation, with ±10% allowance for AC fluctuations. CONNECTION TO 240V WILL IMMEDIATELY BLOW THE AMP and is not covered by the warranty.

2.24 Never connect the speaker terminals (red binding posts) together on any power amplifier. The two channels will fight each other and possibly blow. Do not connect the speaker ground terminals (black binding posts) to chassis or signal grounds, as the resultant ground loop could cause ultrasonic oscillations.

2.25 Do not remove the amplifier cover as there are dangerous voltages inside. Do not expose to rain or moisture. Refer all servicing to qualified personnel. The warranty may be void if the amp is tampered with by non-QSR repair centers or personnel.

2.26 The QSC Warranty does not cover tampering by unqualified personnel, or repairs made at non-QSC repair centers. Please call the factory for Service Center information and locations.

2.27 High voltages can be present on the speaker terminals, peak voltages can range from 68 to 90 volts. Always connect speaker terminals with the power off, and observe safe wiring practices.

2.28 Always be aware that power amplifiers are heavy and must be properly supported to avoid injury. High powers are handled internally; never plug in a damaged amplifier until the condition of the internal insulation is checked. If the circuit breaker blows quickly upon turning the amp on, that channel is defective, and should not be restarted until repaired or replaced. If the other channel functions normally, it may still be used. Failure to observe these precautions could lead to fire or shock hazard.
2.32 Quick Instructions

2.33 Speaker Connections. Banana plugs, spade lugs, or bare wire ends can be connected to the 8-way binding posts. Spade lugs, or bare wire ends (with caution) can also be connected to the barrier strip screws for permanent installations. Be sure to observe correct polarity (red/black terminals) for each speaker.

2.38 Power Up. Start with Gain control off until proper operation is verified. Upon turning on the switch, that channel's 'PowerProtect' LED should come on red. After three seconds, the relay should click on and the LED should turn green. The amp should now be working, and the Gain control can be advanced. If the relay does not come on (LED stays red), then there is something wrong. In this case, consult Section 3.8.

2.39 Operation and Indicators. Note that the Gain control is calibrated in dB, with 0 dB above the top half of its range. Gain should be kept in this region for full performance. The "0dB" reference matches the full-gain performance (30dB) of many expected pro-audio power amplifiers.

Two yellow LED's show signal presence at levels 30dB and 60dB below clipping. For maximum undistorted performance, the -6dB "LED should trigger on peaks. The red "Clip" LED will begin to trigger about 10 degrees below thermal shut-down. This is your warning to increase ventilation or reduce power before the amp shuts off temporarily.

The muting relay should cut the speakers off as soon as you turn off the amp, and wait three seconds to restore the speakers when turning on. This blocks turn-on and turn-off thumps.

Please refer to Section 3 for more detailed instructions.
3.1 Cooling

3.11 High Efficiency Circuit. Because of the high-efficiency design, the Series Three amplifiers only waste 10 to 1/2 the heat of comparable power amplifiers. Despite this, we have used the largest possible heats sinks. The two factors combined assure minimal temperature rise even under heavy usage.

3.12 Cooling Precautions. The heats sinks are located within the vented areas along both sides of the chassis. If these vents are kept clear of obstructions, no fan cooling should be needed over the normal range of ambient temperatures. Please see Section 6.2 for a deeper discussion of the high-efficiency circuit, and Section 4.1 for more precautions when rack-mounting or using stacks of amplifiers.

3.2 AC Requirements

3.21 AC Tolerances. Series Three amplifiers are designed for safe operation on AC voltages 19% higher than rated; however, temperature rise and transformer hum may increase somewhat. Operation on lower-than-normal AC voltages is not harmful to the amp, but performance will be progressively lost. For voltages down to 75% of rated voltage, no effect other than loss of peak power should be noticed. If voltage declines further, short-circuit protection (current limiting cutout) may be experienced on heavy loads into low impedance loads. The muting relay may not come on at less than 10% rated voltage but once on, it should stay on at about 30% of rated voltage. There should be no subwoofer or DC transients caused by fluctuating AC voltages, you should suspect poor regulated preceding components if hums or voice-coil excursions are observed.

3.22 AC Supply. In order to maintain full rated power, power amplifiers as a rule require well-regulated AC voltage of the proper rating. This is not always easy to assure when large banks of amplifiers are used. The problem is further complicated by the fact that virtually all practical amplifier power supplies use peak rectification of the AC waveform. This means that power is drawn only from the tips of the AC sine wave. When many amps are used, or there is an excessive length of inadequate-gauge AC wiring to the amps, these tips can be seriously eroded without a major effect on measured voltage. Poor bus power devices, such as tanks, on the same circuit may not be greatly affected, but other electronic components, which normally use the same type of rectification, may be seriously affected during high-power peaks. This is especially true of sensitive devices like computers, video gear, etc. This is any power amplifiers should have their own circuit if possible.

3.23 AC Consumption. Series Three power amplifiers will use much less power at low power levels, and somewhat less power at high power levels, compared to conventional efficiency amps. (See Performance Graph 15.4) This means that there will be a slightly greater power fluctuations, which may cause the impression that there are dimming more heavily during peaks. This should not be overlooked with the relatively excessive current drawn by at least one other high-efficiency amplifier, which has a special type of power transformer.

3.24 Power Factor. The more knowledgeable user may ask how a more efficient amplifier can draw higher AC currents than a conventional design. In AC power networks, it is possible to have a substantial current without delivering any useful power. The concept when the current is not in phase with the voltage. The term “power factor” is used to describe how much of the current is actually delivering energy to the load. A power factor of 1, or unity, means that the current is 100% effective, and normally applies to a resistive load. Lower power factors mean that some of the current is reflected back to the AC source. This means that less energy is consumed, but the wiring and circuit breakers still have to bear the total current. Since wire and circuit breaker capacity limits the available power, it can be desirable to see that the power factor of the amplifiers be as high as possible. At least one high-efficiency amplifier, designed for home use, has a very poor power factor; this makes it a poor choice when many amps are needed, even though the waste heat is reduced. Since the QSC Series Three uses the same conventional AC transformer and rectifier as ordinary amps, the power factor is the same, and power demand is reduced because of the decreased circuit losses.

3.25 Average Current Requirements. Actual AC current will depend on the amount of output power, as shown in Graph 15.4. The current rating shown on the back of the amp is determined according to the AC circuit and, maximum undistorted power is measured at an idle power level, the current required to achieve this power is rated at 120 or 1200 Hz, to represent an average condition. As it turns out, for the Series Three this value is determined by the US military code. Therefore, the rated current will be extended when using full power for four, especially heavy load, but the average current requirements should be equal or less for actual music, speech, or pink noise signals into all impedances. If extended operation at full RMS power is anticipated, impedances should be kept at 8 ohms or higher to avoid AC overload and circuit breaker tripping. Even a few dB loss average power will eliminate the need for this precaution, frequently-clipped program material will usually meet this requirement.

3.3 Input Connection (See Illustration in Section 2.3)

3.31 Input Leveling. All input functions are shown in blue on the three color rear labels.

3.32 Input Jacks. 1/4-inch ring-tip-sleeve for XLR, and three-circuit barrier strip terminal blocks are provided for input connections.

3.33 Input Circuit. An electronic balanced input is standard. This uses matched, 20,000 ohm resistors and the differential input terminals at a low performance 5002 q-eq is a perfect carrier level and balanced input signal inputs and correct common-mode signals. For best performance in the balanced input, the source should have equal impedances for both signal conductors, so that the loading effect on each leg will be the same for common mode signal inputs. Minor mismatches will result in slight loss of common-mode rejection, but will still have much greater noise reduction than unbalanced tees.

3.34 Balanced Inputs. For proper balanced-line operation, the cable shield must be kept separate from both signal conductors. The shield should be connected to the ground of the 0.1-inch plug, pin 1 of an XLR plug, or to the “GND” terminal of the barrier strip, shown in blue. Balanced loads carry only a quad signal, a “null” polarity, often defined as “high” or “low” or “return.” The “null” con- ductor should go to the ring of a 1/4-inch plug, pin 2 of an XLR plug or is the “null” input of the barrier strip, for the amplifier to reproduce the signal in the same polarity (non-inverting operation). The “null” conductor goes to the tip of a 1/4-inch plug, pin 3 of an XLR connector, or to the “null” terminal on the barrier strip for the amplifier to invert the polarity of the 1/4-inch conductor’s output compared to other amps, for greater stability in the unbalanced mode and to match other QSC amps. Also note that XLR polarity is switchable (see Section 3.5)

3.35 Unbalanced Inputs. Since the input signal responds to the difference between the plus and minus signal, only a single-ended signal is needed. Unbalanced input signals only need to be grounded for operation without loss of gain. The ability to reject cable-induced hum and noise is lost, however the balanced designs still have an advantage, including unbalanced environments with short distances between audio components. For unbalanced inputs, the barrel of the 0.1-inch plug is the “GND” terminal, and the signal conductor should be connected to the “+” and “-” as desired. In all cases, of course, the shield goes to the ground terminals.
3.36 Solid-Balanced Lines. Even if a balanced-line output is not available, the benefits of balanced-line input can still be obtained. Several cables will need to be made as follows:

The cable end which connects to the power amplifier would best be made as described in Section 334, using balanced-line cable. At the other end, using whatever plug matches the unbalanced output, connect the 'plus' conductor to the signal terminal, and connect the "minus" and shield conductors to ground. Do not connect the "minus" and shield conductors together at the power amplifier (balanced input end of the cable). This minimizes the inessence of signal ground and shield circuit ground needed to obtain balanced-line noise rejection. For more refinement, a variable-value resistance can be connected in series with the "minus" conductor, with a value roughly equal to the output impedance of the signal (usually less than 600 ohms). This resistance can be adjusted to null out any residual hum or interference.

3.37 Cross-Connecting Both Channels. In many professional systems, multiple amplifiers must be connected to the same signal, in order to drive banks of speakers to the desired sound level. The two individual channels of the Series Three amplifiers can be wired together by using a short patch cord from one of the output jacks on Channel 1 to any input jack on Channel 2, but a more permanent and dependable connection can be made using the barrier strip. To preserve the option of using the balanced line, connect the two "plus" terminals and the two "minus" terminals together with a shielded or twisted pair of wires, making sure to keep the conductors in the same polarity at each end. When this has been done, the signal can be brought into Channel 1, using either the XLR or X'mcJack, and it will feed both channels. The signal can be taken out of any remaining input jack on Channel 1 or Channel 2, etc., for additional amplifiers, etc. This "daisy chaining" procedure allows for many amps to be driven as required, subjected only to having sufficiently low source impedance. Since each channel has a 2Ω input impedance, equal to this value by the number of channels, for example, 16 channels will have a combined impedance of 38.5 ohms. In order to ensure that the source impedance is well above this value, to avoid excessive amounts of signal loss due to loading, if the combined impedance of the amplifier inputs is low enough to equal the source impedance, there will be a 4Ω loss of input level, which may still be acceptable as long as it is allowed for.

3.38 Good Quality Connections. Proper contact and stable performance are essential for good sound, and to avoid erratic noises or unreliable performance. 1/4-inch connectors are suitable for low-cost portable systems, but dependable being removed and replaced frequently to avoid corrosion build-up. 1/4-inch plugs are not recommended for long, undisturbed service, especially in corrosive environments. Copper plugs are especially bad in this respect. XLR plugs are preferred by professional users for reliable contact and better isolation. For permanent wiring harnesses, the barrier strip is cheapest and best. Spade terminals can be soldered or crimped onto the ends of the signal conductors. Be sure to use generous pressure, and test the resultant connection by pulling and checking. If the wire wiggles inside the cramped terminals, the contact will go bad. The speaker lug, or bare wire ends, with care, can then be tightly screwed down to the proper positions on the barrier strip. If high pressure is maintained in the crimp and the screw terminal, a "gas-tight" connection is formed which will exclude corrosion for many years.

3.4 Qucik Module Accessories

3.41 Quick Connector. Each channel has an octal socket for plug-in accessories. This is shipped with a protective label to prevent corrosion of the pins. The socket can be used with plug-in transformers, and has plus and minus 10 volts of DC power for a series of quick accessories. See Section 8.4 for pin assignments.

3.42 Input Transformer. Although the audio benefits of transformerless coupling are increasingly well recognized, certain users still prefer the security of a passive isolated input. It is possible to argue that extreme conditions of common mode noise and RF interference require transformer isolation to guarantee continued operation where an electronic input might become overloaded. QSC supplies a good quality input transformer model PSJ. Jensen Electronics (213) 787-0559 can supply an extremely fine line input transformer for QSC amps. model: JE-115-QN

3.43 Active Accessories. In a number of special cases, the user needs built-in power, high input impedance, remote gain control, input awaiting, etc. In order to serve these needs without adding to the basic cost of the amplifier, the octal socket has been equipped with low-level DC power tapped off the input transformer of the amplifier. Please contact QSC or your QSC dealer for a current list of available Octal Module accessories.

3.44 Passive Accessories. While Instruments, (510) 992-0752, can supply passive input accessories as well as input transformers.

3.45 Module Installation. Peel away the protective cover and plug in the module, observing correct alignment of the slot post in the socket. The internal switches (if any) are in the off position, and should remain in this position unless the switch is to be changed. The module is inserted into the slot on the amplifier. Please contact QSC or your QSC dealer for a current list of available Octal Module accessories.

3.5 Input Switches and Mono Bridging.

3.51 Each channel has a set of eight input program switches. These are located below the barrier strip, and are accessible by removing the screw-machined "switch access" and swinging back the plastic label (see Notes Section, 2.3). The switches can be actuated by any known object. Push the switch up to set the switch on (marked with an up arrow on the label) or push the switch down to turn the switch off.
SECTION THREE: INPUT SWITCHES

3.52 Switch Functions. A schematic is shown in Section 8.4. Switches 1 and 2 bypass the
octal socket when not in use. Switch no. 3 (on both channels) sets the amp for the bridged
mono mode, by connecting channel 2 in reverse polarity to channel 1. Switch no. 4 is used
connected to both channels, in various combinations, to a single Octal Module. Switches 8
and 7 and 8 set the XLR input polarity.

3.53 Table of Switch Settings. The following definitions need to be remembered:

a. Direct Input: Using channel without any module in place.

b. Bridged Mono Mode: Operation of the amplifier with channel 1 and 2 connected
to the same signal, but in reverse polarity, so combining the power of both
channels into one load (see Section 3.54).

c. Parallel Mode: Connecting both channels to the same input signal, in the same polarity,
for driving multiple sets of speakers or zones.

d. One-Way Octal Module: A module, such as a frequency filter or power limiter, which
has only one output signal.

e. Two-Way Octal Module: A module, such as an electronic crossover, which has two
output signals, such as high and low frequencies.

<table>
<thead>
<tr>
<th>Desired Set-Up</th>
<th>Switches “On” (Up/Down)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Input,</td>
<td>1, 1, 2, 2</td>
<td>For normal use of the amplifier</td>
</tr>
<tr>
<td>Stereo/Mono</td>
<td>(none)</td>
<td>Using a separate module for each channel</td>
</tr>
<tr>
<td>Octal Modules,</td>
<td>1, 2, 3, 4</td>
<td>Electronic balanced/unbalanced input into</td>
</tr>
<tr>
<td>Grow Mode</td>
<td>(none)</td>
<td>Channel 1, bridged mono output (see Section 3.54)</td>
</tr>
<tr>
<td>Direct Input,</td>
<td>3, 3</td>
<td>Channel 1, bridged mono output (see Section 3.54)</td>
</tr>
<tr>
<td>Bridged Mode</td>
<td>4, 1, 2, 4</td>
<td>Octal Module in Channel 1 feeds both channels</td>
</tr>
<tr>
<td>Octal Modules</td>
<td>4, 1, 2, 4</td>
<td>in same polarity for driving two separate</td>
</tr>
<tr>
<td>Permo Mode</td>
<td>4, 1, 2, 4</td>
<td>speakers, or zones with the same signal</td>
</tr>
<tr>
<td>One-Way Octal</td>
<td>4, 4</td>
<td>For Blanking, Low freqs. go to Channel 1, High</td>
</tr>
<tr>
<td>Module,</td>
<td>4, 4</td>
<td>Freqs. to Channel 2</td>
</tr>
<tr>
<td>Two-Way Octal</td>
<td>4, 4</td>
<td>Example: Bi-amp module in Channel 1, with</td>
</tr>
<tr>
<td>Module, to Both</td>
<td>4, 4</td>
<td>Limiter Module in series with High-Freqs. in</td>
</tr>
<tr>
<td>Channels</td>
<td>4, 4</td>
<td>Ch. 2 for tweeter protection</td>
</tr>
</tbody>
</table>

3.54 Bridged Mono Mode. With most stereo amps, it is possible to combine both channels
in series. This delivers twice the normal output voltage, and therefore permits the full
power of both channels to be combined in a single load of twice the normal impedance.
In other words, the combined four-ohm power ratings can be delivered to a single eight-
ohm speaker. This can be useful where headroom must be greatly increased, another
application is to drive high-voltage leads such as 75-volt and 100-volt audio distribu-
tion systems. Since both channels share a common ground, it is not possible to put them
in series in the ordinary sense: what is done is to feed the same signal to each channel
in opposite polarity. Thus, when one channel has, say, a 10-volt signal, the other channel
has a -10 volt signal. If the speaker is connected, or “bridged” from one channel’s out-
put to the other, the total voltage across the load will be 20v, or twice the value for either
channel.

To engage the bridged mode, connect the input to Channel 1 only (see Section 3.3 and
3.4). Set the Input Switches for each channel so that switch No. 3 is on (see Mode 5.33).
Connect the Speaker Input cable to the red binding post of Channel 1, or the “Spkr
1” position on the barrier strip; connect the negative speaker cable to the red binding
post of Channel 2, or to the “Spkr 2” position on the barrier strip. Finally, set both chan-
nels for the exact same Gain, recounting the detents to get the same setting.

A remarkable benefit is available in the bridged mode. The protection and muting relay
for each channel is designed to turn on that channel’s speaker to ground if the relay
shuts off. This will occur if the channel stops for any reason. In this case, the remaining
3.54 BRIDGED MONO CONNECTIONS

**APKR PLUS CONNECTION**

**APKR MINUS CONNECTION**

**CH 2**

**CH 1**

**USE CH 1 INPUT CONNECTIONS ONLY**

**DO NOT USE CH 2 INPUTS (POLARITY REVERSED) OR OCTAL MODULE SOCKET**

Channel can still drive the speaker in the normal (non-bridged) mode, at a level 6dB below the original level. Furthermore, the load on the remaining channel will be halved, which should ensure that it survives whatever the first channel takes. This sets the "Auto Back-Up" mode, and it can be used whenever the show simply must go on.

3.6 Speaker Connections

3.6.1 Speaker Terminals. Red and Black 5-way binding posts, on standard 34-inch centers, are located on the rear of the chassis. In addition, speaker connections can be made to the "SPKR" and "COM" connections or the barrier strip. All speaker labels are shown in red.

3.6.2 SPEAKER POLARITY

3.6.3 Terminal Polarity. The mil binding post, or "SPKR" terminal of the barrier strip, carries the positive or "hot" speaker output. The black binding post, or "COM" terminal of the barrier strip, are ground returns for the speaker. Do not ground the speaker common to other parts of the chassis or use the "COM" terminals for input signal grounding, as this will interfere with the groundlift function and might cause audio ground loops and oscillations.

3.6.4 Speaker Voltage. Because of the high power capabilities of Series Three amplifiers, there is a possibility of shock hazard at the speaker terminals, which can have peak voltages in excess of 90V (or 350V). Always make connections with the power off, and observe good wiring practice and avoid stray wire strands.

3.6.5 Speaker Cables. In order to obtain the full benefit of the high power and high damping factor, use must be careful to avoid cable losses. The basic idea is to use heavy-gauge, silver-stranded wiring possible, 12 gauge speaker cable is available, and heavier-gauge "specialty" cable is sold by audio dealers. We do not know of any advantage of "ultrashielding" braided or foil cables, over and above the total wire gauge and stranded (see Section 3.45).

3.6.6 Cable Termination. A major problem with heavy-gauge cables is that the ends are too large to fit most speaker terminals. Usually, it is necessary to install spade lugs on each end, which must be insulated or securely crimped. These must then be screwed firmly under the binding posts or barrier strip screws. Dual banana plugs are more convenient for portable systems, and will normally accept at least 12-gauge wires.

3.6.7 Bridged Mono. Please see Section 3.34 for the bridged-mono speaker connection.

3.6.8 Speaker Impedance. The Series Three amplifiers have adequate current capability to fully drive loads down to two ohms. However, many high-performance "booth" loudspeakers, especially multi-way systems with passive crossovers, have impedances at some frequencies which are far below the average earring. An impedance minimum of 2 ohms or less is not uncommon. For this reason, speaker impedance curves should be consulted before connecting speakers in parallel. We would expect Series Three amps to do an outstanding job with any 8-ohm, full-range speaker system, and we expect equally outstanding performance when driving 8-ohm loads without passive crossovers (as a sort of a back-fed system, for instance); 2-ohm loads should be approached with caution, as there is no further margin for impedance dips. The amp should not be damaged, but high power operation into reactive 2-ohm loads may result in overheating or excessive AC current consumption, causing shutdowns. In addition, some power may be lost at those frequencies where impedance dips below 2 ohms. For these regions operation with 2ohm loads should be limited thoroughly below fulling into use. The 3800 is best suited for continuous 2-ohm operation due to its wider power supply and greater number of output devices.

3.6.9 Speaker Wire Table. The following table is prefaced to assist in selection of appropriate speaker wire. Power losses and net damping factors (including the amplifier) are shown for a variety of lengths and gauges. Note that load power and damping factor are more severe for longer lengths, lower insulation loads, and higher amplifier ratings. One should maintain a minimum damping factor of 20, and preferably 50, for high-quality systems; this will automatically yield significant power loss. Although a power loss of 10% is barely audible, the resultant low damping factor will prevent the amplifier from fully controlling the peaks and dips in frequency response caused by speaker impedance variations. This will result in more coloration and fuzziness.
### Speaker Wire Table

<table>
<thead>
<tr>
<th>CABLE LENGTH, FEET</th>
<th>CABLE GAUGE</th>
<th>EACH CONDUCTOR</th>
<th>CABLE RESISTANCE 8 OHMS</th>
<th>POWER LOSS 8 OHMS</th>
<th>POWER LOSS 4 OHMS</th>
<th>DAMPING FACTOR ALLOWING FOR AMP.</th>
<th>DAMPING OF 200%</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.08</td>
<td>0.79</td>
<td>0.58</td>
<td>77</td>
<td>38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>0.12</td>
<td>1.58</td>
<td>1.18</td>
<td>48</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>0.19</td>
<td>2.56</td>
<td>2.08</td>
<td>66</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0.25</td>
<td>3.16</td>
<td>2.63</td>
<td>74</td>
<td>44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>0.50</td>
<td>6.32</td>
<td>5.84</td>
<td>14.7</td>
<td>7.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>0.75</td>
<td>9.46</td>
<td>8.76</td>
<td>22.0</td>
<td>11.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>1.40</td>
<td>18.00</td>
<td>16.00</td>
<td>33.3</td>
<td>16.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>320</td>
<td>2.80</td>
<td>36.00</td>
<td>32.00</td>
<td>66.7</td>
<td>33.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.7 Protection Features

#### 3.7.1 Summary
We've now ensured that accidents, mysteries, and abuse will have the minimum possible chance of harming the amplifier. The major challenge was to do this without impairing the audio performance into normal loads.

#### 3.7.2 Short Circuit Protection
The active region in a power transistor is surprisingly small—pointed tips of 5/8 of an inch. This little piece of silicon must control up to hundreds of watts of power. If not managed properly, this can burn out the silicon, instantly destroying the transistor. Under normal conditions, most of the power passes through the transistor, into the speaker, producing useful power and only some waste heat. Too many speakers (too low of an impedance) are connected, more power will be drawn through the transistor, and more heat will be wasted. If the load impedance drops to zero, which might happen if the speaker wires are shorted together, then there would be almost no limit to the power drawn through the transistors, and the waste heat will be so high that the transistor will burn out. This is why solid state amps need short circuit protection. The patented QSC "Output Averaging" short circuit protection acts by monitoring the load impedance. As long as it is within rated limits (above 2 ohms on the Series Three), the amount of waste heat in the power transistors is accepted, and full audio power is allowed to continue. If the output impedance is reduced below 2 ohms, two things will happen.

First the instantaneous current peaks will be limited, but to a fairly high value, that the transistors can handle for a short time, if a strong signal persists for more than a fraction of a second, the current limit is smoothly cut back to a lower value which the transistors can handle indefinitely. The result is full performance into rated loads, ability to handle normal program peaks into marginal loads, and good audio quality into short circuits. At no time will the circuit cause abnormal distortion spikes or loss of sound. You should expect short or abnormally low load impedances if the "Clip" LED lights before both "Signal Present" LED's come on.

#### 3.7.3 Thermal Protection
In case of blocked ventilation or prolonged short-circuit operation, the temperature of the heat sinks and power transistors may rise to excessive levels. If the heat sink temperature exceeds the "Flashing Red" TEMP LED on the front panel will begin to come on. The transistors will begin to overload and the power will be decreased. The temperature will continue to rise, and the "Flashing Red" LED will begin to blink, and the "Power Protect" LED will start to turn on. At this point, the cooling fan will begin to work, and the amplifier will enter a cooling mode. The "Flashing Yellow" LED will continue to blink, and the control circuitry will continue to run.

If the fans stop running, the "Flashing Red" LED will turn off, and the circuitry will be turned off. At this point, the "Power Protect" LED will turn off, and the circuitry will return to normal operation. If the fans start running again, the "Flashing Red" LED will turn off, and the control circuitry will continue to run.

#### 3.7.4 DC Fault Protection
All direct-coupled (DC) power amplifiers can dump raw uncontrolled power into the load if a power transistor burns out. In high-power amplifiers, this can destroy the speakers quickly. Therefore, many pro-audio amplifiers incorporate "DC fault" protection. The Series Three amplifiers have a circuit which detects the presence of abnormally DC and opens the speaker relay to prevent damage. The circuit triggers on long-term DC levels over 3 volts, and triggers within 0.3 seconds on DC faults of half the unipolar voltage, and within 0.1 second on full-voltage faults. This is the quickest response possible without triggering on very low-frequency program transistors, such as base drum beats. False triggering and unwanted shutdowns have been a problem with "nibbling" circuits which force the amp to turn off. The QSC circuit is free of false triggering because the low frequency response at the input is rolled off just before the trigger point for the DC fault detector. In addition, the circuit will automatically react in five seconds after the DC fault is corrected. An actual fault in the circuit will result in no hum, with the "Power Protect" LED lit.

### Section Three: Protection Features

#### 3.7 Protection Features

- **3.7.1 Summary:** We've now ensured that accidents, mysteries, and abuse will have the minimum possible chance of harming the amplifier. The major challenge was to do this without impairing the audio performance into normal loads.
- **3.7.2 Short Circuit Protection:** The active region in a power transistor is surprisingly small—pointed tips of 5/8 of an inch. This little piece of silicon must control up to hundreds of watts of power. If not managed properly, this can burn out the silicon, instantly destroying the transistor. Under normal conditions, most of the power passes through the transistor, into the speaker, producing useful power and only some waste heat. Too many speakers (too low of an impedance) are connected, more power will be drawn through the transistor, and more heat will be wasted. If the load impedance drops to zero, which might happen if the speaker wires are shorted together, then there would be almost no limit to the power drawn through the transistors, and the waste heat will be so high that the transistor will burn out. This is why solid state amps need short circuit protection. The patented QSC "Output Averaging" short circuit protection acts by monitoring the load impedance. As long as it is within rated limits (above 2 ohms on the Series Three), the amount of waste heat in the power transistors is accepted, and full audio power is allowed to continue. If the output impedance is reduced below 2 ohms, two things will happen:
  - First, the instantaneous current peaks will be limited, but to a fairly high value, that the transistors can handle for a short time. If a strong signal persists for more than a fraction of a second, the current limit is smoothly cut back to a lower value which the transistors can handle indefinitely. The result is full performance into rated loads, ability to handle normal program peaks into marginal loads, and good audio quality into short circuits. At no time will the circuit cause abnormal distortion spikes or loss of sound. You should expect short or abnormally low load impedances if the "Clip" LED lights before both "Signal Present" LED's come on.
  - **3.7.3 Thermal Protection:** In case of blocked ventilation or prolonged short-circuit operation, the temperature of the heat sinks and power transistors may rise to excessive levels. If the heat sink temperature exceeds 80°C, the flashing red "TEMP" LED on the front panel will begin to come on. The transistors will begin to overload and the power will be decreased. The temperature will continue to rise, and the "Flashing Red" LED will begin to blink, and the "Power Protect" LED will start to turn on. At this point, the cooling fan will begin to work, and the amplifier will enter a cooling mode. The "Flashing Yellow" LED will continue to blink, and the control circuitry will continue to run. If the fans stop running, the "Flashing Red" LED will turn off, and the circuitry will be turned off. At this point, the "Power Protect" LED will turn off, and the circuitry will return to normal operation. If the fans start running again, the "Flashing Red" LED will turn off, and the control circuitry will continue to run.
- **3.7.4 DC Fault Protection:** All direct-coupled (DC) power amplifiers can dump raw uncontrolled power into the load if a power transistor burns out. In high-power amplifiers, this can destroy the speakers quickly. Therefore, many pro-audio amplifiers incorporate "DC fault" protection. The Series Three amplifiers have a circuit which detects the presence of abnormally DC and opens the speaker relay to prevent damage. The circuit triggers on long-term DC levels over 3 volts, and triggers within 0.3 seconds on DC faults of half the unipolar voltage, and within 0.1 second on full-voltage faults. This is the quickest response possible without triggering on very low-frequency program transistors, such as base drum beats. False triggering and unwanted shutdowns have been a problem with "nibbling" circuits which force the amp to turn off. The QSC circuit is free of false triggering because the low frequency response at the input is rolled off just before the trigger point for the DC fault detector. In addition, the circuit will automatically react in five seconds after the DC fault is corrected. An actual fault in the circuit will result in no hum, with the "Power Protect" LED lit.
3.75 Turn-On/ Turn-Off Muting. The same protection relay used for thermal and DC fault protection serves to mute the speakers during turn-on and turn-off. When turning on the amplifier, the expected response is three seconds of silence, with the "PowerProtected" LED red. After three seconds, the LED should turn green as the relay "clicks" on. This allows any turn-on thumps to die away before the speakers are connected. As soon as the AC power is turned off, the relay should "click" off, silencing the speaker and muting any turn-off thumps. If AC power is lost for a fraction of a second, the relay will cycle briefly and then resume operation.

3.76 Input/ Output Protection. The amplifier inputs are isolated by 50K resistors, which are part of the balanced-input circuit. This provides the inputs from turn-on out due to extremely high input signals or RF interference. The amplifier output is isolated capacitor and inductive loading and a high frequency, RLC network, which decouples the speaker terminations at frequencies above about 50KHz.

3.77 Indicators and Protection Circuits. The "Signal Presence," "Clip" and "Temp" indicators will continue to function with the relay on or off as shown by the "PowerProtected" LED. The "Clip" LED accurately triggers on distortion of the power amplifier itself, but cannot distinguish between distortion caused at the inputs or prior to the amplifier. However, if the Gain control is kept above the half-way mark, premature input distortion should not be a problem. If you hear distortion without seeing any "Clip" indication, check the preceding components and the speaker. See Section 3.8 for trouble-shooting hints using the indicators.

3.8 Operational Troubleshooting

3.81 Summary. This Section contains troubleshooting hints which should help you determine if a problem is caused by the amplifier or elsewhere in the system. Using a step-by-step procedure, by comparing the function of both channels, and by using one channel to check the inputs and outputs of the other, a problem can usually be isolated. Refer to Section 2.3 for an illustration of the front panel and indicators.

3.82 No Sound.

"PowerProtected" LED does not come on at all.
No AC power—check AC switch (note: one for each channel), check AC plug, depress AC circuit breaker "Reset" on front panel. NOTE—the AC breaker requires a few seconds after an overload before it can be reset.

"PowerProtected" LED comes on, but stays red.
The amplifier channel is being held in the protect mode. If the fast-fading red "Temp" LED is on, the amp is overheated and will normally feel pretty hot.
If any of the "Signal Presence" or "Clip" indicators are on, the channel may be faulty. Try a normal level signal to see if the "Signal Presence" indicator appears to be tracking the signal. If this fails to release the relay, the channel is faulty and should be turned off and replaced.

A faulty Ostat Module or preceding component could also cause this symptom. Try unplugging any Ostat Modules and input cables and see if the relay will turn on in the normal three-second interval.

"PowerProtected" LED comes on, and turns green in three seconds.
The channel is probably OK, but there is a bad connection somewhere. If a normal input signal shows up on the "Signal Presence" LED's, check for faulty speakers or speaker cables (Section 3.6). If no "Signal Presence" indication is present, check the input cables (Section 3.3), input switches (Section 3.5), and preceding components.
If all of this checks good (by using the other channel, for instance the channel must have a faulty connection inside. It also fails that the relay "click" or cable feeding is faulty. Check the relay by trying it on the other channel. Check the jack by trying another type jack on the defective channel. A defective jack or plug can be bypassed in an emergency by cutting the plug off the cable and wiring directly to the barrier strip (Section 3.3).

3.83 Weak But Clear Sound.
Normal Signal Presence indication—both the "3 dB" and the "6 dB" LED's come on before the red "Clip" comes on. This indicates that normal signal level is reaching the amplifier but not getting through to the speakers. Check for defective or improper (thin-gauge) speaker cables, or bad speakers. A lack of treble or bass would normally be caused by failure of part of a two or three-way speaker system.

Low or Missing Signal Presence if only the "3 dB" LED comes on, or none at all, the signal going into the amp is weak. First check the amplifier's Gain control, ensuring that it's not the line out of the tape deck. Then check sound distortion. If the Gain is normal, then the problem should be prior to the amplifier. Some loss of volume without distortion is usually not a connection problem. However, a moderate 6dB (loss of volume) will occur if an unbalanced input is made without proper termination of the "unins" input (Section 3.5).

3.84 Weak and Distorted Sound.
"Clip" indicator comes on before the "6 dB" indicator: this indicates that the amplifier is clipping before full output is reached. This can be the result of a faulty channel, but usually it indicates a shorted cable or excessively low load impedance.
If the "Temp" LED begins to flash after a while, this is almost certainly the problem. If two speaker systems are connected to the same channel, a short at one of the speakers will cause this symptom in the other (the shorted speaker will usually be dead).
Distortion without "Clip" indicator: This shows that the distortion is not being caused in the amplifier itself. "Mechanical" distortion, such as rattles, scraping, cutting in and out, etc., will usually be caused by bad speakers or speaker cables. "Electronic" distortion, such as background hiss, buzzing, or static, will usually be traced to defective electronics. In most cases, defects in the amp will trigger the "Clip" LED, so check the preceding components by connecting to the other channel and check the sound. Please note that the Gain control on the amp must be kept above half, and should be kept within a few clicks of full, in order to assure full output from the amp before the input stage overloads. If the amplifier Gain is less than half, it is possible to distort the input without showing on the "Clip" indicator.

3.85 Sound Cuts In and Out.
This is caused by a bad connection somewhere. See if shunting the amp or the inputoutput connectors causes the problem. If the sound seems to vary by itself, examine the Signal Presence LED's, to see if the dropouts show up on the indicators. If they do, the problem is in the amp or before the amp. If the indicators hold steady, sound variations must be coming from the speaker or speaker cables. An intermittent connection on one side of the balanced input can cause a 6dB fluctuation of input level (Section 3.3 and 3.4).

3.86 Sound Has Bad Tone (poor treble or bass).
The amplifier itself is very unlikely to develop a frequency response problem, without more
SECTION THREE: TROUBLESHOOTING

serious effects. Therefore, lack of frequency range must be traced to the speakers or preceding units (mid-adjusted equalizers, etc.).

3.87 Lacks Power.
This is a common but indefinite complaint. Is there a lack of power in the sense that it is soft but clear (see Section 3.88) or does it seem to distort too easily (see Section 3.84)? Also, be aware that speaker efficiency will drop perceptibly after heavy usage, due to the increased resistance of the voice coils as they heat up; this will return when the speakers cool down. In a multi-speaker system, be sure all of the speakers are still working. Finally, of course, your ears get used to high sound levels, and as the room fills up with people, the sound will also absorb much more easily. Only a sound level meter, used with a standard signal level as a reference, from a distance from the speaker, can tell if you are getting the output expected.

3.88 Unwanted Noises.
Hum—in this case, defined as a fairly rounded 60-cycle tone. Severe hum usually is caused by broken cables or jacks, with disconnected grounds (shield). This problem can also be caused by corroded connectors, especially 1/4-inch type. For this reason, high-quality systems should use the XLR or barrier-strip inputs. A milder form of hum, often with a little more "tone" or harmonic content, is usually the result of ground loops. This problem is caused by 60-cycle magnetic fields, which radiate from power transformers, including the ones in amplifiers. By repositioning the cables away from the various components, note that tape recorder heads, phone cartridges, and electric guitar pickups are especially sensitive to this type of interference, and must be kept away from high-power electronics.

Buzz—defined as a very "nasty" kind of hum. This is usually caused by interference from solid-state light-dimmer circuits. Follow the same precautions shown above, and make sure the electronics are not connected to an AC outlet which has a dimmer control.

Hiss—defined as a smooth "shsh" noise. This is always a problem with sensitive, high-gain electronic inputs, and usually starts at the point of weakest signal. In a properly designed system, this will be the internal microphone, phono, or tape source. There is a noise "floor" caused by random atomic vibrations. This limits the signal-to-noise ratio of the input signal. The goal of a proper system is to immediately amplify any signal well above the noise floor so that further degradation does not occur. "Gain staging" is a principle subject in itself, but the principle is to maintain a reasonably constant signal level after leaving the initial pre-amp. The signal must be kept below the point of distortion, but still high enough to adequately drive the source of unwanted hiss, start at the amp, and work backwards, reducing and then restoring gain. You should hear a reduction in hiss, and also a signal improvement. This process can be repeated in earlier. When you find a control which lowers the audio volume, but not the hiss level, you know the hiss is coming in after that stage. Assuming that the hiss has not always been there, this indicates defective electronics. Certain special-effects units are rather noisy, so compare with other units.

Crackles—defined as a "popcorn" noise. If the crackle persists during pauses, this indicates defective electronics, and must be traced down using the above procedure. Crackles which occur during audios pre-rolls or when the electronics are vibrated usually indicate bad connections.

SECTION FOUR: RACK MOUNTING, SPEAKER PROTECTION

4.1 Rack Mounting and Cooling.
4.11 Heat Production. Many users question the ability to avoid excessive temperature rise when packing high power performance into a low-profile chassis. This is a valid concern, which has required fan cooling in past designs. In order to avoid the fan noise and dust buildup, we decided to reduce the waste heat by using a higher efficiency design (see Section 4.1). The resultant heat production is equivalent to an amp of only three or four times the power. By looking through the vents on each side of the chassis, you will see more heat sink area than some conventional amplifiers. Our combination of combined with generous dissipation surface results in cool running with normal convective cooling. For instance, maximum unencumbered mantle operating at 120W will see a 25W resistive load (to simulate 40W reactive load) will cause a temperature rise of only 30C.

4.12 Air Flow in Racks. While the amp will handle high powers comfortably while standing alone, the usual precautions are necessary when mounting several in a stack. -As air rises, and the amplifiers at the top of the stack will get heated after the low ones. This tendency can be circumvented in several ways. The usual method is to fan cool the entire rack, which circulates enough fresh air to all racks to prevent heat build-up towards the top. If fans can't be used because of noise or maintenance, then spaces should be left between the amps. The amount of space depends on the average power and duty cycle of the program, for low powers or reduced duty cycles, no spacing may be necessary.

4.13 Rack Mounting. Because of the chassis depth and low profile of the mounting ears, we recommend rear support, especially in portable systems. The Series Three amplifiers are rear mounting ears with the same EIA rack holes as the front ears, but parallel with the sides of the chassis so the amp can slide into position. One must be careful following diagram for mounting dimensions. Please note that extended rear support ears are available for the 3200 chassis, which match the mounting-dimensions of the 3500/3500 chassis. DSC also has rear support straps available.

4.2 Speaker Protection.
4.21 Background. Speakers have several limits which should not be exceeded for reliable operation. It is the user's responsibility to determine these limits and operate the amplifier accordingly. We offer several ways to avoid unexpected accidents, but you must still select speakers of appropriate type and power capacity.

4.22 DC Protection. The use of direct-coupled electronics extends the bass response, and prevents low frequency phase shift, but the penalty is signal. The goal of a proper system is to immediately amplify any signal which can become excessive in case of electronic failure. For this reason, we have included a "DC Protection Relay" on Series Three amplifiers. This will quickly remove the output to the speakers if excessive sub-woofer or DC signals are detected. The circuit responds to DC outputs in excess of 3 volts, and will also detect the source of unwanted hiss, start at the amp, and work backwards, reducing and then restoring gain. You should hear a reduction in hiss, and also a signal improvement. This process can be repeated in earlier. When you find a control which lowers the audio volume, but not the hiss level, you know the hiss is coming in after that stage. Assuming that the hiss has not always been there, this indicates defective electronics. Certain special-effects units are rather noisy, so compare with other units.

4.23 Hum Driver Protection. The compression drivers used with horns for high-frequency reproduction have special protection requirements. These drivers are more delicate than large cone speakers, and more vulnerable to overload damage. In particular, the driver has a low-frequency limit which must be carefully observed. Below this frequency, the driver diaphragm can "bottom out" which will immediately alter the frequency responses, and quickly cause failure. To prevent this, the user must make sure that a proper crossover network is installed. In bi-amp systems, where the driver is connected directly to the amplifier, the user must be especially certain that the correct frequency is used on the electronic crossover, and that no low-frequency signals, such as loud horns, get into the signal path between the electronic crossover and the power amplifier. As further pro-

4.24 Tension, especially against accidental mis-adjustment or bad cables, many users install...
4.23 HORN PROTECTION CAPACITORS

- Mount protection capacitors in series with tweeter.
- - Example: 3 capacitors combined in parallel for total value of 15 pf.

4.24 Power Capacity. All speakers have a maximum long-term power limit which is determined by the temperature rise of the voice coil. The speaker can withstand short peaks above this level, since the voice coil takes a little while to heat up. The time lag depends on the size and mass of the voice coil and ranges from a fraction of a second to several seconds. The required speaker rating for a given amplifier power depends on the type of program material. Extreme cases such as lead guitar work may require speaker ratings of twice the RMS power of the amplifier to withstand the full peak power. The average power of signals where some attempt is made to prevent overdrive distortion will be less than the amplifier RMS rating; however, it depends on the dynamic range and headroom allowance. In live-performance situations where feedback and high-energy artists may push the system to its limits, it would probably be wise to match the RMS ratings of the speakers and the amplifiers.

4.25 Power Limiting. There are several ways to limit the power to safe levels without operator intervention. Some speaker systems have protective circuits, or all of these. Fuses can be added which will blow in case of overloads, the problem is to select a fuse with the correct time lag and overload characteristics to match the speaker limitations. The speaker manufacturer is in the best position to specify these values, the following table is presented for rough guidance only. The fuse values shown are calculated for flat-topped fuses, which will carry 150% of their rating for an hour, and which blow within 1 second at 200% current. The RMS power rating is correlated to 133% of the fuse current.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>8-ohm Driver</th>
<th>16-ohm Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>800f</td>
<td>40,000f</td>
</tr>
<tr>
<td>800</td>
<td>500</td>
<td>25</td>
</tr>
<tr>
<td>1000</td>
<td>400</td>
<td>20</td>
</tr>
<tr>
<td>2500</td>
<td>500</td>
<td>16</td>
</tr>
<tr>
<td>3000</td>
<td>330</td>
<td>10</td>
</tr>
<tr>
<td>3500</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>7000</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

The fuse voltage is not critical; 32 volt fuses should have the lowest resistance which will avoid loss of damping factor.

The power supply may also be limited with active circuits. QuadBoard compressors or limiters are used for this function. In addition, QSC offers a plug-in Octal Module Limiter which can be adjusted to cut a ceiling on the power level, as high as any compressor, the circuit should be reduced volume as necessary to keep the power below the desired ceiling. Individual plug-in limiters let you set the power ceiling independently for each channel, without the 'nonsense and interruptions of fuse protection. Please ask QSC for separate literature on the Octal Modules.

4.26 User Responsibility. Remember that the Series Three amplifiers are very powerful, with extra peak power (dynamic headroom) in reserve. Observe the hookup and operating precautions. QSC is not liable for any damage to loudspeakers caused by overloading, wrong-frequency operation or electronic failure.

4.3 Distributed Sound Systems

4.31 Definition. A distributed sound system uses a constant voltage distribution network which feeds many individual speakers. The principle of operation is similar to an ordinary AC power system—a fixed voltage is sent to all the speakers, and each speaker is adjusted to draw the desired power level. Standard voltage levels like 25V, 70V and 100V, or higher, of which 70V is the most common. A complete treatise on such systems is beyond the scope of these instructions, but a primary benefit to the installer is the elimination of complicated impedance calculations when setting up many speakers. Each speaker has a small transformer which can be set, or "latched," to provide various power levels, such as 1 watt, 2 watts, etc. To match the total number of speakers to the amplifier, all that is required is the impedance and up to settings of all the speakers, and then ensure that at least this much amplifier power is available. The other requirement is that the amplifier be able to deliver the correct voltage for the desired system (25V, 70V, etc.).

4.32 70-Volt Systems. Most commercial sound-distribution systems use 70-volt components. In this capacity the speaker works at a relatively high voltage, and using small transformers to convert to the desired voltage at each speaker, the losses in the speaker distribution wiring are reduced without the expense of extra heavy gauge wire. Furthermore, as explained above, the individual speakers can be separately adjusted for power level. Speaker mounting and adjustment are outside of the scope of these instructions. The main concerns here are in ensuring the Series Three amplifiers to drive 70-volt lines, and the amount of power available to each system or zone. Series Three amplifiers can be bridged to deliver 70-volt lines directly. The amount of power available is determined by the amount of loading which brings the clipping voltage down...
SECTION FOUR: DISTRIBUTED SOUND

4.34 100-Volt Systems. For very large stadium systems, 100-volt and higher distribution is often used. Since these installations normally use large numbers of amplifiers, QSC will be happy to consult directly with installers. Because of the high rail voltages, the 3300 is capable of delivering at least 600 watts, and the 3800 will deliver 1200 watts in the bridged mode to 100-volt systems. QSC does not have any stock transformers for 100-volt or higher conversion.

4.4 Ground-Lift Strap

4.41 Background. AC ground loops are a constant problem in very high-quality systems, where hum is to be eliminated completely. The primary cause of AC hum in cable systems is due to AC currents which are induced in the chassis and cable by the large power transformers. It becomes a problem when there is a “conflict” between the secondary grounds of the chassis (connected to the third pin of the AC plug), and the signal grounds of the circuit and input jacks. The best way of eliminating this conflict is to use balanced lines, since, by design, balanced lines reject the effect of ground conflicts. In some cases, however, due to only unbalanced lines being available, or because of slight residual hum, it is still desired to eliminate the ground conflict. Some users do so by lifting the third pin on the AC plug with a two-wire adaptor. This may be used as an ad hoc test, to see if the offending hum is caused by a ground loop or by other causes (see Section 3.88). If the hum is eliminated by the two-wire adaptor, you have identified the problem, but the amp should not be operated this way. Safety considerations require that the chassis be kept grounded, to protect against shock hazard should something burn out.

4.42 Ground Lift Straps. Series Three amplifiers have the electronic circuitry isolated from the chassis; all jacks and speaker “grounds” are insulated from the chassis. For normal operation, the chassis grounds and circuit grounds are connected by a metal jumper connected between the two terminals of the “Ground Lift Strap” located on the rear of the amplifier. This jumper should be left in place if possible, since this maximizes chassis sharing, and decreases the possibility of electric shocks being coupled to other parts of the system in case of severe faults. If the ground lift is Section 4.41 is removed, the hum, return the full three-wire plug to the socket and remove the ground lift jumper. This should have the same effect on the circuit, without loss of safety grounding. Be aware, however, that the amp’s electronic ground now depends on the components to which it is connected; safe consistent operation now depends on the installer and the quality of the other equipment. We strongly advise that the ground strap be left in place in ordinary installations and especially in portable service.

4.33 25 Volt Systems. Although this voltage is not as common as 70 volt systems, these systems have definite advantages, especially in smaller installations. First, local building codes usually require special “Class I” wiring for 70 volt systems, which is not required for 25 volt systems. Secondly 25V is available directly from the output of all Series Three amplifiers, and thus no output transformer or bridging is required. The maximum power available into a 25V system, for each channel is:

- 3300: 250 watts
- 3800: 350 watts
- 3330, 350 watts
- 3800: 425 watts
- 3300: 600 watts

As explained in the previous section, these powers should be derated somewhat for most reliable operation, although systems with low duty cycles can use the full rating without safety. Also note that because the 3300 has an output voltage which is much higher than 25V, it is somewhat of an “anomaly” compared to the 3300, and performance is not fully utilized.
5.1 Overview
The Series Three power amplifiers from QSC Audio Products are designed to meet the challenges of commercial and pro-audio applications better than any products now on the market. We have incorporated an outstanding combination of performance and reliability features, based on extensive discussions with leading audio consultants as well as our own experience. We think you will find that attention to detail and thoroughness of execution, combined with definite design breakthroughs, distinguish this exceptional new series of power amplifiers.

Our overall goal has been to provide a series of reference-quality professional amplifiers, designed specifically for major shows, touring companies, and engineered sound installations. The audio performance is designed to meet the standards of recording engineers and other sensitive listeners over the entire audio range. Equal attention has been paid to operational ruggedness, both electronic and mechanical. We have protective features to guard against all known hazards and user errors, yet the warnings have been kept on maintaining operation and avoiding mishaps wherever possible. This series is explicitly designed for a long, maintenance-free lifetime, and thus no cooling fans or other moving parts are used. We have developed an effective high-efficiency circuit which reduces waste heat by at least 50%, with minimal complexity or untried new techniques. This permits the use of a lighter weight, low-profile chassis without compromising load carrying ability or temperature rise. Conventional power transformers are retained for reliability, reasonable power factor and to permit operation on various AC voltages. A full complement of independent output connections and socket connectors for each channel provide unmatched installation flexibility. And finally, an infinitely variable modular design permits fast on-site repair, without compromising the basic ruggedness of the unit.

5.2 Input Section
We have obtained truly superb audio performance through a combination of basic design and parts selection, each verified during repeated listening tests by audio engineers and audiophiles. We have retained the basic circuit topology pioneered in our existing line of power amplifiers, since it requires a minimum of amplifying stages. This, combined with careful selection of metal film resistors and parts construction, contributes to electronic and thermal stability.

One of the basic requirements of a professional amplifier is that it interface to preceding components in the system without hum or other interference. A balanced line input is often required, and is standard on an QSC amp. We use a high-performance dual op-amp for the balanced input stage so that the gain block for the power amplifier in the Series Three, this is the highly-regarded 5521, which has exceptionally low input noise, a power bandwidth of 300 kHz, and a noise floor of +50 dB.

The balanced-line input stage operates at unity gain and has an impedance of 100 ohms per side, for a reasonable compromise between line loading and low input noise. The resulting signal-to-noise ratio is 100 dB or unwrapped. We use precision metal-film input protection for stability, low noise and high common-mode rejection. Full range distortion of the stage remains well below 0.003% and the 1% bandwidth product of 101 M

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5.3 Output Section
The power amplifier circuit itself must deliver as much undistorted power as possible to a wide range of different loads. This means that it must deliver stable, output into reactive as well as resistive and adequate load bearing capability for years of reliable operation at high power.

The QSC circuit basically consists of three stages; the op-amp gain block, the complementary driver transistors, and the complementary output transistors. The op-amp gain block uses the high gain-bandwidth and well-balanced phase shift of the 5521 to assure high loop gain and stability, and its fast slew rate ensures quick recovery form clipping. This type op-amp also has a generous and symmetrical output current, which allows the primary phase-capacitor a high and symmetrical slew rate while still using enough leg compensation to assure stability. The resultant power bandwidth of the amplifier is over 50 kHz.

Several forms of high frequency compensation are used to minimize high frequency distortion. The primary leg compensation is taken around both the output and driver stages, so that this extra high frequency feedback helps to minimize crossover distortion rather than simply damping the high frequency gain. We also use phase-cancellation at various points in the circuit, which extends the amplifier bandwidth and prevents the need for excessive leg compensation. This maintains the high slew rate. High frequency response is down only approximately 0.003 dB at 20 kHz, and -3 dB at 300 kHz.

DC offset at the output is only several millivolts, due to the very low output resistance of the 5521 and the use of a single-pole low frequency rolloff in the feedback network, which reduces DC voltage gain to unity. We added a Butterworth compensation network to this low frequency rolloff to hold response flat with a 100 kHz bandwidth and a -1 dB point at 140 kHz. This configuration is necessary for excessive sub-2 kHz response. Response is -3 dB at 8 kHz, which preserves the response of other levels between any sub-2 kHz response. Response is -3 dB at 8 kHz, which preserves the response of other levels between any sub-2 kHz response. Response is -3 dB at 8 kHz, which preserves the response of other levels between any sub-2 kHz response. Response is -3 dB at 8 kHz, which preserves the response of other levels between any sub-2 kHz response.
SECTION FIVE: HIGH EFFICIENCY DESIGNS

device which we ultimately selected have an outstanding combination of good high frequency response, linear gain, crisp saturation, and excellent noise operating area. In addition, the dynamic and static characteristics of the NFPh and NFPH pair are better matched than the more common SiN-MOS pairs.

The Rf is better than 6 MHz, which means that the open loop gain does not begin to fall off until the frequency increases beyond the audio range. In addition, the variation of gain vs collector voltage is quite minimal, as is the variation of gain vs current. The combination of these factors explains the consistency good listening properties of these devices as gain and phase shift at high frequencies is not greatly modulated by lower frequency current and voltage excursions. This subtle effect, which is not measured by distortion or Mfactor analyzers, is in the overall circuit damping factor; and comprises a more likely explanation of "solid-state harshness" than the recent obses- sion with extremely low and sometimes vanishingly low distortion.

These power transformers also have an outstanding self operating area, certainly as good as any devices we have tested. They will withstand even greater short term overloads, which provides excellent SOA capabilities during extreme low frequency operation and reactive loads, as well as enduring the stress of short circuits.

Since long-term reliability is of paramount importance, we have decided not to use the new plastic-case output transformers. There are potential long-term problems which are difficult to uncover with accelerated testing. Experience has shown that plastic case devices are more vulnerable to vibration of the leads, which can loosen slightly in the plastic and allow corrosion to creep in, which eventually causes no ments. In addition, the encapsula- tion of the coil and bonding wires in solid epoxy greatly increases the stress caused by thermal expansion, leading to thermal fatigue after as low as 10% of the thermal cycles of the plastic case format. The non-permeable nature of epoxy also allows contaminants to diffuse in which places sole isolation on chip passivation to resist degrada- tion over a period of 10 to 20 years.

Some plastic case clamps claim a larger heat transfer surface to the heat sink, although this advantage is somewhat negated by a 10°C to 20°C temperature limit. However, the heat dissipation is directly to a common heat sink, without the usual mica insulating washers. This gives the lowest possible thermal impedance and keeps all devices at a more even temperature than any style case using insulators.

In short, plastic-molded power transformers may serve well for consumer electronic prod- ucts, but at this time only hermetic metal-case power transformers have a proven reliability record in high stress, high volume professional amplifiers.

5.4 HIGH EFFICIENCY

One of the problems in a high-power design is the thermal losses inherent in the conventional linear output stage. A major circuit innovation in the Series Three is our first use of an 80% efficient, linear output section with fairly good efficiency, at full power, of about 65%, depending on saturation losses. However, efficiency drops rapidly as power is reduced, and losses actually vary from about one-third power. Even at 10% of rated power, losses are about as high as full power. Users who need maximum power output may operate their amplifiers at 10% to 30% average power levels (10D to 50D crest factors) depending on the amount ofclip- ping which is intended. This means that conventional amps are frequently used at their worst-case power losses under realistic operating conditions.

The reason for these high losses, of course, is that the output transistors must dissipate the difference in voltage between the DC supply and the audio output voltage. At full power, this voltage difference is fairly small and the efficiency is acceptable. At lower powers, the output current is less but still required, while the output voltage is only a fraction of the maximum. This means that a large, at substantial current levels, must be
dispatched. Only when the power drops well below 5% will the currents become small enough for the output losses to abate.

One class of solutions to this problem is the class D or PWM amplifier, where a varying output voltage is synthesized using a rapid transistor switch whose duty cycle is varied. In principle, this design can have a high and constant efficiency at all powers. To achieve this in practice requires low saturation voltage and very fast switching transistors, as the dissipation is very high during the transition periods. The switching frequency must also be many times higher than the maximum audio frequency to achieve the high quality, low-distortion performance we are used to. In addition, RF problems must be overcome, new protection circuits devised, and sensor circuits to detect current must be derived. An entirely new technique for these reasons, class D amplifier designs have not been practical for high qual- ity, high reliability applications.

Another conceptual approach is the "smart" power supply whose DC level changes quickly in accordance with the audio level. This scheme retains the well-understood linear output stage, and has actually been offered in various forms. A high-speed switching power supply would offer more weight and power reductions, but suffers from most of the objections of the class D amplifier, as well as possibly giving a lower power factor and needing a serious objection in any large system, as AC wire sizes and circuit breaker are sensitive to current levels, which increase when the power factor is reduced. Even the conventional AC power transformer with rectifier has a fairly low power factor, and no further reduction is desirable.

We have therefore adopted a multiple level DC supply, with conventional power transformer and rectifier. Output voltages from 0 to 50% are derived from a full, high-voltage output power supply, thus splitting the large losses into many small ones. If these voltages were drawn from the full supply, only the instantaneous voltage level exceeds that of the half-supply, the full voltage supply utilized. At these voltages, of course, the losses are reasonable in comparison to the output power being delivered. The net effect is very much like replacing a large inefficient engine with a smaller engine having a supercharger for peak demand. Even during severe flame, the amplifier spends most of its time run- ning from the lower power supply, thus dramatically increasing efficiency and reducing wasted heat. Even at full single-ended output, the parts of the waveform below 50% are pre- duced from the lower supply, which still reduces losses considerably.

The primary design challenge is to achieve this result with a minimum of extra com- plexity and without impairing audio performance. We experimented with switching tran- sistor in series with the output transistors, but the added saturation losses diminished full power efficiency and high frequency spikes were coupled to the output. In short, it was not possible to retain the direct-metal mounting for all devices. Therefore we use a parallel structure of half-voltage and full-voltage transistors. The signal switches from one set to the other much as it switches from the PNP to the NPN transistors at the crossover point. The switching transistor is comparable to the crossover switch, without any large-scale spikes. The added distortion and noise level for the output section occurs within 6dB of clipping. The added distortion at lower frequencies is proportionately less, giving overall distortion, including hum and noise, 3 to 4% at 40m volts, and about 1% at 1mV. At 1kHz distortion does not exceed 0.2% over the full power operating range.

This approach does not save on the number of output transistors, since each set of devices is called upon to handle about half the total power. However, the voltage stress on each set is reduced, which helps improve safe operating area, especially for reactive loads. Since the two sets are in parallel, there is no accumulation of saturation voltage, which gives maximum output power for a given excursion. The output device can be direct-metal mounted on a common heat sink, which greatly assists in equalizing temperature in case the output signal happens to dwell. Because of the parallel arrangement, there are several "softstart" modes where the power amp...
can continue to operate at reduced efficiency where conventional designs would fail completely. Since the circuit is a direct extension of our existing design, servicing is straightforward, and we can take advantage of the excellent reliability history of our present series.

The overall advantage is, of course, the significant reduction of waste heat. This lets us reduce the size and temperature rise of the heat sink without the long term noise and dust problems of internal fans. A tightly loaded rack of these amps, if heavily driven, will require a fan pack, but this is easier to clean and maintain than multiple internal fans, and smaller installations using only a few amps need no forced cooling at all.

5.5 Mechanical Design

The chassis and mechanical structure of the Series Three meets the following objectives: maximum power per unit of rack space, extreme ruggedness for safe transport, good ventilation and protection of the heat sinks, excellent internal shielding, and provision for front-removable modular channels for fast replacement in case of breakdown.

The high efficiency circuit, combined with twin low-profile transformers enables us to offer unprecedented power per inch of rack height. Extreme ruggedness is achieved by use of #14 ga. steel for the overall chassis, and 1/8 inch steel for rack mounting flanges and rear support flanges. The rear support flanges are provided with matching rack mounting holes to permit use of standard rails for rear support. The shallower 1.75 in. chassis is available with optional extended rear supports for mounting on the same rear rails as the deeper 3.15 in. chassis, if desired. Internal welded bracing and steel faceplate augment the strength of the design.

The heat sinks are mounted along each side of the chassis for maximum cooling sur-
face without using upper panel space. The chassis completely encloses the heat sinks in a machined vented cage for protection without impairing air flow. Vents are also pro-
vided around the power transformer, and all vents align vertically when racking for un-
blocked air flow and better forced cooling when needed.

The power transformer and AC wiring are housed in a central bay with welded steel walls on each side. This assures full shielding and separation from the channel modules mounted on each side.

The channel modules themselves contain all amplifier parts except the rear connec-
tors, AC switch, circuit breaker, and power transformer. The major reason, of course, for front removable modules is to quickly restore a faulty amp without removing and replac-
ing all of the rear connections. For performance-oriented use this restores function in the shortest time, and for fixed installations it saves a second trip by the technician to return the required amplifier. Since these amps are designed for extreme reliability, the modular feature should rarely be needed, but it can be invaluable on those few occa-
sions, if only as a troubleshooting device. Since this is basically a form of insurance, we look care that the modular design does not add to the cost of the amp or become a source of unreliability in itself.

To ensure long-term integrity, even after rough handling, we avoided using rigid con-
nectors which could crack or become misaligned because of chassis deformation. A locking gold-plated connector with flexible cable handles the input signals, and a high-current insulation-displacement cable connector locks into place to handle the high power con-
extors. Due to reduced labor, the expense cost of these connectors is equivalent to soldered wires or good quality edgecard connectors. Unlike rigid plug-in systems these connectors have the flexibility to withstand vibrations without damaging the contacts.

Both channel modules are accessed by removing the faceplate. This retains the full strength of a single faceplate, and avoids the problem of recycling a used faceplate when a module is replaced. After removing the faceplate, the channel is removed by unplugging the two connector cables, which are located up front for access. Safety considera-
tions can for complete removal of AC power until the integrity of the transformer insulation is determined (see Section 8.2).

Stereo amplifiers have the potential advantage of having two channels available in case one should fail. However, this advantage is lost if a faulty channel forces shutdown of the whole unit. The Series Three has completely separate power supplies and protection systems for each channel. Separate AC switches and breakers are front-mounted for easy access. This assures maximum independence of operation. Cross-talk and especially cross-distortion and cross-modulation effects are inherently eliminated. This maintains a stable image for stereo applications, or permits each channel to be used for indepen-
dent signals. Any possible failures will be confined to the affected channel. This makes complete loss of performance very unlikely.

The use of two power transformers distributes the weight and heat more evenly, and contributes to the low profile of the chassis. Transformers are mounted in a central bay enclosed by welded steel channels, which gives good shielding and resists damage. Each channel module has heavy duty bridge rectifiers which are mounted on the heat sink for full back-barring capability. Multiple, parallel, high density filter capacitors are used to store the DC energy. This provides the high energy storage for sustained low frequen-
cy notes, good transient capability (high dynamic headroom), and minimal AC ripple. These capacitors have low ESR and inductance, especially since they are used in parallel, and are mounted directly on the modular PC board for minimum stray inductance. The filter council or caps are manufactured using automated process control and high purity materials which give low electrical leakage, even at high temperature. This, combined with voltage derating, assures a long service lifetime. The table below shows the values for each model in the series.

<table>
<thead>
<tr>
<th>Model</th>
<th>Total Capacity (uF)</th>
<th>Capacity Per Channel (uF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3200</td>
<td>26,400</td>
<td>13,200</td>
</tr>
<tr>
<td>3300</td>
<td>26,400</td>
<td>13,200</td>
</tr>
<tr>
<td>3500</td>
<td>31,200</td>
<td>17,600</td>
</tr>
<tr>
<td>3800</td>
<td>57,200</td>
<td>28,600</td>
</tr>
</tbody>
</table>
6.1 Bench Tests vs. The Real World

The objective of bench testing is to predict the amplifier’s suitability for real-world applications. The success of this endeavor depends on the choice of tests made and their relevance to the actual applications. It is well-known that two amplifiers which have similar specs on the bench may sound different in use. This suggests that the bench testing was incomplete or that the wrong tests were used.

Most reviewers have a well-established body of tests which they have performed on a large number of amplifiers. The experience gained with many different amplifiers gives the reviewer a better chance for comparative analysis of the amp under test. The Series Three amplifier is designed for demanding professional service, and should be able to handle any combination of input signal and load. The reviewer is invited to “thrust” the amplifier with demanding abuse tests, including high-frequency square waves, low impedance loads, reactive loads, light and heavy clipping, short circuits, open circuits (both inputs and outputs), tone burns, and any other test which the reviewer can devise to exploit “bad habits.” We have designed the Series Three to sail through such tests gracefully, or at the worst, activate a protective circuit to prevent damage. We are always interested in any misbehavior during such tests, as we feel that proper handling of unusual signals can improve real-world performance greatly.

6.2 High Efficiency vs. Standard Efficiency

One factor which should be recognized is the difference in behavior of Series Three amplifiers in the different classes in which they are designated. The high efficiency class of amplifier has a smaller efficiency, and this class of amplifier should be used for lower heat dissipation. The amplifier is designed for demanding professional service, and should be able to handle any combination of input signal and load. The reviewer is invited to “thrust” the amplifier with demanding abuse tests, including high-frequency square waves, low impedance loads, reactive loads, light and heavy clipping, short circuits, open circuits (both inputs and outputs), tone burns, and any other test which the reviewer can devise to exploit “bad habits.” We have designed the Series Three to sail through such tests gracefully, or at the worst, activate a protective circuit to prevent damage. We are always interested in any misbehavior during such tests, as we feel that proper handling of unusual signals can improve real-world performance greatly.

The thermal losses of the standard circuit are well-understood. Losses are substantial at full power, but actually increase as power is reduced, passing through a peak at about 210 power. Not until the power drops below 10% will the losses become less than the full-power losses. Since professional amplifiers are often used at 10% average power and at 30% or higher, the full-power operation is a fairly realistic test of the standard circuit’s thermal dissipation capability. This is not true at high-efficiency design, where the output stage is designed for high efficiency, and the heat dissipation is therefore lower. The objective of high-efficiency design, including the Series Three amplifier, is to reduce the thermal losses in the region of most frequent operation, namely 30-100. The improvement in efficiency of this amplifier may not be as dramatic. Therefore, it can be expected that high-efficiency amplifiers will run cooler at realistic power levels, into realistic loads, than those which may be used in professional service. This may call for some reduction in acceptability criteria when evaluating power-temperature rise.

Since the Series Three is designed for the most demanding applications, sufficient heat sinking is provided for continuous operation at full power. Temperature rise will be about 30-40°C at full power, 8-ohms, and will reach the thermal cut-out limit of about 90°C at full power, 4-ohms. This performance is comparable to other conventional cooled amplifiers. However, when testing with pink noise or actual program material, substantially cooler operation should result than one would expect of conventional amplifiers, because the amplifier will spend most of its time operating from the more efficient, lower power half of the circuit.

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The amplifier’s power ratings are measured following the FTC burn-in period (one hour at 25% power followed by 5 minutes at full power). We elected to set the voltage for the lower-power section at half of the main voltage. The success of this endeavor depends on the choice of tests made and their relevance to the actual applications. It is well-known that two amplifiers which have similar specs on the bench may sound different in use. This suggests that the bench testing was incomplete or that the wrong tests were used.

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6.3 Recommended Performance Tests

Basically, there are no performance tests which are not recommended. Series Three amplifiers should be able to handle any conditions which other professional amplifiers can handle, without damage, and with a minimum of program impairment or interruptions. The average user will of course be interested in the amplifier’s behavior at full power and at all frequencies. Further information which should demonstrate the areas where we tried to improve Series Three performance for real-world benefits not always incorporated in other designs, would include:

6.3.1 Clipping Test: Operate the amp into light and heavy clipping, at all frequencies. Series Three should show instant overload recovery; minimal "slicing" and recovery transients into a variety of loads, including open circuits, straightforward clipping of the peaks without glitches, pedestals or other aberrations; and minimal DC offset of the quiescent point after a clipping burst. Failure of any of these points could lead to hairiness during heavy transients, which frequently clip in high-voltage systems.

6.3.2 Short Circuit Protection. Operate the amp into momentary, continuous, and "chaotic" shorts, all of which will be encountered in the field. Check for excessive dissipation, as evidenced by AC current draw which could lead to overheating, degradation, or outright failure of the power transistors. The amp responds to momentary shorts by blowing a fuse or circuit breaker, this could cause operational problems. The fuse is rated to protect the amplifier, and should not be replaced until the cause is located or otherwise eliminated in the course of the performance.

6.3.3 Short Circuit Protection Impairments. Besides protecting the amplifier, short circuit protection should not impair the audio performance into normal, reactive loads, over the full frequency range. VI limiting will protect the circuit with the load (as part of the load’s normal impedance) will usually trigger excessive “flyback” distortion as the load-impedance approaches the amplifier’s maximum limit. The overload protection circuit should be biased to a point where the amplifier can be safely driven into low impedance loads. For loads above 2 ohms the amplifier is voltage limited. For loads below 2 ohms, attempts to drive the output to inductive currents will result in a current-limited output after about half a second. Continuous drive into shorts will cause the current limit to stabilize at a lower value, and you will see a pronounced reduction of AC current draw.

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High Frequency Tests. In addition to the basic power and distortion tests, behavior at "abnormal" frequencies can also be examined. Although music does not contain full-power harmonics beyond about 10kHz, and therefore any amp with reasonable low distortion at full power 20kHz should be "home free," there are second-order effects which may explain some of the minor differences in the quality of high frequency reproduction. Because it is possible for high-frequency oscillations to occur in complex systems, an amp should tolerate clipping at frequencies above 20KHz. Some designs have a disturbing amount of common-mode conduction caused by one polarity of a transistor turning on before the other can turn off. This excess dissipation adds to thermal stress and usually causes the amp to partially "give up" during high-frequency peaks. Sometimes this problem is aggravated by attempts to push the slew-rate limit higher than the inherent speed of the components. We see no high-order requirement for a slew rate which yields a power bandwidth in excess of 20kHz, but because of a variety of arguments based on second-order effects, the slew rates of Series Three amplifiers are sufficient for power bandwidths of about 60kHz. It is interesting to examine behavior as the slew-rate is raised. Does distortion increase well below the slew-rate limit, or does it remain well-controlled up to the limit? Is the slew-rate symmetrical? Is recovery from slew-rate limiting quick without serious glitches? Series Three amplifiers will draw no more than 10% excess power at very high frequencies compared to lower frequencies. The harmonic distortion at full power should remain below 3% at the way up to 50kHz. We have allowed the frequency response to extend well beyond the power bandwidth, so it is possible to "beat" the slew-rate with artificial signals such as square waves. However, music signals will not contain such steep rising/times, and some users feel that responses beyond 20kHz (at lower powers of course) is desirable for best quality. If input filtering is desired to eliminate all possibility of slew rate distortion, an input filter can be plugged into the octal socket. In the second generation of Series Three amplifiers, we have added a high frequency overload protection circuit. Attempts to override the amp with single frequen- cies well above 20kHz, such as might occur due to system instabilities, will result in temporary reduction of power to protect the output stage. This will not occur as long as there are frequencies below 20kHz, so normal program material will not be affected.

6.35 High Frequency Distortion. Most of the "progress" in high frequency performance has concentrated on improving the ability to handle full power signals at ever-higher frequencies. However, listening judges the amplifier on its ability to reproduce "velvety nuances," and, in fact, the average high-frequency content of music is relatively low compared to the midrange and bass. Therefore, audible testing of amplifiers will examine performance at modest powers, and will include the effects of inter-modulation of small high frequency components by large low frequencies. In this regard, cross-over distortion must be carefully examined, as it is typically more severe at lower powers. And while some feel that harmonic distortion above 10kHz is immaterial, because nobody can hear the harmonics, remember that non-linearities always add to FM distortion with complex material, whose effects definitely extend into the lower frequencies. It is worth noting that the circuit im- provements required to increase slew rate generally lead to increased crossover distortion: the reduction of crossover distortion may be more important to improve perfor- mance than the higher slew rate. Most of the "low-level" distortion can be reduced by minimizing crossover distortion or other high-order harmonics, although there must be a threshold of inaud- ability for these as with all other distortions. In the Series Three amplifier, crossover distortion is held to the crossover notch as far as possible without leading to the possibility of thermal runaway during short circuits or severe overloads; in addition, no attempt is made to "mask" or conceal the residual (such as with a low-pass filter) so that it would measure better without improvement of the actual FM distortion. The crossover phase shift is held to about 5 degrees in the switching transition from the low to the high power circuits, the switching residual can be 6dB with instruments, but the perceptual effect, if any, is well below the threshold of audibility. Those with a strong aversion to "discontinuities" are advised to consider the difference between an imperceptible switching transition and the gross clipping that would occur at this level, this was a conventional amplifier of the same era.

6.36 Low Frequency Tests. Most manufacturers feel that Series Three amplifiers have more "bass punch" or "tightness." Bats which may reveal reasons for this would include clamping factor (actually useful at all frequencies), general highfrequency output, under-damped transients conditions into reactive and/or low impedance loads; and finality of frequency response. The importance of phase shift has been getting much attention lately; the trademark is min- imal low-frequency phase shift requirement. Caused by the high-speed transistors in turn- ing on before the other can turn off. This excess dissipation adds to thermal stress and usually causes the amp to partially "give up" during high-frequency peaks. Sometimes this problem is aggravated by attempts to push the slew-rate limit higher than the inherent speed of the components. We see no high-order requirement for a slew rate which yields a power bandwidth in excess of 20kHz, but because of a variety of arguments based on second-order effects, the slew rates of Series Three amplifiers are sufficient for power bandwidths of about 60kHz. It is interesting to examine behavior as the slew-rate is raised. Does distortion increase well below the slew-rate limit, or does it remain well-controlled up to the limit? Is the slew-rate symmetrical? Is recovery from slew-rate limiting quick without serious glitches? Series Three amplifiers will draw no more than 10% excess power at very high frequencies compared to lower frequencies. The harmonic distortion at full power should remain below 3% at the way up to 50kHz. We have allowed the frequency response to extend well beyond the power bandwidth, so it is possible to "beat" the slew-rate with artificial signals such as square waves. However, music signals will not contain such steep rising/times, and some users feel that responses beyond 20kHz (at lower powers of course) is desirable for best quality. If input filtering is desired to eliminate all possibility of slew rate distortion, an input filter can be plugged into the octal socket. In the second generation of Series Three amplifiers, we have added a high frequency overload protection circuit. Attempts to override the amp with single frequen- cies well above 20kHz, such as might occur due to system instabilities, will result in temporary reduction of power to protect the output stage. This will not occur as long as there are frequencies below 20kHz, so normal program material will not be affected.

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the use of adequate capacity components, with suitable drilling, and the avoidance of touchy designs with regenerative "runaway" failure mechanisms. An often overlooked point is mechanical construction. Professional amps literally take a beating, and thin-gauge chassis, poorly supported transformers and heat sinks, unsupported electronic components of the larger sizes, loose wiring, absence of lock washers on machine screws (which turn freely once loosened), and low-grade PC substrates will not pass the test of time in the field. Remember, loss of output is "100% distortion." The many mechanical features of Series Three amplifiers which contribute to ruggedness and crash resistance are described in Section 5.5.

7.1 Cleaning

The faceplate and chassis can be cleaned with a soft cloth and a mild non-abrasive cleaning solution, such as Windex. Avoid cleaning powders and solvent-based pastes, as these will scratch and dull the paint. Be sure to unplug the unit prior to cleaning. Do not apply liquid directly to the surface. Gently wipe the cloth with the cleaning solution and wipe gently. You may want to buff the surface lightly with a soft cloth.

7.2 Dust Removal

After prolonged use, especially in dusty environments or in fan-cooled racks, the heat sinks may become clogged with dust. This will interfere with cooling, leading to higher temperature conditions and reduced life. Dust build-up can be most easily removed by directing an air jet between the fins of the heat sinks, which are located inside the vented areas along both sides of the chassis.

7.3 User Maintenance

There are no periodic "tune-up" adjustments required; the amplifier should provide stable performance until parts fail from age. Internal servicing must be referred to qualified personnel. The amplifier may be impaired for loose screws on the outside. If any loose parts rattle around on the inside when the amp is turned over in all directions, please have it serviced immediately, as a loose part could lodge in a dangerous place and cause further damage or shock hazard.

7.4 Obtaining Service

If the amplifier isn't working properly, please consult the troubleshooting chart in Section 8. If proper operation cannot be restored, the amplifier may require service. This must be performed by a qualified technical personnel. To obtain service, contact your QSC dealer or the QSC factory (714-465-2540, Costa Mesa, California).

Please note that the Series Three warranty does not cover repairs made by non-authorized service personnel, and that improper repairs may void future warranty coverage. If the amplifier or a channel module is returned to the factory for service, it must be sent in the original type of packaging or, at your dealer's option, in an adequate box or container. The Series Three warranty does not cover shipping damage caused by returning the amplifier in the wrong container.
SECTION EIGHT: CHANNEL REMOVAL

8.1 CAUTION:
These servicing instructions are for use by qualified personnel only. To avoid electric shock do not perform any servicing other than that contained in the Operating Instructions unless you are qualified to do so; refer all servicing to qualified service personnel.

8.2 Channel Removal and Replacement

8.2.1 Channel-Module Description. Each channel is built on a circuit board with integrated heat sinks. The channel slides in and out of the amplifier on tracks, and is cinched-up with two flexible cables. The same module fits both sides; the module is simply removed for Channel 2. When the facia plate is removed to access the channel modules, the PhaseLock switch will remove AC power, but certain precautions, as shown below, should still be followed for maximum safety.

8.2.2 Channel Removal. First, turn off the unit and remove the AC plug(s) from power. Then remove the facia plate from the chassis. It is not necessary to remove the chixkies from the rack. Be sure not to lose the black screws or lock washers. As soon as the facia plate is removed, the AC power for both channels will be shut off by an interlock switch. (YFRE, not on the 3800. Be sure AC switch is off.) Despite this precaution, it will still take several minutes for the filter capacitors in each module to discharge completely, so do not rush to remove the channel module. Wait until the "PowerProtect" LED (which should show red for a little while after shut-off) is fully off. If the channel has suffered catastrophic failure, and especially if the circuit breaker has blown or there is evidence of arcing, the AC transformer might be damaged. To eliminate the possibility of shock hazard, it is always advisable to completely disconnect AC from the amplifier during channel exchange.

While waiting for complete discharge, note the "Module Pull" label. The arrow directs you to a safe finger grip which you can use to withdraw the module. Once the power has drained completely, pull on the module to start withdrawal. The module may stick at first, if it has been in place for a long time. Do not attempt to fully withdraw the module until both cables are undamaged. After pulling the module out about two inches, stop and unlatch the multi-color transformer plug and the grey jacketed signal connector. The transformer plug is a friction-snap fit; the signal connector has a release tab located at the front of the jack (see drawing). The 3800 uses a heavy gauge powered connector with locking tabs. After the cables are discon- nected, swing them to the side and withdraw the module the rest of the way. If the amplifier has just been in use, the heat sinks and other parts may be hot, be so careful.

SECTION EIGHT: CHANNEL REPLACEMENT

8.2.2 CHANNEL MODULE CONNECTORS

AMPLIFIER CIRCUIT SECTION

SIGNAL CONNECTOR LOCKING SNAP'S FRONT SIDE TOWARDS CABLE TO RELEASE

POWER CONNECTOR CABLES FACE TOWARDS SOCKET 1300: MALE AND FEMALE PLUGS HAVE INSERTED INVERTERS WHICH ONLY MATHE IN CORRECT ORIENTATION

VENTS
HEAT SINKS
PC GUIDES
PRINTED CIRCUIT (P/C)
HEAT SINK GUIDES
SECTION EIGHT: CHANNEL REMOVAL

8.23 Channel Replacement. Before the replacement channel is installed, the orientation of the knob must be checked. The knoc has a small flat spring inside which can be set to either side of the shaft, so that the knob aligns correctly for either channel. Knobs are shipped in the Channel 1 position. To switch to Channel 2, remove the knob (press 10), withdraw the flat spring with needle-nose pliers, invert in the opposite set of slots, and press the knob back on the post shaft. The white pointer should point to the lower right, on full Gain, with the channel in position for installation.

Before the channel is installed, please check for bent parts which might short out, especially any of the driver transistors mounted in the midst of other circuitry. The heat sinks for the drivers must be kept isolated, or the channel will fail instantly.

Start the channel carefully into the guide tracks, ensuring proper alignment. Hold the cables to one side, making sure that they are on the correct side of the boards. When the board is almost in, the two cables must be inserted carefully, using the drawing in 8.23 as a guide. Make sure that the 6 pin connector is properly aligned; and note that the locking tab for the signal connector faces forward.

After cable installation, the module can be fully inserted and the faceplate replaced. In order for the interlock switch to engage, the center of the faceplate must go straight in through the chamfer hole.

Later units use an interlock screw in the center of the faceplate. This screw engages the interlock switch when fully installed. Be sure to use the original screw only as the length is critical.

If the circuit breaker still blows immediately, the power transformer is bad, and must be replaced. This should be very unlikely.

8.3 Converting AC voltages. Series Three amplifiers are wired for 120V, 60Hz operation. Please contact factory for latest information on transformers suitable for other voltages.

8.4 Schematics

Schematics are presented for the Input/Output Jack Plans, and for each module, 3000, 3300, 3500, and 3800.

A complete Service Manual for the Series Three is available from QSC Audio Products. To assist experienced technicians in emergency repairs, the following points are noted:

QSC amplifiers differ from conventional circuits in the arrangement of the power supply and circuit ground. Note that instead of grounding the center point of the power supply, and taking the speaker output from the common point of the output transistors, we ground the output transistor common and take the speaker signal from the center point of the power supply capacitors. The current flows and voltages across the parts are identical in either case, but this permits us to use a ground-referenced common emitter configuration for the driver transistors, and permits the output transistors to be arranged so that the collectors are common, at ground potential. This lets us eliminate the meta-insulators for the output transistors. Note, however, that the output transistors must still be isolated.

Because of this arrangement, a single dual op-amp can handle the rest of the circuit gain requirements. One section is used for the differential (balanced) input stage, and the other half is used in the actual amplifier.

The remaining major differences in the Series Three circuit is the dual-level, high-efficiency output stage. Keeping in mind that the entire power supply, with bipolar full-voltage and half-voltage levels, moves as a unit when the speaker voltage varies, you will see that at voltage excursions below half, only the inner sets of output transistors conduct. As the output voltage approaches 50%, the outer sets of driver and output transistors are brought to the voltage levels set by the two zener diodes in series with the crossover bias diodes and the bases of the inner driver transistors. This allows the outer devices to take over conduction when the inner transistors are within several volts of saturation. The inner devices are out of use as the high-speed switching diodes in series become reverse biased, and the outer power transistors handle the remaining 50% of voltage swing.

The bipolar 15-volt supplies for the opamps are ground referenced, and derived by resistive dividers from the main supply, the voltage is normally fixed by 15v zener diodes, but will decay to about 5 volts when opamplified into a short circuit. This is the normal reaction of the patented QSC short circuit protection; you are referred to the complete Service Manual for further details.