SERIES THREE OWNERS MANUAL

QSC SERIES THREE OWNER'S MANUAL

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QSC AUDIO PRODUCTS
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PP-000015-OM, 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 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 **Warrranty**

QSC AUDIO PRODUCTS 3 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 combines high power handling with outstanding audio performance. A high-performance op-amp accepts 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. This, 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 overheats, 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 user's 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 breakdown) in the amplifier or any 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.

Front-panel indicators have been designed to present all essential operating information and are recessed to prevent damage. The 31-step detented Gain control allows precision 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 front-removable slide-out channels, ensures against total loss of the program, and allows fast restoration 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-tip-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 connections 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.

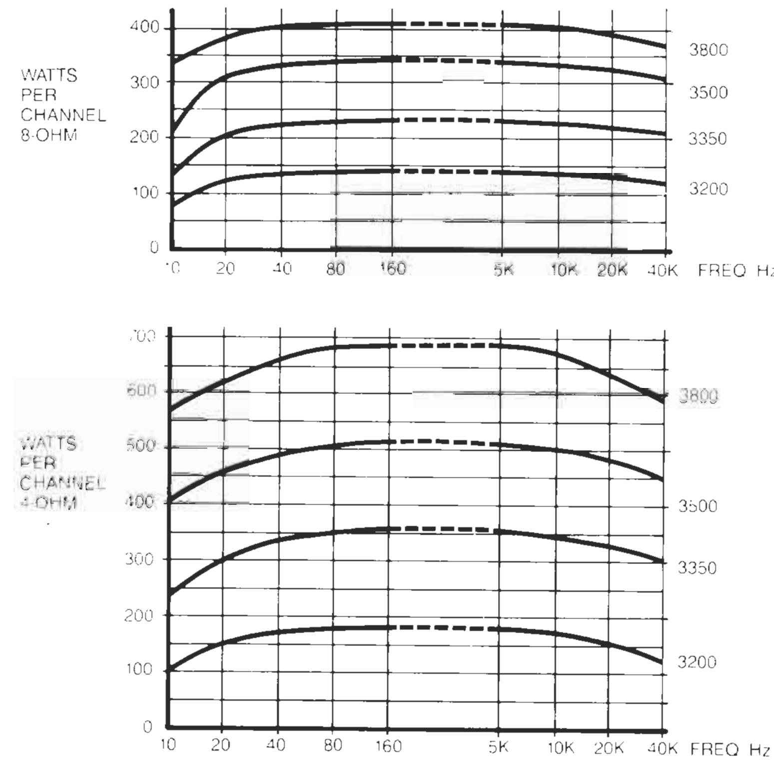
1.4 Specifications

MODEL				3200	3350	3500	3800
OUTPUT POWER (per channel)							
Continuous Average Output Power both channels driven							
8 ohms,	20-20 kHz	0.1%	THD	110	200	300	360
	1 kHz	0.015%	THD				
4 ohms,	20-20 kHz	0.1%	THD	140	300	450	600
	1 kHz	0.025%	THD				
2 ohms,	1 kHz	0.1%	THD	NR	400	625	950
Bridged-mono operation							
16 ohms,	20-20 kHz	0.1%	THD	220	400	570	720
	1 kHz	0.015%	THD				
8 ohms,	20-20 kHz	0.1%	THD	280	550	850	1200
	1 kHz	0.025%	THD				
4 ohms,	1 kHz	0.1%	THD	NR	800	1250	1900
DYNAMIC HEADROOM				3.0dB @ 8 ohms	3.0dB @ 4 ohms	3.0dB @ 4 ohms	2.0dB @ 4 ohms

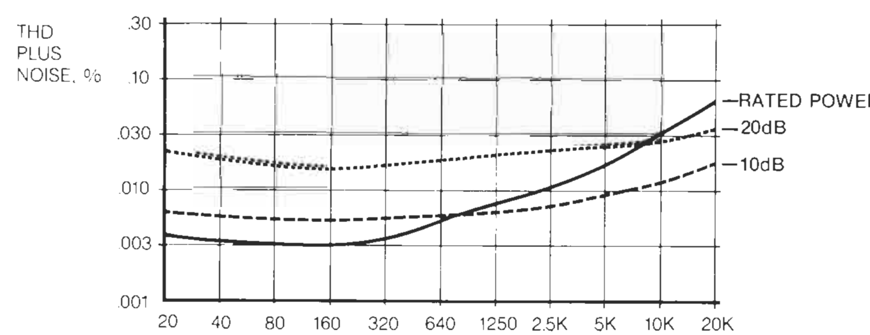
DISTORTION	THD	20-20 kHz, from 250 millwatts to rated power shall be less than 0.1%, 0.015% typical.
	SMPTE-IMD	less than 0.020%, 250 millwatts to rated power
FREQUENCY RESPONSE		20-20 kHz +/– 0.1dB 8-200 kHz +/– 3dB
DAMPING FACTOR		Greater than 200
NOISE		–100dB 20-20 kHz
SENSITIVITY		1V RMS for rated power (8 ohms)
INPUT IMPEDANCE		20K balanced or unbalanced
CROSSTALK		–75dB, 20-20K
CONTROLS	Front—	Flush detented gain control. Recessed AC switch and AC circuit breaker for each channel
	Rear—	Mono-bridging and accessory module switches
INDICATORS (per channel)		Bi-color LED indicating DC power-OK/Protect mode. LED clip indicator. –30dB and –6dB signal level indicators. Flashing over-temp indicators.
CONNECTORS (per channel)		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 lift 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.

AMPLIFIER PROTECTION		Indefinite short circuit,* open circuit, over-temp, ultrasonic and rf protection. Stable into reactive and mismatched loads. Inputs protected from overload. All protection completely independent on each channel. *Output Averaging™ Short Circuit Protection (U.S. Pat. 4,321,554)	
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 pop suppression is also provided.	
OUTPUT CIRCUIT TYPE		Full complementary two-level high efficiency.	
OUTPUT DEVICES (Total)	3200	8	
	3350	16	
	3500	24	
	3800	40	
POWER SUPPLY		Two completely separate power supplies including AC switches and AC circuit breakers.	
POWER REQUIREMENTS	3200	4.4A 120 Volts, 60Hz	
	3350	8A 120 Volts, 60Hz	
	3500	12A 120 Volts, 60Hz	
	3800	20A 120 Volts, (10A per AC cord)	
DIMENSIONS	3200	Faceplate 19" x 1.75" Depth (with rear support) 16.5" Depth (chassis) 14.6"	
	3350	Faceplate 19" x 3.5" Depth (with rear support) 17.9" Depth (chassis) 15.9"	
	3500	Faceplate 19" x 3.5" Depth (with rear support) 17.9" Depth (chassis) 15.9"	
	3800	Faceplate 19" x 5.25" Depth (with rear support) 17.9" Depth (chassis) 15.9"	
WEIGHT	3200	Shipping (lbs.)	31
		Net (lbs.)	26
	3350	Shipping (lbs.)	46
		Net (lbs.)	41
	3500	Shipping (lbs.)	55
		Net (lbs.)	50
	3800	Shipping (lbs.)	83
		Net (lbs.)	75

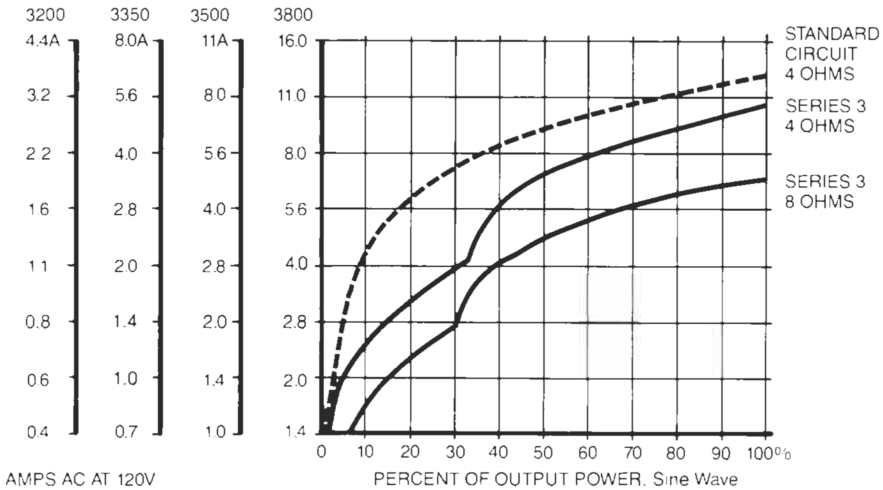
1.51 POWER vs. FREQUENCY at 0.1% Clipping



1.52 DISTORTION vs. FREQUENCY THD Plus Noise, 8 Ohms

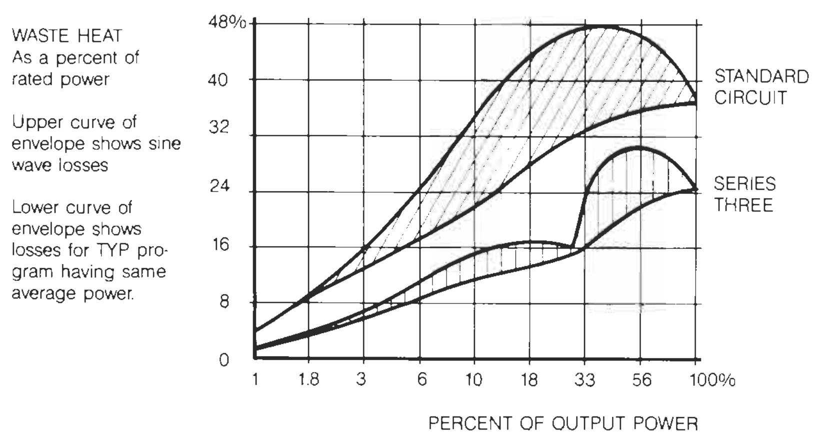


1.53 AC CURRENT vs. POWER



1.54 HEAT LOSS vs. POWER

Per Channel



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, rotate it in all directions to check for loose parts inside. The slide-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 shipper 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 a 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 92 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.

2.3 Quick Instructions

REAR VIEW (Ch.2 Shown)

2.31 These instructions cover the normal use of the amplifier in two-channel or stereo applications. See Section 3 for detailed installation instructions and special cases.

2.32 AC power. Connect AC cord to standard 120V, 60Hz, three-pin (grounded) outlet. The amplifier should operate satisfactorily from 100-130V, but full performance will be met only at 120V.

2.33 Ground Lift Strap. A two-position barrier strip on the back has a "U" jumper connecting the two screws. This should normally be left in place, to keep the circuit ground connected to the chassis groun. for maximum safety. See Section 4.4.

2.34 Input Switches. Four-position micro-switches are located by the rear jacks, under the barrier strip screw terminal block. They come from the factory in the correct position for stereo operation. Remove the small screw marked "Switch Access" and lift the plastic strip to access the switches. The correct settings for stereo operation, as shown on the label, is switches 1 and 2 up (on) and switches 3 and 4 down (off). See Section 3.5 for other cases.

2.35 Octal Socket. For normal stereo operation, nothing should be plugged into the octal socket. It comes from the factory with a protective label to prevent corrosion of the pins.

2.36 Input Connections. Please note input polarity as follows:

1/4-inch plug:	Tip is "minus" (inverting input)
	Ring is "plus" (non-inverting input)
	Barrel is ground, as always.
XLR plug:	Pin 1 is ground, as always.
	Pin 2 and 3 have switchable polarity. Please see Sec. 3.5.
	Factory preset, pin 2 plus, pin 3 minus (international standard)
Barrier Strip	"GND" is circuit ground
	"+" is the plus input
	"−" is the minus input (all marked in blue)

When making unbalanced connections, the barrel of an ordinary two-wire 1/4-inch plug will ground the "plus" side of the balanced input; XLR plugs will need to have the unused pin grounded inside the plug, and the installer will need to ground the unused screw on the barrier strip.

2.37 Speaker Connections. Banana plugs, spade lugs, or bare wire ends can be connected to the 5-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 controls off until proper operation is verified. Upon turning on the switch, that channel's "Power/Protect" 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.

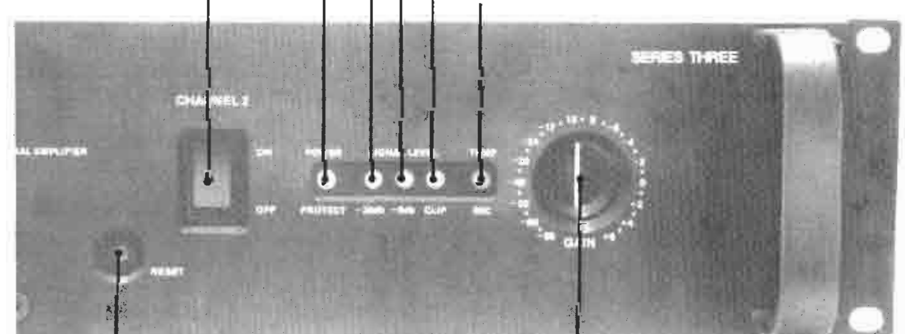
2.39 Operation and Indicators. Note that the Gain control is calibrated in dB, with 1-dB steps over the top half of its range. Gain should be kept in this region for full performance. The "0dB" reference matches the full-gain performance (26dB) of many respected pro-audio power amplifiers.

Two yellow LED's show signal presence at levels 30dB and 6dB below clipping. For maximum undistorted performance, the "−6dB" LED should trigger on peaks. The red "Clip" LED will show any distortion in the amplifier. The flashing red "Temp" 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.

FRONT VIEW (Ch.2 Shown)



3.1 Cooling

3.11 High Efficiency Circuit. Because of the high-efficiency design, the Series Three amplifiers only waste 1/3 to 1/2 the heat of comparable power amplifiers. Despite this, we have used the largest possible heat sinks. The two factors combined assure minimal temperature rise even under heavy usage.

3.12 Cooling Precautions. The heat 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 10% 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 cutback) may be experienced on heavy peaks into low impedance loads. The muting relay may not come on at less than 70% of rated voltage, but once on, it should stay on down to about 30% of rated voltage. There should be no sub-audio or DC transients caused by fluctuating AC voltages; you should suspect poorly regulated preceding components if thumps or voice-coil excursions are observed.

3.22 AC supply. In order to maintain full rated power, power amps as a rule require well-regulated AC voltage of the proper rating. This is not always easy to assure when large banks of amps 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. Bulk-power devices, such as lamps, 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 why power amps 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 1.54). This means that there will be a slightly greater power fluctuation between peaks and lulls, which may create the impression that lights are dimming more heavily during peaks. This should not be confused with the rather excessive current draw created by at least one other high-efficiency amplifier, which has a special type of power transformer.

3.24 AC 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 flow without delivering any useful energy. This occurs when the current is out-of-phase with the AC 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 limit the available current, it is desirable that the power factor of the amplifiers be as high as possible. At least one high-efficiency amp, 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 1.54. The current rating shown on the back of the amp is determined according to the UL test procedure; maximum undistorted power is measured at all load impedances, until the worst case current draw is discovered; then the current is measured at the same impedance for 1/3 power, to represent an average condition. As it turns out, for the Series Three this value is also about equal to the current consumption at full power, eight-ohms per channel. Therefore, the rated current will be exceeded when testing at full power for four, and especially two-ohm loads, 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 about 8 ohms or higher to avoid AC overload and circuit breaker tripping. Even a few dB less 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 Labeling. All input functions are shown in blue on the three color rear labels.

3.32 Input Jacks. 1/4-inch ring-tip sleeve, female 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, 20K resistive dividers and the differential input terminals of a high performance 5532 op-amp to accept balanced input signals and reject common-mode signals. For best performance in the balanced-input mode, 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 (noise) signals. Minor mismatches will result in slight loss of common-mode rejection, but will still have much greater noise rejection than unbalanced inputs.

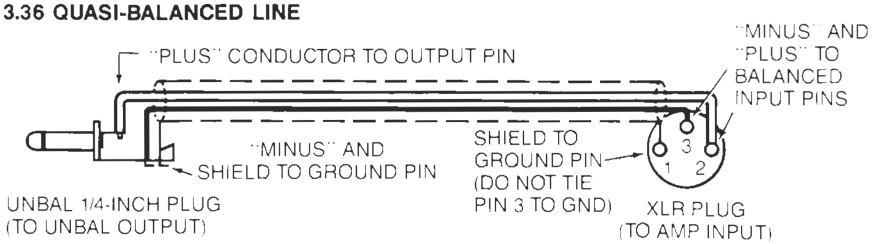
3.34 Balanced Inputs. For proper balanced-line operation, the cable shield must be kept separate from both signal conductors. The cable shield is connected to the barrel of a 1/4-inch plug, to pin 1 of an XLR plug, or to the "GND" terminal of the barrier strip, shown in blue. Balanced-line cables contain two signal conductors, a "plus" polarity, often called "high" or "hot", and a "minus" polarity, often called "low" or "return." The "plus" conductor should go to the ring of a 1/4-inch plug, to pin 2 of an XLR plug or to the "plus" input of the barrier strip, for the amplifier to reproduce the signal in the same polarity (non-inverting operation). The "minus" conductor goes to the tip of a 1/4-inch plug, to pin 3 of an XLR connector, or to the "minus" terminal of the barrier strip. Please note that the polarity of the 1/4-inch connector is reversed compared to many 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 signals, if only a single-ended, unbalanced signal is available, the unused input terminal need only be grounded for operation without loss of gain. The ability to reject cable-induced hum and noise is lost, but this may not be needed in well-shielded environments with short distances between audio components. For unbalanced signals, the barrel of an ordinary two-conductor (mono) 1/4-inch plug will ground the sleeve terminal when pushed all the way into the 1/4-inch jack, so no special wiring is required. For XLR plugs, the signal conductor should be connected to pin 2, and pin 3 should be connected, inside the plug, to pin 1 (ground). On the barrier strip, the unused terminal should be tied to the "GND" terminal, and the signal conductor should be connected to the "+" or "–" as desired. In all cases, of course, the shield goes to the ground terminals.

3.36 Quasi-Balanced Lines. Even if a balanced-line output is not available, the benefits of balanced-line input can still be obtained. Special cables will need to be made as follows:

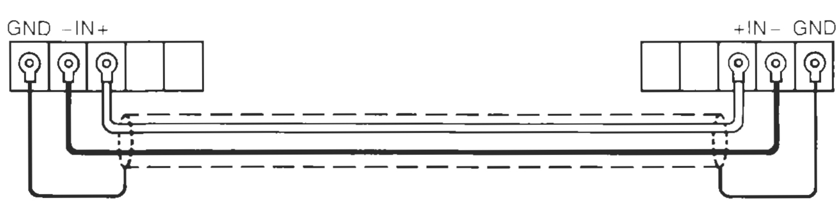
The cable end which connects to the power amplifier would be made as described in Section 3.34, using balanced-line cable. At the other end, using whatever plug matches the unbalanced output, connect the "plus" conductor to the signal terminal, and connect the "minus" and shield conductors to ground. Do not connect the "minus" and shield conductors together at the power amplifier (balanced input) end of the cable. This maintains the separation of signal ground and shield (circuit) ground needed to obtain balanced-line noise rejection. As a further refinement, a small variable 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.

3.36 QUASI-BALANCED LINE



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 input 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 may be brought into Channel 1, using either the XLR or 1/-inch jacks, and it will feed both Channels. The signal may be taken out of any remaining input jack on Channel 1 or Channel 2 to feed additional amps, as required. This "Daisy-Chaining" procedure allows as many amps to be driven as required, subject only to having a sufficiently low source impedance. Since each channel has a 20K input impedance, divide this value by the number of channels; for example, 10 channels will have a combined impedance of 2K ohms. Then, ensure that the source impedance is well below this value, to avoid even minor 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 6dB loss of input level, which may still be acceptable as long as it is allowed for.

3.37 CROSS-CONNECTING BOTH CHANNELS USING BARRIER STRIPS



3.38 Good Quality Connections. Proper contact and stable performance are essential for good sound, and to avoid erratic noises or unstable performance. 1/4-inch connectors are suitable for low-cost portable systems, but depend on 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. The "military" brass-type plugs are especially bad in this respect. XLR plugs are preferred by professional users for reliable contact and better retention. 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 crimp by pulling and close inspection. If the wire wiggles inside the crimped terminal, the contact will go bad. The spade 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 Octal Module Accessories

3.41 Octal Socket. 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 15 volts of DC power for a series of active accessory modules. 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 T-1. Jensen Electronics (213) 876-0059 can supply an extremely fine input transformer for QSC amps, model JE-11P-QN

3.43 Active Accessories. In a number of special cases, the user needs built-in power limiting, bi-amp capability, remote gain control, input summing, etc. In order to serve these needs without adding to the basic cost of the amplifier, the octal socket has been designed with low-level DC power tapped off the internal supply of the amplifier. Please contact QSC or your QSC dealer for a current listing of available Octal Module accessories.

3.44 Passive Accessories. White Instruments, (512) 892-0752, 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 guide post in the middle. The internal switches (see Section 3.5) numbers 1 and 2 must be turned off. Other switches may need to be set in accordance with the type of module and combination of channels desired. See the instruction for each module for these details. Input to the module occurs automatically through the amplifier input connections.

3.5 Input Switches and Mono Bridging.

3.51 Each channel has a set of eight input programming switches. These are located below the barrier strip block, and can be accessed by removing the screw marked "Switch Access" and swinging back the plastic label (see Rear View, Section 2.3). The switches can be actuated by any pointed 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.

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 to connect both channels, in various combinations, to a single Octal Module. Switches 5, 6, 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, for 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 cross-over, which has two output signals, such as high and low frequencies.

INPUT SWITCHES (2.34)
UNDER LABEL FLAP

There are seven basic combinations for setting the input switches:

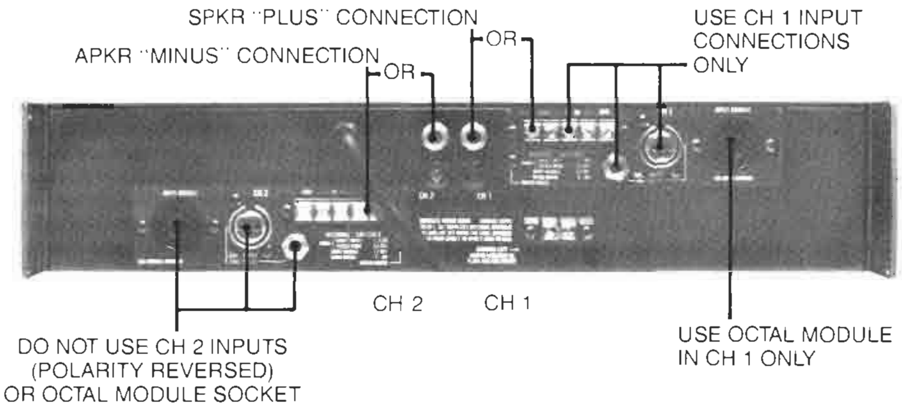
Desired Set-Up	Switches "On" (Up) Ch. 1	Ch. 2	Remarks
Direct Input, Stereo Mode	1, 2	1, 2	For normal use of the amplifier
Octal Modules, Stereo Mode	(none)	(none)	Using a separate module for each channel
Direct Input, Bridged Mode	1, 2, 3	1, 2, 3	Electronic balanced/unbalanced input into Channel 1, bridged mono output (see Section 3.54)
One-Way Octal Module, Bridged Mode	3	3	Octal Module in Channel 1, bridged mono output. (See Section 3.54)
One-Way Octal Module, Parallel Mode	4	1, 2, 4	Octal Module in Channel 1 feeds both channels in same polarity, for driving two separate speakers, or zones with the same signal.
Two-Way Octal Module, to Both Channels	4	1, 2, 4	For Bi-amping; Low freqs. go to Channel 1, High Freqs. to Channel 2
One or Two-Way Module in Ch. 1, Second Module in Series for Ch. 2	4	4	Example: Bi-amp module in Channel 1, with Limiter Module in series with High-Freqs. in Ch. 2 for tweeter protection
XLR Polarity Pin 2 plus (hot) Pin 3 minus	7, 8	7, 8	Set both channels. Keep unused polarity switches off to avoid shorting input signal
Pin 3 plus (hot) Pin 2 minus	5, 6	5, 6	

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 typical application is to drive high-voltage loads such as 70-volt and 100-volt audio distribution 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 output 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 table 3.53). Connect the Speaker Positive 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 channels for the exact same Gain, counting 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 connect 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

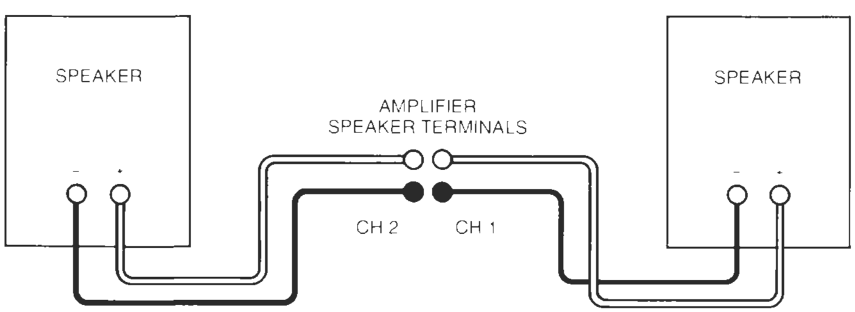


channel can still drive the speaker in the normal (non-bridged) mode, at a level 6dB below the original level. Furthermore, the load on the remaining channel will be cut in half, which should ensure that it survives whatever made the first channel fail. We call this the "Auto Back-Up™ Mode," and it can be used wherever the show simply *must* go on.

3.6 Speaker Connections

3.61 Speaker Terminals. Red and Black 5-way binding posts, on standard 3/4-inch centers, are located on the rear of the chassis. In addition, speaker connections can be made to the "Spkr" and "Com" connections of the barrier strip. All speaker labels are shown in red.

3.62 SPEAKER POLARITY



3.62 Terminal Polarity. The red 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 ground-lift function and might cause audio ground loops and oscillations.

3.63 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 (on the 3500). Always make connections with the power off, and observe good wiring practice and avoid stray wire strands.

3.64 Speaker Cables. In order to obtain the full benefit of the high power and high damping factor, users must be careful to avoid cable losses. The best way is to use the heaviest-gauge, finely 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 "esoteric" braided or flat cables, over and above the total wire gauge and stranding (see Section 3.69).

3.65 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 soldered or soundly 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.

3.66 Cable Polarity. Be sure to observe correct polarity at both the speaker and amplifier end. Most present-day speaker cable is color-coded in some way, either by insulation color or by copper and tin-plated wires. Adopt a consistent wiring convention and stick to it. We suggest Black for "Com" (ground or negative) and red or white for "Spkr" (hot or positive). These colors match the binding posts. By the same logic, we can assign the copper-colored wire to the red ("Spkr") terminal, and the silver-colored wire to the black ("Com") terminal.

3.67 Bridged Mono. Please see Section 3.54 for the bridged-mono speaker connection.

3.68 Speaker Impedance. The Series Three amplifiers have adequate current capability to fully drive loads down to two ohms. However, many high-performance "8-ohm" loudspeakers, especially multiple-way systems with passive crossovers, have impedances at some frequencies which are far lower than the average rating. 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 4-ohm loads without passive crossovers (as part of a bi-or-tri-amped system, for instance). 2-ohm loads should be approached with caution, as there is not 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 reasons, operation with 2-ohm loads should be tested thoroughly before putting into use. The 3800 is best suited for continuous 2-ohm operation due to its larger power supply and greater number of output devices.

3.69 Speaker Wire Table. The following table is presented 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 loss of power and damping factor are more severe for longer lengths, lower impedance loads, and higher (thinner) gauges. One should maintain a minimum damping factor of 20, and preferably 50 for high-quality systems; this will automatically prevent 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 muddiness.

Speaker Wire Table

CABLE LENGTH, FEET	CABLE GAUGE, EACH CONDUCTOR	CABLE RESIS-TANCE OHMS	POWER LOSS 8 OHMS	POWER LOSS 4 OHMS	DAMPING FACTOR ALLOWING FOR AMP DAMPING OF 200 8 OHMS	4 OHMS
5	18	.063	.79%	1.58%	77	38
	16	.040	.5	1.0	100	50
	14	.025	.31	.62	123	61
	12	.016	.20	.40	142	71
	10	.010	.125	.25	160	80
10	18	.126	1.58%	3.16%	48	24
	16	.080	1.0	2.0	66.6	33
	14	.050	.62	1.25	89	44
	12	.032	.40	.80	111	56
	10	.020	.25	.50	133	66
20	18	.252	3.16%	6.3%	27.4	13.7
	16	.160	2.0	4.0	40	20
	14	.100	1.25	2.5	57	28
	12	.064	.80	1.6	77	38
	10	.040	.5	1.0	100	50
40	18	.50	6.32%	12.6%	14.7	7.3
	16	.32	4.0	8.0	22.2	11.1
	14	.20	2.5	5.0	33.3	16.6
	12	.128	1.60	3.2	47.6	23.8
	10	.080	1.0	2.0	67	33
	8	.050	.625	1.25	89	45
80	16	.64	8.0%	16.0%	11.8	5.9
	14	.40	5.0	10.0	18.2	9.1
	12	.256	3.2	6.4	27	13.5
	10	.160	2.0	4.0	40	20
	8	.10	1.25	2.5	57	29
160	14	.80	10.0%	20.0%	9.5	4.75
	12	.51	6.4	12.8	14.5	7.25
	10	.32	4.0	8.0	25	12.5
	8	.20	2.5	5.0	33.3	16.6
320	12	1.04	12.8%	25.6%	7.4	3.7
	10	.64	8.0	16.0	11.76	5.88
	8	.40	5.0	10.0	18.2	9.1

3.7 Protection Features

3.71 **Summary.**We have ensured that accidents, mistakes, 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.

3.72 **Short Circuit Protection.** The active region in a power transistor is surprisingly small—perhaps 1/5 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. If 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 transistor, 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 acceptable, 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, which 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 protection into short circuits. At no time will the circuit cause abnormal distortion spikes or loss of sound. You should suspect shorts or abnormally low load impedances if the "Clip" LED lights before both "Signal Presence" LED's come on.

3.73 **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 80C, the flashing red "TEMP" LED on the front panel will begin to come on. The flashes will get longer and brighter as the temperature increases. At about 90C, when the flashing rate is about twice a second, an automatic circuit will open the protection relay, and disconnect the speaker. This takes the load off the amplifier, allowing it to cool down. The flashing "TEMP" indicator will continue to blink, and the "Power/Protect" LED will change from green to red. As the amp cools down, the "TEMP" indicator will flash more quickly and less brightly, until the speaker relay re-connects. This usually takes about 60 seconds. As soon as you notice the "TEMP" indicator, check for blocked vents, reduce audio level by a few dB, or check for shorted speaker cables. If the amp refuses to come back on, AC power to that channel can be removed for a few minutes; the channel may need replacement if it still won't come on.

3.74 **DC Fault Protection.** All direct-coupled (DC) poewr 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 abnormal 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 possible voltage, and within 0.1 second on full-voltage faults. This is the quickest response possible without triggering on very low-frequency program transients, such as bass drum beats. False triggering and unwanted shutdowns have been a problem with "crowbar" 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 below the trigger point for the DC fault detector. In addition, the circuit will automatically reset three seconds after the DC fault is corrected. An actual fault in the channel will result in no sound, with the "Power/Protect" LED showing red, and usually a steady illumination of one or the other of the "Signal Presence" LED's. Try reducing the Gain control. If the situation remains unchanged, the channel is faulty and should be turned off. If the relay re-connects at zero Gain, the fault is in some component before the input to the amplifier.

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 "Power/Protect" 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 off briefly and then resume operation.

3.76 **Input/Output Protection.** The amplifier inputs are isolated by 10K resistors, which are part of the balanced-input circuit. This protects the inputs from burn-out due to extremely high input signals or RF interference. The amplifier output is isolated from capacitative and inductive loads by a high frequency RLC network, which decouples the speaker terminals slightly at frequencies above about 50K Hz.

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 "Power/Protect LED"). The "Clip" LED accurately triggers on distortion of the power amplifier itself, but cannot distinguish 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/or the speakers. 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. By using a step-by-step evaluation, 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. Please refer to Section 2.3 for an illustration of the front panel and indicators.

3.82 No Sound.

"Power/Protect" 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.

"Power/Protect" LED comes on, but stays red:

The amplifier channel is being held in the protect mode. If the flashing red "Temp" LED is on, the amp is overheated and will normally feel pretty hot.

If any of the "Signal Presence" or "Clip" indicators is on, the channel may be faulty. Try a normal-level signal, to see if the "Signal Presence" indicators appear 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 Octal Module or preceding component could also cause this symptom. Try unplugging any Octal Modules and input cables and see if the relay will turn on in the normal three-second interval.

"Power/Protect" 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 is also possible that the input jack or cable is defective. Check the cable 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 "−30dB" and the "−6dB" 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 "−30dB" 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 goes all the way up, and each step seems equal. If the Gain is normal, then the problem should be prior to the amplifier. Severe 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 "minus" input (Section 3.35).

3.84 Weak and Distorted Sound.

"Clip" indicator comes on before the "−6dB" 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" Indication: 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 overloading, 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 component by connecting to the other channel and checking 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 shaking the amp or the input/output connectors causes the problem. If the sound seems to vary by itself, examine the Signal Presence LED's, to see if the drop-outs show 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 to one side of the balanced input can cause a 6dB fluctuation of input level (Section 3.34 and 3.35).

3.86 Sound Has Bad Tone (poor treble or bass).

The amplifier itself is very unlikely to develop a frequency response problem, without more serious effects. Therefore, lack of frequency range must be traced to the speakers or preceding units (mid-adjusted equalizer, 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 3.83) 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 be absorbed more greatly. Only a sound level meter, used with a standard signal level and at a standard distance from the speaker, can tell if you are getting the expected output.

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 ground (shield). This problem can also be caused by corroded connectors, especially 1/4-inch types. For this reason, high-reliability 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 the amplifier. Try re-positioning the cables away from the various components. Note that tape recorder heads, phono cartridges, and electric guitar pick-ups are especially sensitive to this type of interference, and must be kept away from high power electronics.

Buzz—defined as a very "razzy" 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 "shhh" 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 initial microphone, phono, or tape source. There is a noise "floor" caused by random atomic vibrations. This limits the signal-to-noise ratio of the original signal; the goal of a proper system is to immediately amplify that signal well above the noise floor so that further degradation does not occur. "Gain-staging" is a 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, and above the noise floor. To isolate the source of unwanted hiss, start at the amp, and work backwards, reducing and then restoring gains. You should hear a reduction of hiss and audio together at each point, showing that the hiss is coming 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 users.

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 audio peaks or when the electronics are vibrated usually indicate bad connections.

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 build-up, we decided to reduce the waste heat by using a higher efficiency design (see Section 5). The resultant heat production is equivalent to an amp of only one-third to one-half the power. By looking through the vents on each side of the chassis, you will see more heat sink area than some conventional amplifiers. The combination of reduced waste heat combined with generous dissipation surface results in cool running with normal convection cooling. For instance, maximum undistorted music signals, played into a 2.6 ohm resistive load (to simulate a 4-ohm 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. Hot air rises, and the amplifiers at the top of the stack will get heated air from the lower units. 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 amps 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 source; 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 amps all have 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. Consult the 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 3350/3500 chassis; QSC also has rear support straps available.

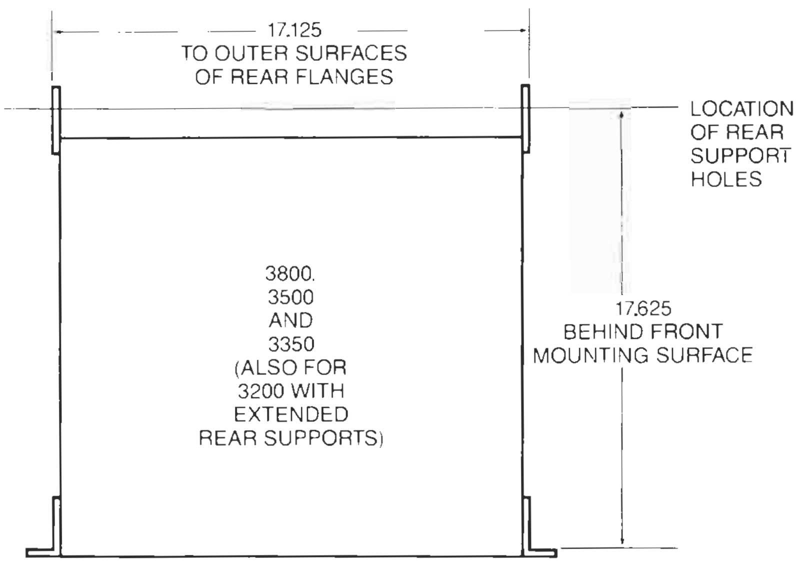
4.2 Speaker Protection.

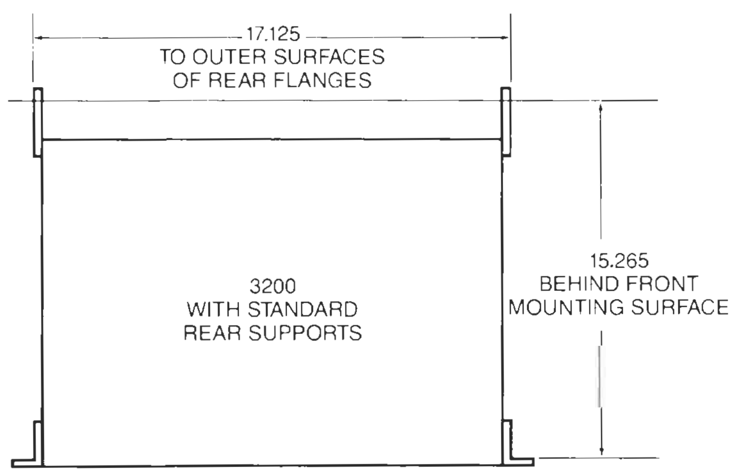
4.21 Background. Speakers have several limits which should not be exceeded for reliable operation. It is the user's responsibility to determine these limits and operate the amplifier accordingly. We offer several ways to avoid unexpected accidents, but you must still select speakers of appropriate type 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 reproduction of sub-audio signals 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-audio or DC signals are detected. The circuit responds to DC outputs in excess of 3 volts; the response time will depend on the magnitude of the DC voltage. For voltages of half the maximum possible, the speaker will be lifted in .3 seconds; for full-scale DC the speaker will be lifted in .1 second. This is the fastest response possible without "nuisance tripping" on very low audio frequencies. This should protect speakers which have adequate power capacity for the size of amplifier (see Section 4.24).

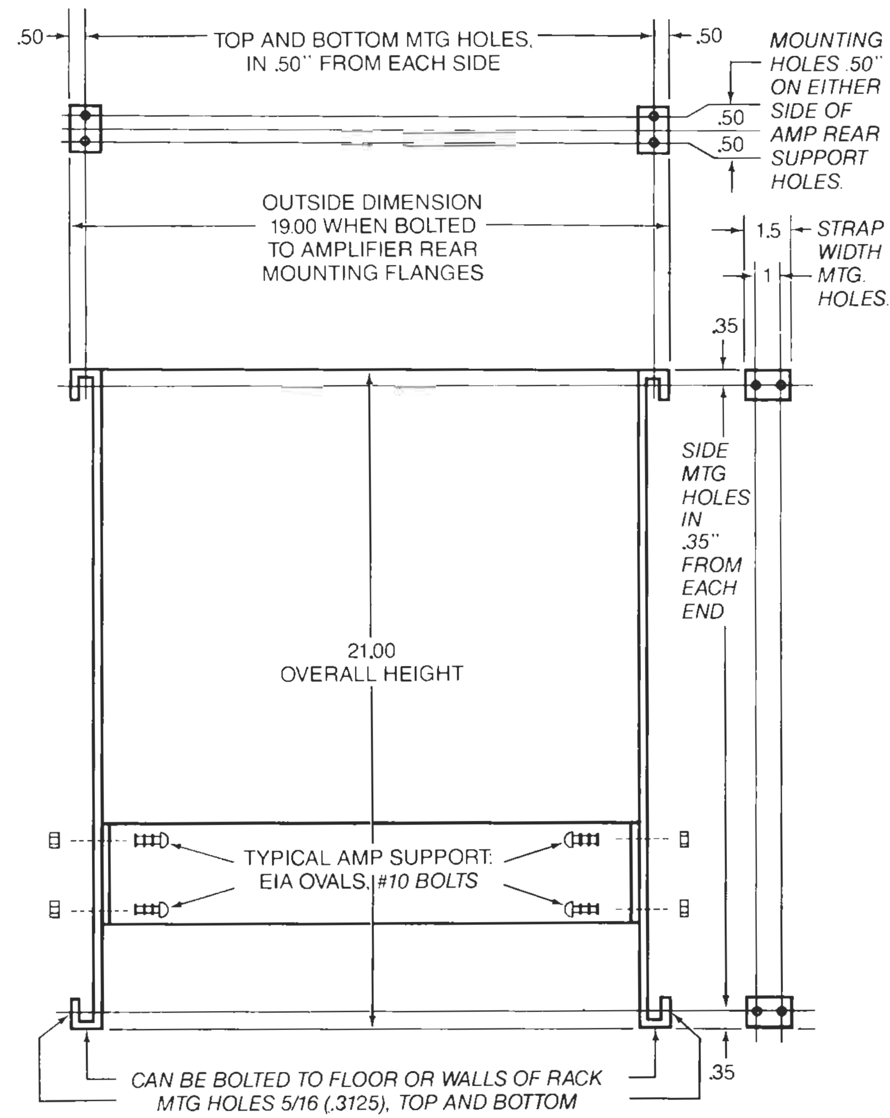
4.23 Horn Driver Protection. The compression drivers used with horns for high-frequency reproduction have special protection requirements. These devices are more delicate than large cone speakers, and more vulnerable to overload damage. In particular, the driver has a low-frequency limit which must be carefully observed. Below this frequency, the driver diaphragm can "bottom out" which will immediately alter the frequency response, and quickly cause failure. To prevent this, the user must make sure that a proper crossover network is installed. In bi-and-tri-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 hums, get into the signal path between the electronic crossover and the power amplifier. As further protection, especially against accidental mis-adjustment or bad cables, many users install

4.14 RACK MOUNTING SUPPORT DIMENSIONS (Inches)





4.15 REAR SUPPORT STRAP DIMENSIONS (Inches)



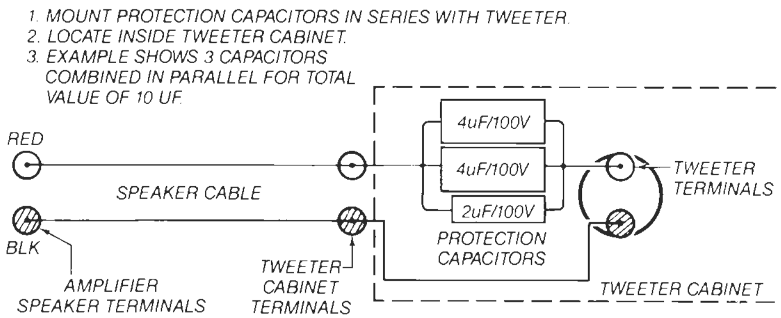
"horn protection capacitors" between the amp and horn driver. This part inherently blocks lower frequencies and DC, but must be selected so as not to disturb the crossover frequency. A reasonable rule of thumb is to let the capacitor roll off one octave below the intended crossover frequency. A table of values is presented below. Be sure to use non-polarized capacitors, of at least 50V, or preferably 100V rating.

Table
Horn Protection Capacitors.
(Values in microfarads)

Frequency	8-ohm Driver	16-ohm Driver
500	80uf	40uf
800	50	25
1000	40	20
1200	33	16
2000	20	10
3500	12	6
7000	6	3

You will have some problems finding the larger value capacitors in the preferred film-type construction. If necessary, several can be paralleled; simply add the individual capacitances together to get the total rating. You will probably have to locate non-polar electrolytics for values greater than 10-20uf.

4.23 HORN PROTECTION CAPACITORS



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 overheat. 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; how much less depends on the dynamic range and headroom allowance. In live-performance situations where feedback and high-energy artists can 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 at least fuses. 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 fast-blow fuses, which will carry 135% of their rating for an hour, and which blow within 1 second at 200% current. The RMS power rating is correlated to 135% of the fuse content.

RMS Power	4-ohms	8-ohms	16-ohms
30	2 amps	1.5 amps	1 amp
50	2.5	1.6 or 2	1.25
75	3	2. or 2.5	1.5
100	4	2.5	1.6 or 2
200	5	3 or 4	2.5
400	7.5	5	3 or 4

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

The power may also be limited with active circuitry. Outboard compressors or limiters are used for this function. In addition, QSC offers a plug-in Octal Module Limiter which can be adjusted to put a ceiling on the power level; as with any compressor, the circuit acts to reduce 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 nuisance 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 hook-up and operating precautions. QSC is not liable for any damage to loudspeakers caused by overpowering, wrong-frequency operation or electronic failures.

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 in concept to ordinary AC power systems—a fixed level voltage is sent to all of the speakers, and each speaker is adjusted to draw the desired power level. Standard voltage levels include 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 lies in the elimination of complicated impedance calculations when setting up many speakers. Each speaker has a small transformer which can be set, or "tapped," 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 that the installer add up the total wattage 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. By distributing the speaker signal 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 the scope of these instructions. The main concerns here are adapting 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 drive 70-volt lines directly. The amount of power available is determined by the amount of loading which brings the clipping voltage down to 100V peak, as required for undistorted reproduction of 70V sine waves. Since the bridged mode adds the output voltage of both channels together, the equivalent figure for each channel is 50V peak. Since the higher power amps have greater internal voltages, they can deliver more of their power before this limit is reached. The following table shows the power available into 70 volts, using the bridged mode, measured at 1K Hz.

3200: 200 watts RMS (note: up to 300 watts is available if 1% clipping is acceptable)
3350: 600 watts
3500: 1200 watts
3800: 1800 watts

Because of non-ideal speaker transformer and other losses, it is wise to design-in a 25% safety margin. This also allows for future expansion or up-powering of the speakers. The exact safety margin, if any, depends on the installer's experience and the duty cycle of the program material, as well as the reliability and lifetime requirements. Note that the bridge mode gives you the outstanding fail-safe protection of the Auto Back-up™ feature (see Section 3.54), which makes this approach very attractive for high-reliability systems.

In many cases, however, the installer needs many individual channels, for zone control or the like. In this case, each channel should be used separately, since a pair of bridged channels acts as a single unit. To convert individual channels to 70V output, QSC offers a 300-watt autotransformer which will work with all Series Three amplifiers, especially the 3200 and the 3350. The 3500 can also be used, but the amplifier has more power than the transformer can handle without low frequency distortion, so the performance is not fully utilized. The output transformer will have to be mounted in a convenient spot in the rack, and wired to the barrier strip screws or binding posts. Refer to the instructions with the transformer (Part No. OT-300). The following powers and bandwidths are available for each channel:

3200	150 watts,	30-15K Hz	(using the 24V transformer tap)
3350	300 watts,	30-15K Hz	(using the 28V transformer tap)
3500	300 watts,	30-15K Hz	(using the 35V transformer tap)
3500	500 watts,	50-12K Hz	(reduced frequency range and duty cycle)
3800	500 watts,	50-12K Hz	(transformer limited)

In all cases, the lower frequency limit is determined by transformer distortion of about .1%, and the upper frequency limit is determined by frequency rolloff (about 1.5dB). These performance figures exceed typical commercial speakers and transformers. Because of an increasingly reactive load below 50Hz, and because commercial speakers lack response below this fequency, installers are advised to limit bass response to 50 or 60 Hz. This prevents power from being wasted on inaudible frequencies. Ask QSC for Octal Module filter availability.

4.33 25 Volt Systems. Although this voltage is not as common as 70 volts, these systems have definite advantages, especially in smaller installations. First, local building codes usually require special "Class 1" wiring for 70V systems, which is not required for 25V 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:

3500: 150 watts
3350: 350 watts
3500: 425 watts
3800: 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 more safely. Also note that because the 3500 has an output voltage which is much higher than 25V, it is somewhat of an "overkill" compared to the 3350, and performance is not fully utilized.

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 3500 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 cabling by the large power transformers. It becomes a problem when there is a "conflict" between the electrical grounds of the chassis (connected to the third pin of the AC plug), and the signal grounds of the circuit and input cables. 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 a quick 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 shielding, and decreases the possibility of electric shocks being coupled to other parts of the system in case of severe fault. If the ground-lift test is Section 4.41 appears to reduce 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 expertise of 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.

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 studios, 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 emphasis has been on maintaining operation and avoiding shutdowns whenever 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%, without excessive 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 input/output connectors, and octal sockets for each channel, provide unmatched installation flexibility. And finally, a front removable modular design permits fast one-step 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 studio 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 carefully selected parts and advanced 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 all QSC amps. We use a high performance dual op-amp for the balanced input stage and as the major gain block for the power amplifier. In the Series Three, this is the highly regarded 5532, which has exceptionally low input noise, a power bandwidth in excess of 140K Hz, and a gain-band-width product of 10M Hz.

The balanced-line input stage operates at unity gain and has an impedance of 10K ohms per side, for a resonable compromise between line loading and low input noise. The resulting signal-to-noise ratio is 100dB, unweighted. We use precision metal-film input resistors for stability, low noise, and high common-mode rejection. Full-range distortion of this stage remains well below .005%, and the 140K Hz power bandwidth ensures that this stage is not a limiting factor in overall performance.

Both inputs to the op-amp are isolated from the outside world by the 10K input resistors. This prevents accidental high voltage signals from burning out the op-amp protection diodes. This resistance also prevents low impedance RF signals from reaching the input junctions at levels sufficient to cause rectification and thus prevents RF interference. Certain amplifier designs which connect the base of the input transistor to the outside world with little or no series resistance may have theoretically better signal-to-noise ratios, but are vulnerable to RF interference, input burn-out, and require an input transformer for balanced-line operation. The Series Three input stage avoids these problems, while maintaining a signal-to-noise ratio in excess of virtually any preceding device or program source.

You will note (Sect.2.36, Sect.3.3) that the 1/4-inch jack is connected for inverting input polarity (tip minus). This is opposite to many other amps using 1/4-inch input jacks, but repeated experiments have shown that for unbalanced input signals, the amplifier is far more stable with inverting rather than non-inverting inputs. We attribute this effect to the polarity of stray ground-loop leakage results in positive feedback, which depends on variables such as cable dress, humidity, and speaker impedance. The result is unpredictable high frequency oscillations. To avoid this, we have used negative polarity on the 1/4-inch input jack. Balanced inputs reject this type of interference.

We provide a 31-step detented pot to facilitate the exact setting of desired gain. This control has 1dB steps over the upper half of its range for increased resolution at the most frequently used settings. A multiple-finger gold plated wiper and precision element give a voltage co-efficient (distortion) of less than .001% and the rated accuracy of each step is +/−1dB overall.

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 requires high voltage and current capabilities, stable output into reactive as well as resistive frequencies, and adequate load bearing capability for years of reliable operation at high power.

The QSC circuit consists basically 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 controlled phase shift of the 5532 to assure high loop gain and stability, and its fast slew rate ensures quick recovery from clipping. This type op-amp also has a generous and symmetrical output current, which allows the primary phase-lag capacitor a high and symmetrical slew rate while still using enough lag compensation to assure stability. The resultant power bandwidth of the amplifier is over 50K Hz.

Several forms of high frequency compensation are used to minimize high frequency distortion. The primary lag compensation is taken around both the output and driver stages, so that this extra high frequency feedback tends to minimize crossover distortion rather than simply diminishing the high frequency gain. We also use phase-lead compensation at various points in the circuit, which extends the amplifier bandwidth and prevents the need for excessive lag compensation. This maintains the high slew rate. High frequency response is down only −0.1dB at 20K Hz, and −3dB at 300K Hz.

DC offset at the output is only several millivolts, due to the very low offset voltage of the 5532 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 within 0.1dB, down to 20Hz without the need for excessive sub-audio response. Response is −3dB at 8Hz, which preserves the speakers from high level reproduction of record warps, breath pops, etc., and prevents false triggering of the DC protection relay.

The QSC circuit is complementary push-pull through all discrete stages. By avoiding any single-ended stages, an intermittent connection in the small signal section will not cause the amp to latch to one of the rails. At the same time, since our circuit only needs two stages of discrete transistors after the op-amp, the problem of cumulative bias errors over many push-pull stages is minimized.

The driver transistors have an Ft of 20-30 MHz, and thus have enough bandwidth to obtain full performance from the output transistors. In addition, this extra frequency response avoids cumulative phase shifts at the same frequency as the output transistors, which would impair stability. Out circuit uses the driver stage for current and voltage gain, where most circuits require at least two stages.

We spent a great deal of time selecting and testing output transistors, since these devices form the heart of any power amplifier. The triple diffused, complementary TO-3 Toshiba devices which we ultimately selected have an outstanding combination of good high frequency response, linear gain, crisp saturation, and excellent safe operating area. In addition, the dynamic and static characteristics of the NPN and PNP pairs are better matched than the more common epi-base parts.

The Ft is better than 6MHz, 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 IM analyzers was pointed out by Otala in the 1981 AES convention at Hamburg[1] and comprises a more likely explanation of "solid-state harshness" than the recent obsession with extreme slew rates and vanishingly low distortion.

These power transistors also have an outstanding safe operating area, certainly as good as any devices we have tested. They will withstand even greater short-term dissipations, which provides excellent SOA capabilities during extreme low frequency operation into 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 transistors. 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 intermittents. In addition, the encapsulation of the chip and bonding wires in solid epoxy greatly increases the stress caused by thermal expansion, leading to thermal fatigue failure after as few as 10% of the thermal cycles of the heremetic TO-3 package. The non-hermetic nature of epoxy also allows contaminants to diffuse in which places sole reliance on chip passivation to resist degradation over a period of 10 to 20 years.

Some plastic power cases claim a larger heat transfer surface to the heat sink, although this advantage is somewhat negated by a 150C rather than 200C temperature limit. However, the QSC circuit allows us to mount the output transistors directly to a common heat sink, without the usual mica insulating wafers. 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 transistors may serve well for consumer electronic products, but at this time only hermetic metal-case power transistors have a proven reliability record in high stress, high voltage professional amplifiers.

5.4 High Efficiency Designs

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 increased efficiency linear design. The conventional linear output section has fairly good efficiency, at full power, of about 65-70%, depending on saturation losses. However, efficiency drops rapidly as power is reduced, and losses actually peak out at about one-third power. Even at 10% of rated power, losses are about as high as at full power. Users who need the maximum power output may operate their amps at 10% to 30% average power levels (10dB to 5dB crest factors) depending on the amount of clipping which is tolerated. This means that conventional amps are frequently used at their worst-case power losses under realistic 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 significant, while the output voltage is only a fraction of the maximum. This means that a large voltage, at substantial current levels, must be

dissipated. Only when the power drops well below 5% will the currents become small enough for the output losses to abate.

One classes solution 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 from on to off. The switching rate 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, RFI problems must be overcome, new protection circuits devised, and servicing would require training in completely new techniques. For these reasons, class D amplifiers have not been practical for high quality, 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 size and weight reductions, but suffers from most of the objections of the class D amplifier, as well as possibly having a poorer power factor. This would be a serious objection in any large system, as AC wire sizes and circuit breakers are sensitive to current levels, which increase when the power factor is diminished. 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 rectifiers. Output voltages from 0 to 50% are drawn from a half-voltage power supply, thus slashing the large losses which would occur if these voltages were drawn from the full supply. Only when the instantaneous voltage level exceeds that of the half-supply, is 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 demands. Even during severe usage, the amplifier spends most of its time running from the lower power supply, thus dramatically increasing efficiency and reducing waste heat. Even at full sine-wave output, the parts of the sine wave below 50% are produced from the lower supply, which still reduces losses considerably.

The primary design challenge is to achieve this result with a minimum of extra complexity and without impairing audio performance. We experimented with switching transistors 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 addition, 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 transient is comparable to the crossover notch, without any large-scale spikes. The added distortion, at 20K Hz, is less than .03% and only occurs within 6dB of clipping. The added distortion at lower frequencies is proportionately less, giving overall distortion, including switching distortion, of .005% at low frequencies, .01% at upper midrange frequencies, and about .06% at 20K Hz. IM distortion does not exceed .02% over the full power range of the amplifier.

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 supply voltage. In addition all devices can be direct-metal mounted on a common heat sink, which greatly assists in equalizing temperature in case the output signal happens to dwell in one set or the other. Because of the parallel arrangement, there are several "soft-fail" 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 should 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 16 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 the use of standard rails for rear support. The shallower 1.75 inch chassis is available with optional extended rear supports for mounting on the same rear rails as the deeper 3.5 inch 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 surface without using up rear panel space. The chassis completely encloses the heat sinks in a matched vented cage for protection without impairing air flow. Vents are also provided around the power transformer, and all vents align vertically when racked for unblocked 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 connectors, 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 replacing all of the rear connections. For performance-oriented uses this restores function in the shortest time, and for fixed installations it saves a second trip by the technician to return the repaired amplifier. Since these amps are designed for extreme reliability, the modular feature should rarely be needed, but it can be invaluable on those few occasions, if only as a troubleshooting device. Since this is basically a form of insurance, we took 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 connectors 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 connections. Due to reduced labor, the in-place 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 considerations call 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 independent 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 load-carrying capability. Multiple, parallel, high density filter capacitors are used to store the DC energy. This provides the high energy storage for sustained low frequency 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 capacitors 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.

Model	Total Capacitance (UF)	Capacitance Per Channel (UF)
3200	26,400	13,200
3350	26,400	13,200
3500	35,200	17,600
3800	57,200	28,600

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 give the reviewer a better chance for comparative analysis of the amp under test. The Series Three amplifiers are designed for demanding professional service, and should be able to handle any combination of input signal and load. The reviewer is invited to "thrash" 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 bursts, and any other test which the reviewer can device to expose "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 in testing of Series Three amplifiers is the differences in behavior due to the high-efficiency design. We have striven to eliminate any audible effect on the amplifier's distortion, frequency response, and other performance criteria; the major effect should be on the load-carrying ability of the amplifier. Here, we need to recognize and explore the fact that the reviewer's customary load-carrying tests have been performed, and acceptance criteria developed, using amps with conventional efficiency circuits. How will the high-efficiency circuit differ?

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 1/3 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 sometimes at 30% or higher, continuous full-power operation is a fairly realistic test of the standard circuit's thermal dissipation capability. This is not as true of high-efficiency designs.

The objective of most high-efficiency designs, including the Series Three amplifiers, is to reduce the severe losses in the region of most frequent operation, namely 10-30%. The improvement of efficiency at full output may not be as dramatic. Therefore, it can be expected that high-efficiency amps will run cooler at realistic power levels, into realistic loads, than one might expect from full-power temperature rise. This may call for some readjustment of acceptance criteria when evaluating 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 30-40C at full power, 8-ohms, and will reach the thermal cut-out's limit of about 90C at full power, 4-ohms. This performance is comparable to other convection 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. For instance, our experiments using typical rock records, played at the threshold of clipping, with a 2.66-ohm resistive load to simulate the dissipation of a real-world 4-ohm load, reveals a temperature rise of about 30C. A conventional amp, under the same circumstances, will dissipate about as much as it would at full power, and will probably require fan cooling to prevent thermal shutdown. We certainly encourage reviewers to test the amplifiers at full power, but we emphasize that further testing using random signals is necessary for a full appreciation of the advantages of the high-efficiency circuit.

The amplifier's power ratings are measured following the FTC burn-in period (one hour at 33% 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 reason for this was to equalize the safe-operating-area requirements for both the low-power and high-power output transistors, which have the same overall current limits. The transition to the high-power transistors begins to occur at a power of about 28-30% (it would theoretically be 25% except for the fact that the power supply is more heavily stressed in the full power regime, so power supply sag is less in the low power regime). This means that at the FTC power level of 33%, a substantial percentage of the waveform extends into the high-power mode, where losses are closer to that of a conventional circuit; there will be a noticeable temperature rise, although well within the capacity of the amp. If the power were reduced only a few percent, or a real-world, random signal were used, the amp would spend most of its time outside of this narrow region of higher losses, and actual operating temperatures will be very reasonable. Again, we hope that final acceptance will be made after testing with realistic, random signals. We could easily have made the amp "look better" at exactly 33% power, but we designed the amp for best performance into severe real-world loads.

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 respected 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 all frequencies. Further tests, 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:

6.31 Clipping Test; operate the amp into light and heavy clipping, at all frequencies. Series Three should show instant overload recovery; minimal "sticking" 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 harshness during heavy transients, which frequently clip in high-volume systems.

6.32 Short Circuit Protection. Operate the amp into momentary, continuous, and "chattering" 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. If the amp responds to momentary shorts by blowing a fuse or circuit breaker, this could cause operational hassles in the field if a speaker cable is kicked out, inserted, or otherwise momentarily shorted in the course of the performance.

The patented QSC "output averaging" short circuit protection can be seen by operating into very low impedance loads. For loads above 2 ohms, the amp is voltage limited only. For loads below 2 ohms, attempts to drive the output to excessive currents will result in a current-limit cutback after about half a second. Continuous drive into shorts will cause the current limits to stabilize at a lower value, and you will see a pronounced reduction of AC current draw.

6.33 Short Circuit Protection Impairments. Besides protecting the amplifier, short circuit protection shuld not impair the audio performance into normal, reactive loads, over the full frequency range. VI limiting will protect the amp effectively, but inductance in series with the load (or as part of the load's normal impedance) will usually trigger excessive "flyback" distortion as the load impedance approaches the amplifier's minimum rating. This will seriously impair the ability to handle high-level peaks gracefully. In addition, the response to gated pulses or tone bursts should be checked at all frequencies, into various load impedances, to check for abnormal clipping. Ideally, an amp would reproduce bursts at a higher undistorted level than continuous tones, for greater dynamic headroom; however, some designs actually clip sooner on bursts than on continuous tones. This would represent a severe loss of dynamic reproduction capability, which is the heart of high-quality music reproduction. The most severe test of short circuit protection and lack of impairment occurs in the bridge mode, where the impedance presented to each channel will normally be half of the usual, in addition to the problem of dividing the short circuit stress equally between the channels.

Since the QSC circuit uses a variable soft-knee current limit, which varies relatively slowly (over a number of cycles), there is never a chance that instantaneous foldback can occur, which causes the inductive spikes characteristic of VI limiting. A transient burst arising from a lower-power background will always find the current limits at their maximum, so no truncation of the leading edge can result. At a given instant, the current limit of each channel varies somewhat as an inverse function of output voltage. In other words, the effective output resistance during limiting remains positive (rather than the negative output resistance of VI limiting). This means that, in the bridge-mono mode, any inevitable differences in exact current limits will be self-balancing at an operating point not too far from 50% per channel, and unstable responses into reactive loads are impossible.

6.34 **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 10K Hz, and therefore any amp with respectably low distortion at full power, 20K Hz 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 20K Hz. Some designs have a disturbing amount of common-mode conduction, caused by one polarity of 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 first-order requirement for a slew rate which yields a power bandwidth in excess of 20K Hz, 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 60K Hz. It is interesting to examine behavior as the slew rate is reached. 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 about 10% excess power at very high frequencies compared to lower frequencies. The harmonic distortion at full power should remain below .3% all the way up to 50K Hz. 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 rise times, and some users feel that response beyond 20K Hz, (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 overdrive the amp with single frequencies well above 20K Hz, 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 20K Hz, 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, listeners judge the amplifier on the ability to reproduce "delicate nuances," and, in fact, the average high-frequency content of music is relatively low compared to the midrange and bass. Therefore, astute 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 10K Hz is immaterial, because "nobody can hear the harmonics," remember that non-linearities always lead to IM distortion with complex material, whose effects definitely extend into the lower frequencies. It is worth noting that the circuit improvements required to increase slew rate generally lead to faster transition of the crossover region; the reduction of crossover distortion may be more important to improved performance than the higher slew rate. Most of the "sweet-sounding" designs have minimal crossover distortion or other high-order harmonics, although there must be a threshold of inaudibility for these as with all other defects. In the Series Three, we have attempted to minimize the crossover notch as far as possible without leading to the possibility of thermal runaway during short circuits or other severe usage; 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 IM distortion. The same approach is taken with the switching transition from the low to high-power circuits; the switching residual can be detected with instruments, but the percentage of distortion, its occurrence only within 6dB of clipping, and the good performance in IM tests show that the effect is well below the threshold of audibility. Those with a strong aversion to "discontinues," are invited to consider the difference between an imperceptable switching transition and the gross clipping that would occur at this level were this a conventional amplifier of the same size.

6.36 **Low Frequency Tests.** Most listeners feel that Series Three amplifiers have more "bass punch" or "tightness." Tests which may reveal reasons for this would include damping factor (actually useful at all frequencies);.general headroom, especially under transient conditions into reactive and/or low impedance loads; and flatness of frequency response. Importance of phase shift has been getting much attention lately; the trade-off is that minimal low-frequency phase shift requires response down to 1Hz or lower. This leads to excessive sub-audio signal levels which can drive the speaker cones at inaudible, unloaded frequencies, increasing the speaker stress and distortion, and consuming amplifier headroom unnecessarily. Since real-world speakers, microphones, and recording media all have definite low-frequency limits (with the attendant phase shifts), the wisdom of letting the power amp reproduce what will essentially be noise signals (record warps, rumble, traffic noises) is open to question. Digital recording, on the other hand, has no inherent low-frequency limit. To reconcile these factors, we chose to install a simple Butterworth compensation circuit to keep the low frequency response flat within 0.1 dB, down to 20Hz, without the need for flat-DC response. We feel that for every case where the resultant phase shift could tilt or offset the desired signal, there is a complementary situation where the signal might be improved. Thus we chose the design which would reduce stress on the speakers and avoid false-triggering of the DC protection circuit.

6.37 **DC Protection.** In a properly designed amplifier, DC protection should only trigger on hazardous outputs, without false-triggering on program transients (unless truly hazardous). Testing of the circuit's ability to save the speakers from amplifier fault is of course, difficult, since a realistic test would require deliberate destruction of the output transistors while connected to various loads. Field experience may be a better guide here, along with assessment of reported and probable reliability, which reduces the need for DC protection in the first place. Perhaps the most important test will be to operate the amp at increasingly low frequencies or pulses, to see what effect the protection circuit will have on program transients. Series Three uses an output relay in series with the speaker, and will display an absence of shutdowns on audio-frequency material; crisp, positive cut-off of severe sub-audio transients without chattering, and automatic reset upon removal of fault, to assure fast restoration of performance after abnormal program transients. Needless to say, absence of DC protection between the output stages and speakers (i.e. input-level muting) leaves a major liability in case of circuit failure.

6.38 **Reliability Assessment.** The reviewer is usually asked to make a judgment of apparent reliability. Obviously, true reliability can only be assessed through actual experience. However, short-term reliability can be assessed by examining the quality of components, the use of adequate capacity components, with suitable derating, 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 scrubbing pads, 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. Dampen the cloth with the cleaning solution and wipe gently. You may wish to buff the surface lightly with a dry 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 operation 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 periodical "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 inspected 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 3.8. If proper operation cannot be restored, the amplifier may require service. This must be performed by qualified technical personnel, to avoid shock hazard or improper repairs. To obtain the location of the nearest authorized Service Center, please contact your QSC dealer or the QSC factory (714-645-2540, 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 shipping carton. If you have not saved your carton, see if your dealer has one, or call QSC to have an empty carton sent for shipping. The Series Three warranty does not cover shipping damage caused by returning an amplifier in the wrong carton.

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

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

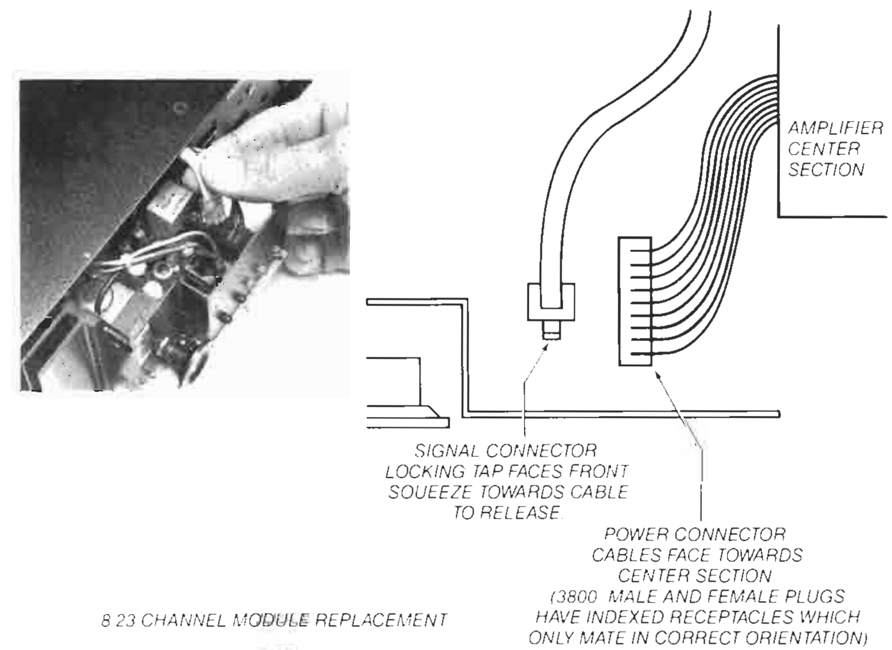
8.22 Channel Removal. First, turn off the unit and remove the AC plug(s) from power. Then, remove the faceplate from the chassis. It is not necessary to remove the chassis from the rack. Be sure not to lose the black screws or lock washers. As soon as the faceplate is removed, the AC power for both channels will be shut off by an interlock switch. (NOTE: 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 "Power/Protect" 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 scorching, 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 the two cables are unplugged.

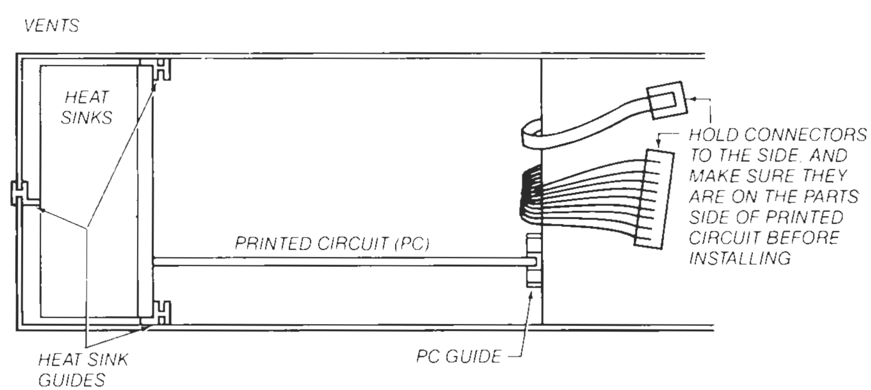
After pulling the module out about two inches, stop and unplug the multi-color transformer plug and the grey jacketed signal connector. The transformer plug is a friction-snap fit; the signal connector has a release tab located at the front of the jack (see drawing). The 3800 uses a heavy gauge powered connector with locking tabs. After the cables are disconnected, 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, so be careful.

8 22 CHANNEL MODULE CONNECTORS



8 23 CHANNEL MODULE REPLACEMENT

RIGHT SIDE UP — CHANNEL 1
UPSIDE DOWN — CHANNEL 2



8.23 Channel Replacement. Before the replacement channel is installed, the orientation of the knob must be checked. The knob 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 fit), withdraw the flat spring with needle-nose pliers, insert in the opposite set of slots, and press the knob back on the pot 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 board. 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 8-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 chassis 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 Plane, and for each model, 3200, 3350, 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:

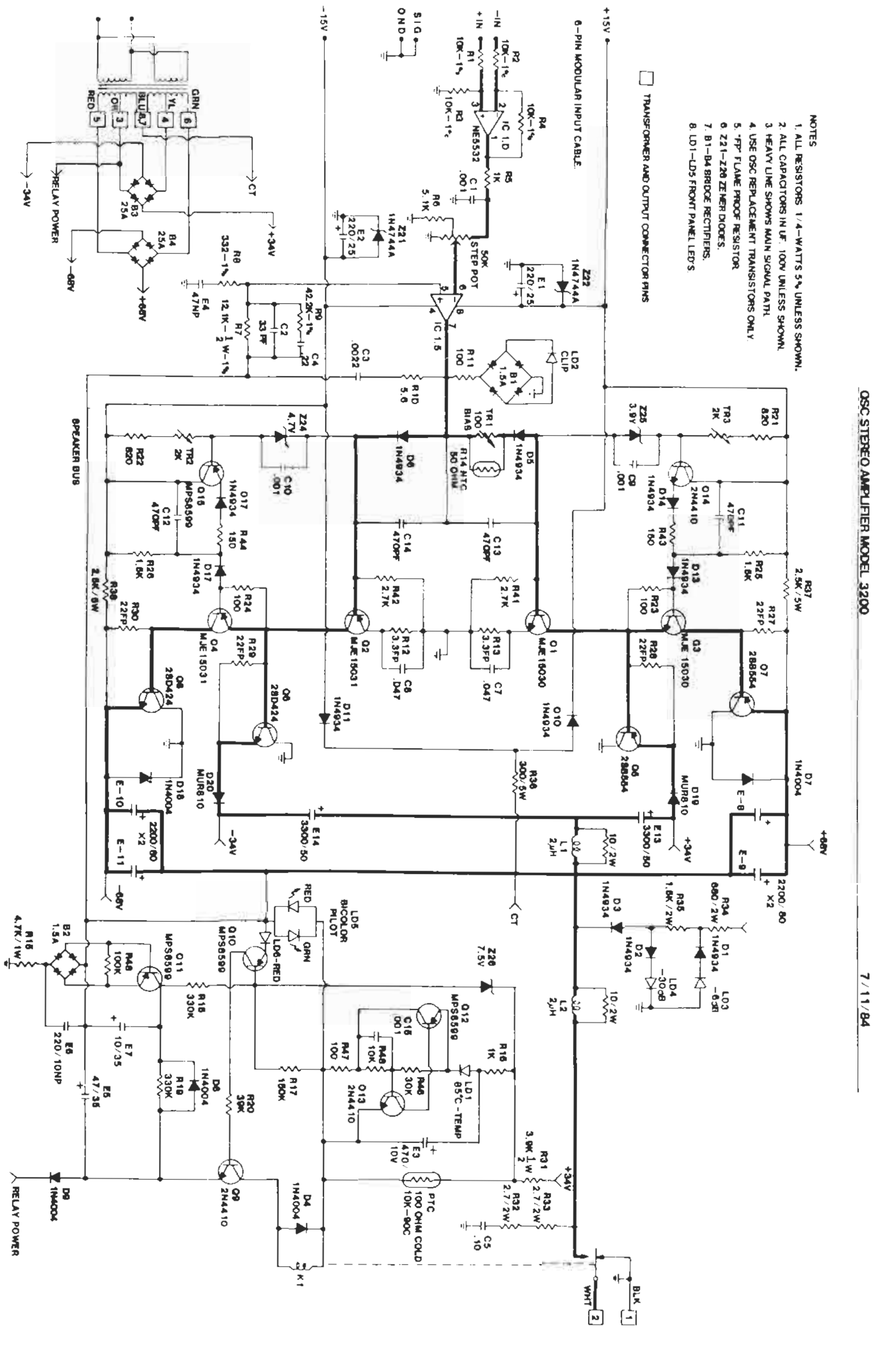
QSC amplifiers differ from conventional circuits in the arrangement of the power supply and circuit ground. Note that instead of grounding the center point of the power supply, and taking the speaker output from the common point of the output transistors, we ground the output transistor common and take 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 all the collectors are common, at ground potential. This lets us eliminate the mica insulators for the output transistors. Note, however, that the driver transistors must still be isolated.

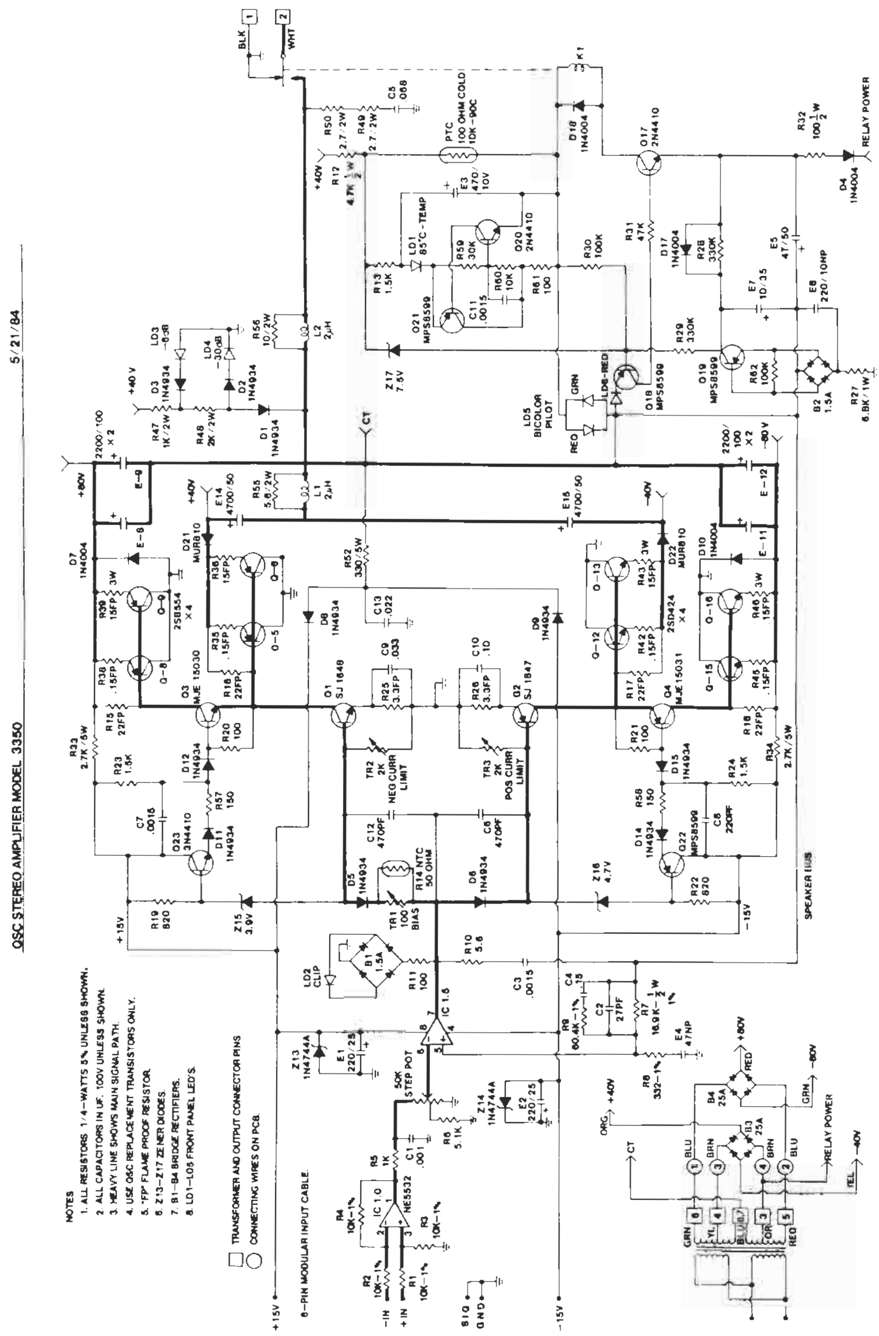
Because of this arrangement, a single dual op-amp can handle the rest of the circuit gain requirements. One section is used for the differential (balanced) input stage, and the other half is used in the actual amplifier.

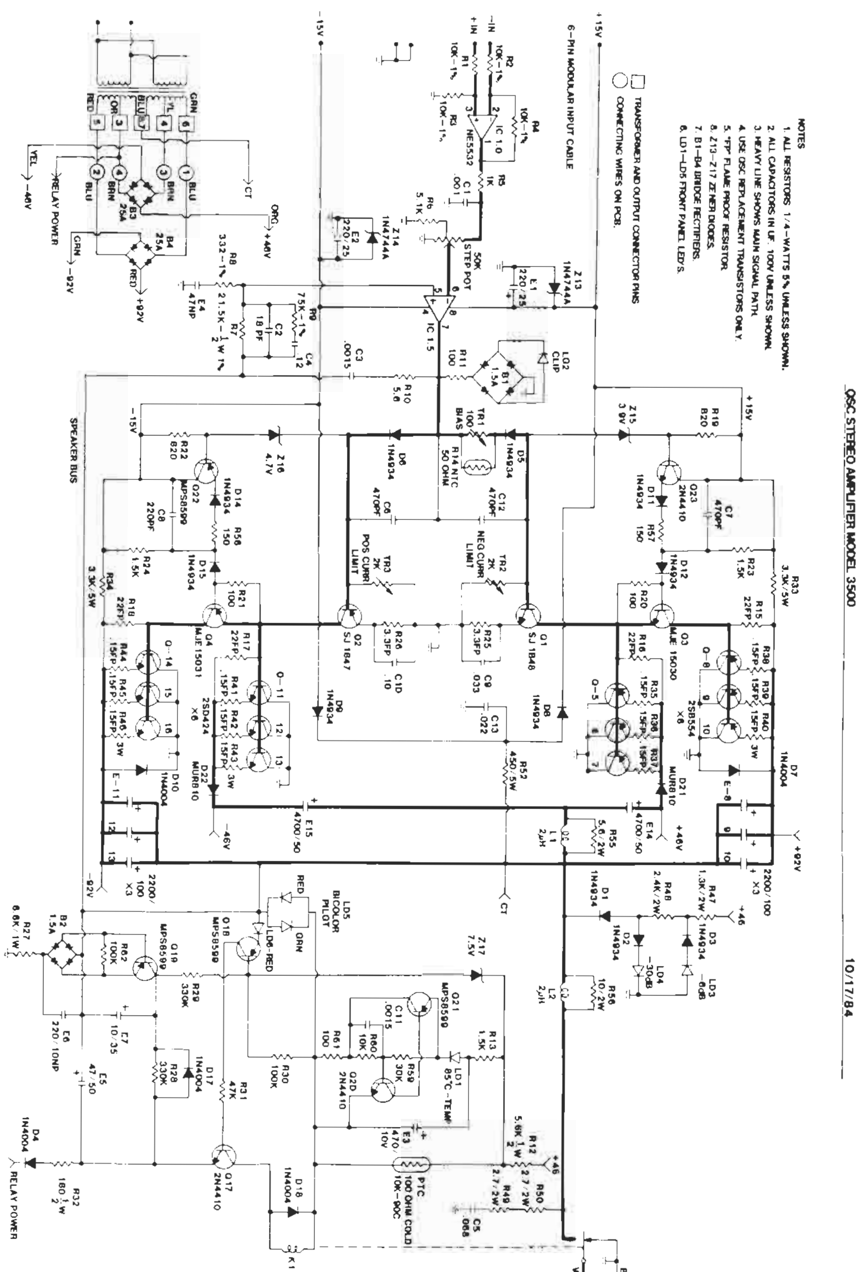
The remaining major differences in the Series Three circuit is the dual-level, high-efficiency output stage. Keeping in mind that the entire power supply, with bipolar full-voltage and half-voltage levels, moves as a unit when the speaker voltage varies, you will see that at voltage excursions below **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

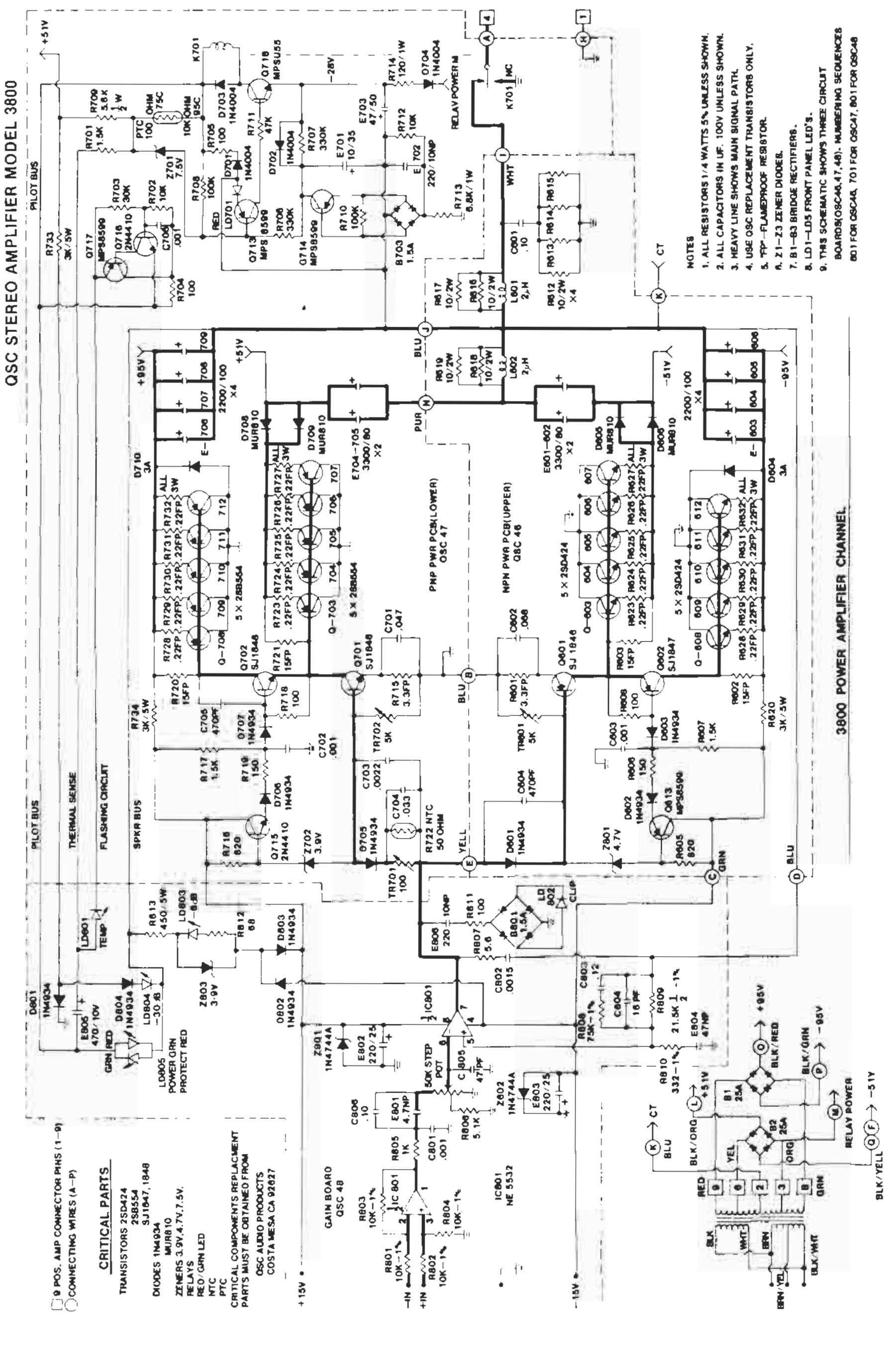
to take over conduction when the inner transistors are within several volts of saturation. The inner devices are cut off as the high-speed switching diodes in series become reversed biased, and the outer power transistors handle the remaining 50% of voltage swing.

The bipolar 15-volt supplies for the op-amp are ground referenced, and derived by resistive dividers from the main supply. the voltage is normally fixed by 15V sener diodes, but will decay to about 5 volts when operated 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.


QSC STEREO AMPLIFIER MODEL 3200
7/11/84
NOTES
1. ALL RESISTORS 1/4-WATTS 5% UNLESS SHOWN.
2. ALL CAPACITORS IN UF. 100V UNLESS SHOWN.
3. HEAVY LINE SHOWS MAIN SIGNAL PATH.
4. USE QSC REPLACEMENT TRANSISTORS ONLY.
5. "FP" FLAME PROOF RESISTOR.
6. Z21-Z26 ZENER DIODES.
7. B1-B4 BRIDGE RECTIFIERS.
8. LD1-LD5 FRONT PANEL LED'S.
TRANSFORMER AND OUTPUT CONNECTOR PINS
6-PIN MODULAR INPUT CABLE


QSC STEREO AMPLIFIER MODEL 3350
5/21/84
NOTES
1. ALL RESISTORS 1/4-WATTS 5% UNLESS SHOWN.
2. ALL CAPACITORS IN UF. 100V UNLESS SHOWN.
3. HEAVY LINE SHOWS MAIN SIGNAL PATH.
4. USE QSC REPLACEMENT TRANSISTORS ONLY.
5. "FP" FLAME PROOF RESISTOR.
6. Z13-Z17 ZENER DIODES.
7. B1-B4 BRIDGE RECTIFIERS.
8. LD1-LD5 FRONT PANEL LED'S.
TRANSFORMER AND OUTPUT CONNECTOR PINS
CONNECTING WIRES ON PCB.
6-PIN MODULAR INPUT CABLE


QSC STEREO AMPLIFIER MODEL 3500
10/17/84
NOTES
1. ALL RESISTORS 1/4-WATTS 5% UNLESS SHOWN.
2. ALL CAPACITORS IN UF. 100V UNLESS SHOWN.
3. HEAVY LINE SHOWS MAIN SIGNAL PATH.
4. USE QSC REPLACEMENT TRANSISTORS ONLY.
5. *FP FLAME PROOF RESISTOR.
6. Z13-Z17 ZENER DIODES.
7. B1-B4 BRIDGE RECTIFIERS.
8. LD1-LD5 FRONT PANEL LED'S.
TRANSFORMER AND OUTPUT CONNECTOR PINS
CONNECTING WIRES ON PCB.
6-PIN MODULAR INPUT CABLE
SPEAKER BUS
RELAY POWER


QSC STEREO AMPLIFIER MODEL 3800
3800 POWER AMPLIFIER CHANNEL
NOTES
1. ALL RESISTORS 1/4 WATTS 5% UNLESS SHOWN.
2. ALL CAPACITORS IN UF. 100V UNLESS SHOWN.
3. HEAVY LINE SHOWS MAIN SIGNAL PATH.
4. USE QSC REPLACEMENT TRANSISTORS ONLY.
5. *FP-FLAMEPROOF RESISTOR.
6. Z1-Z3 ZENER DIODES.
7. B1-B3 BRIDGE RECTIFIERS.
8. LD1-LD5 FRONT PANEL LED'S.
9. THIS SCHEMATIC SHOWS THREE CIRCUIT BOARDS(QSC46,47,48). NUMBERING SEQUENCES 601 FOR QSC46, 701 FOR QSC47, 801 FOR QSC48
POS. AMP CONNECTOR PINS (1-9)
CONNECTING WIRES (A-P)
CRITICAL PARTS
TRANSISTORS 2SD424
2SB554
SJ1847, 1848
DIODES 1N4934
MUR810
ZENERS 3.9V,4.7V,7.5V.
RELAYS
RED/GRN LED
NTC
PTC
CRITICAL COMPONENTS REPLACEMENT PARTS MUST BE OBTAINED FROM
QSC AUDIO PRODUCTS
COSTA MESA CA 92627
PNP PWR PCB(LOWER) QSC 47
NPN PWR PCB(UPPER) QSC 46
GAIN BOARD QSC 48
PILOT BUS
THERMAL SENSE
FLASHING CIRCUIT
SPKR BUS
RELAY POWER

SECTION EIGHT: SCHEMATICS