1.4 Series description

QSC's RMX Series amplifiers are entry-level professional audio products, designed for good, basic performance and reliability at low price. The series comprises three models: the RMX 850, RMX 1450, and RMX 2450. Each one has two audio channels and is two rack spaces tall. See page 2 for complete specifications.

The RMX 850 and RMX 1450 have single-sided printed circuit boards. The RMX 2450 uses double-sided boards.

1.5 Technical descriptions and theory of operation

Note: Some of these descriptions concern circuitry that is duplicated in the amplifier's two channels. For the sake of simplicity, the descriptions are of Channel 1 only. Components in Channel 1 have a 3-digit designation with "1" as the first digit; their equivalents in Channel 2 have a "2" as the first digit, followed by the same two numerals. For example, R122 and R222 have identical functions in their respective channels.
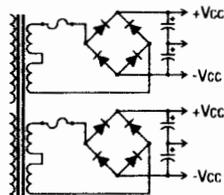
Figure 1.7

Power supplies

Unlike other recent QSC amplifiers, the RMX line uses strictly conventional power supplies, with large transformers that operate at the 50 or 60 Hz frequency of the AC line. The electrical current in the secondary circuitry is converted to DC through a full-wave bridge rectifier. The resulting 100 or 120 Hz ripple is filtered out by large capacitors that also serve as current reservoirs for short-term, transient demands.

The supply provides a bipolar set of supply rails for each channel, with equal quiescent positive and negative voltages, as shown in Figure 1.7. Note that unlike many bipolar supplies for complementary transistor arrangements, the secondary windings are not connected to ground at the center. This is because the output transistors are directly mounted to the heat sink, metal-to-metal, to maximize heat transfer; this grounds the collectors, requiring somewhat different output and power supply arrangements. The grounded-collector concept is described later in this chapter.

In the RMX 2450, the secondaries are tapped to provide an intermediate set of bipolar rails for the Class H output circuitry. Figure 1.8 shows one channel. Class H operation is described later in this chapter.
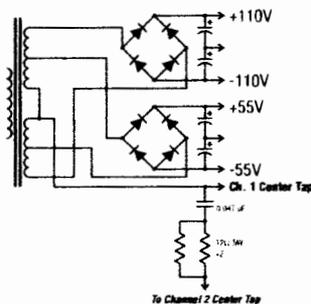
The 24-volt cooling fan is driven by a separate DC supply that is powered by a

Figure 1.8

20-volt tap on the transformer primary. To minimize fan noise, the fan speed is controlled by varying its actual DC voltage in response to the amplifier's heat sink temperatures. An optocoupler isolates the fan control circuitry from the thermal sensors.

Audio circuitry

The audio inputs are balanced to offer a reasonably high amount of common-mode noise rejection. The input balancing is done using a single op amp (one half of an NE5532 dual op amp) arranged as a differential amplifier. The degree of common-mode rejection is dependent on a close match between the input resistors (R100 and R101 in Figure 1.9) and between the feedback resistor and the shunt resistor (R105 and R106). The circuitry uses 1% precision resistors to ensure at least 40 dB of common-mode rejection.

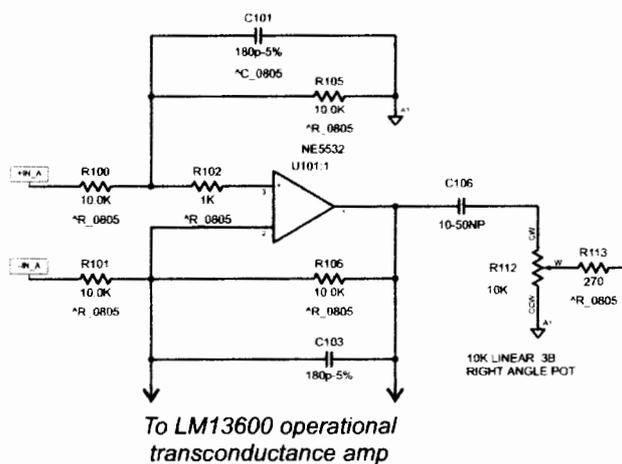To LM13600 operational transconductance amp

Figure 1.9

The feedback and shunt capacitors, C101 and C103, add a first-order high-frequency roll-off, down 3 dB at 88.4 kHz (over two octaves above the high end of the audio spectrum). This makes the amplifier less susceptible to RF interference, high-frequency oscillations, etc.

Also in this stage, the feedback loop contains one half of a 13600 dual operational transconductance amplifier (Figure 1.10). The OTA is part of the clip limiter circuitry; when the clip limiter is activated, a control voltage increases the transconductance of the OTA, which essentially decreases the impedance of the feedback loop and reduces the gain of the stage in order to reduce the amount of clipping.

The gain control uses a linear potentiometer, but the impedances loading the wiper to ground make the pot approximate an audio taper over most of its rotation. After the wiper, RC networks roll off the low end, if the LF filter is set for that channel, at either 30 or 50 Hz, depending on the DIP switch setting on the rear panel.

The next active device is another 5532 op amp, U101:2. Its output drives the driver transistors, which in turn drive the output transistors. The output section has a Class AB+B configuration; the drivers (a complementary pair, Q105 and Q106, comprising an NPN MJE15032 and a PNP MJE 15033) are class AB. A series network of two diodes and a 100-ohm trimpot provide the small amount of forward bias on
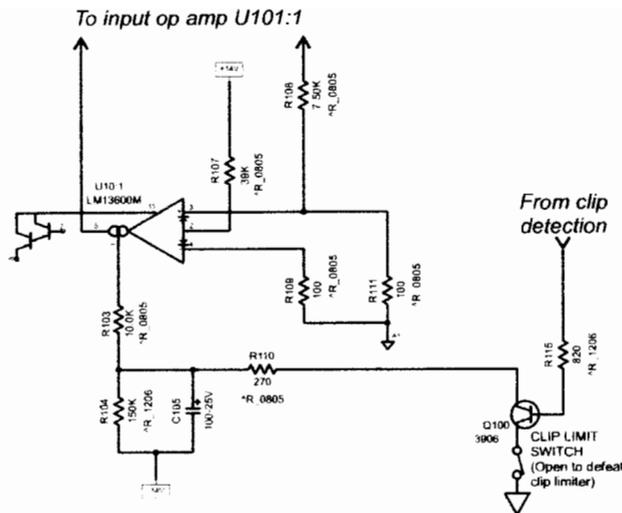
QSC Audio Products, Inc.

To input op amp U101:1

Figure 1.10

the transistor pair to keep crossover distortion minimal. In parallel with the trimpot is a 50-ohm thermistor with a negative temperature coefficient; as the circuitry warms, its resistance decreases. This reduces V_{BE} on both Q105 and Q106, decreasing the bias current to reduce the threat of thermal runaway. The base of each driver transistor is tied to ground through a diode and a 2.2K trimpot in series; these set the current limiting threshold for their respective signal polarities.

The collector of each driver transistor directly drives the bases of its output transistors, which are the main power-handling signal devices. If you're not familiar with the grounded-collector scheme, the arrangement of the output transistors might look somewhat strange: the positive voltage swings are handled by PNP transistors, while the negative swings are handled by NPN devices. The collectors all connect to ground, which allows them to be mounted directly to the heat sink—metal-to-metal, without insulators in between—for the best possible transfer of heat away from the transistors. The emitters of the PNP and NPN transistors are coupled through resistors to the positive and negative supply rails, respectively, forming banks of common-emitter circuits driving the supply rails. Consequently, the devices drive the rails with the audio signal, which rides atop the DC. The output to the speaker load is taken from the point between the positive and negative reservoir capacitors; this is also where the negative feedback is taken from. The nature of this arrangement, with audio signal riding on the supply rails, is why the power supply has no ground reference.

Another unusual characteristic of the grounded-collector output section is that the signal at the output to the speaker is actually opposite in polarity to the signal at the op amp output. This is why the negative feedback resistor, R122, connects to the op amp's non-inverting input instead of the inverting input.

The output point of the circuit couples to the output connector through an RLC network (R160, R161, R162, L100, and C124) that serves as a high-frequency snubber and also helps keep the amp circuitry stable when driving capacitive loads.

Clip detection

The output of the op amp also drives a group of four diodes (D102, D103, D105, and D106) arranged as a full-wave rectifier. Normally, the op amp's output signal level is about 1 volt or less, which is all it takes to drive the driver transistors.

But because this point is within the overall feedback loop, when clipping occurs, the op amp approcahes full open-loop gain and puts out a much higher signal voltage to try to make the output signal track the input. The four diodes rectify the voltage to drive the clip indicator LED, LD100. The current exiting the full-wave rectifier passes to ground through R127 and also drives the base of transistor Q100 through R115. If the clip limiter is switched on, Q100's emitter is grounded, and when the voltage across R127 goes sufficiently negative to forward-bias Q100, which sends current through R111 and R103 into the amplifier bias input of the operational transconductance amplifier (OTA), U10:1. The OTA is in the negative feedback loop of U101:1, and increasing its transconductance essentially reduces the impedance of the feedback loop, which reduces the gain of the op amp stage. This reduces the signal level until the amount of clipping is minimal. When the clipping stops, Q100 is no longer forward-biased, and the gain returns to normal.

DC protection

The RMX 2450 has a crowbar circuit, based on a triac and two silicon controlled rectifiers, on the output to protect against DC faults. If an amp channel puts out a DC voltage, which could be the result of a component or circuit failure, it will first trigger either D119 or D120, depending on the polarity of the voltage. The triggered SCR will in turn trigger triac Q113, shorting the output to ground through fuse F100. The fuse will blow, safeguarding the speaker load from the DC fault.

The output sections of the RMX 850 and RMX 1450 are AC coupled.

Class H

The RMX 2450 utilizes a two-step Class H output section. It is essentially a Class AB+B circuit but with two sets of bipolar supply rails. On both the positive and the negative sets of rails, a comparator circuit, called a "step driver," compares the audio signal to the lower rail voltage. When necessary to fully reproduce the signal's voltage swing—just before the signal voltage reaches the lower rail voltage—the step driver turns on a TMOS power FET to pull the output transistors' supply rail up from the lower voltage to the higher one, and then back down again when the signal allows. By keeping the transistors' supply rails low whenever possible, the devices dissipate less unused power and generate less waste heat, making the amplifier more efficient than a straight class AB amplifier with the same power points.

The comparators are 311-type ICs: U170 on the positive step and U171 on the negative. Each one drives a high-gain complementary transistor pair (2N3904 + 2N3906), which drive the gate of their respective MOSFET.

Bridged mono operation and protection

When the amplifier is operated in bridged mono, its two channels work in tandem to produce up to twice the voltage swing that a single channel is capable of. To do this, Channel 2 produces a signal identical to Channel 1's, but opposite in polarity—in other words, a mirror image.

Channel 2's signal feed (bus BR_MONO_FEED) is an attenuated version of the signal on Channel 1's speaker bus. Closing DIP switch #6 (set to "BRIDGE MONO ON"), connects the BR_MONO_FEED bus on Channel 1 to the BR_RET bus on Channel 2. The BR_RET bus drives the non-inverting input of op amp U201:2 directly.

With two channels operating as one, but each having its own feedback and protection circuitry, it is vital to keep both running as mirror images. A protection circuit monitors the balance between Channel 1's and Channel 2's signals. Resistors R22 and R23 (R22A, R22B, R23A, and R23B on the RMX 2450) are equal in value and form a voltage divider between the two channel outputs. If the output signals are mirror images, the voltage at the junction of the resistors (bus BR_BAL) will be zero. If the signals are not mirror images—for example, one channel is defunct, distorting, or reduced in gain—a voltage will appear on BR_BAL. Through DIP switch 7, the BR_BAL bus becomes bus BR_CUT and feeds the bases of transistors Q8 and Q6, which are part of a 4-transistor circuit across the +15V and -15V rails that supply the op amps and the input circuitry. If the voltage on BR_CUT goes positive enough to forward-bias Q8, the transistor's collector will collapse the +15V rail. At the same time, the emitter current from Q8 will flow through R25 and into the emitter of Q7, forward-biasing it, too. The collector of Q7 will then collapse the -15V rail.

Similarly, if BR_BAL goes sufficiently negative, it will forward-bias Q6, in turn forward-biasing Q9, and these will collapse the ±15V rails.
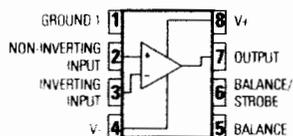
With the rails collapsed, the op amp and the input circuitry will not function, which will mute the audio.
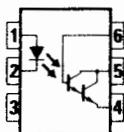
2. Component identification and pinout
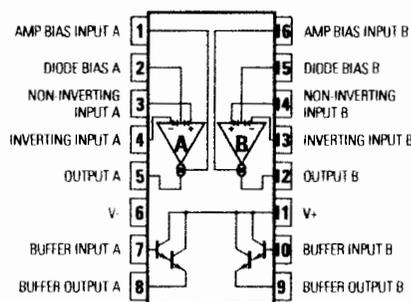
NE5532AN Dual operational amplifier
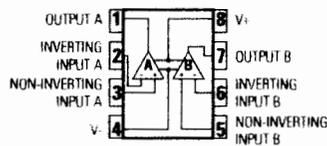
LM311 Voltage comparator

4N29 Opto-isolator

LM13600 Dual operational transconductance amplifier

2N5064 Sensitive gate thyristor

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