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PRO AUDIO REVIEW

Equipment Reviews for Today's Audio Professional

QSC PowerLight 9.0 Amplifier

Power and Efficiency to the Max

QSC PowerLight 9.0 Amplifier

ON THE BENCH

BY TOM YOUNG

Over the years, I have had the experience of using a variety of amplifiers in sound reinforcement applications. All amplifiers do not sound the same, even when their power ratings are identical. The unique way they sound is one way to separate one product line from another when making decisions on whether to purchase a company's line of amplifiers. Features, service and reliability are other determining factors. In my experience with QSC amplifiers, they rate extremely high in all categories, especially in sonic characteristics. The PowerLight 9.0 is no exception.

Features

The latest addition to the QSC PowerLight series, introduced in 1994, is the PowerLight 9.0. From a small chassis, this amplifier is the Godzilla in power for the PowerLight series. Commanding only 3 rack spaces high, 19" deep and weighing 59 lbs., the PowerLight 9.0 has the highest ratio of power to size ever accomplished by a professional power amplifier I have ever seen. In stereo at 8 Ohms,1 kHz, 1% THD, it's rated at minimum 1,950 W, 3,400 W at 4 Ohms, and 4,500 W at 2 Ohms per channel. In bridged mono at 4 Ohms, it has an impressive rating of 9,000 W — extraordinary.

The front of the amplifier consists of fan vents that let the four variable speed fans cool the amplifier from rear to front. The front panel contains a power switch and wisely recessed volume controls to prevent changing the gain of the amplifier by merely bumping into it. The gain controls are detented for incremental 2 dB steps, making resetting amp settings easy and precise. There are also three LED power supply indicators for each channel; red for protect, yellow for standby and green for power-on. The protect light illuminates during on/off muting for three seconds. This protects speakers and drivers during turn on/off operation, eliminating loud pops and clicks in the speaker system. The amplifier has a user-defeatable clip limiter, with switches on the front to reduce distortion and provide loudspeaker protection.

The rear of the amplifier contains a well-designed flexible array of terminations. The input connectors provide a Euro-style terminal strip, XLR and 1/4" TRS terminations. The output connections are achieved by a choice of a "touch-proof" binding post where all conducting metal is recessed, allowing the use of bare wire or banana plug terminations, or Neutrik Speakon connectors. There is a three-way switch for parallel-stereo-bridge operation. Remote AC power control availability and a data port for multisignal processing is provided. Many times when I was in the field and experienced problems with an amp, I had to replace it. It would have been nice to have had an amp this flexible to get up and running.

A power factor correction circuit (PFC) that lowers peak AC current requirements by as much as 40% in the amplifier is a unique feature of this unit. This feature is said to reduce the strain on AC distribution and is critical in large wattage amplifiers where extreme power requirements exceed available supplies. The PowerLight 9.0 also features line and load regulation, making the amplifier's peak power capacity immune to drops in AC line voltage. The amp also features a very low line current draw per watt of output.

AT-A-GLANCE

Applications: Sound reinforcement
Key Features: Power Factor Correction circuitry, 3,400 W at 4 ohms, Euro-style terminal strip, XLR and 1/4" TRS terminations, "touch proof" binding posts.

Price: $6,998

CONTACT: QSC AUDIO AT 714-957-7100

In use

I had the pleasure of using this amplifier for a show I was doing at the Metropolitan Club in New York City where space is a premium. I needed a PA but did not have the space in the room for racks of amplifiers. I was using a pair of Turbosound THL-2 boxes per side, which are a 3-way full range box with a 15" bass that I ran in the passive mode. I have used these boxes many times with other amplifiers, however, none with the power capacity of the PowerLight 9.0. Powered by QSC'sPL 9.0, the speakers had a certain life to them that I had not experienced with these speakers before, even when used previously in an active mode. The transients were tight and clear, and the bass extremely responsive. I was not able to get remotely close to amplifier clipping. I would like to use this amp again powering just the sub bass to listen to it work harder. All in all, I was very impressed.

Summary

The PowerLight 9.0 amplifier came to me as an early production unit with a preliminary spec sheet and no owner's manual. I am glad to see where the state of amplifier technology is going. The ability to package a product this powerful and flexible in a small package is going to set the standard for touring packages in the future. Where size, weight and power consumption are always at a premium in terms of cost, innovative products such as this one will be welcome. My hat is off to the QSC PowerLight series and its newest addition the PowerLight 9.0.

Tom Young has been a live sound engineer for more than 20 years, including many years mixing front-of-house for Frank Sinatra. Young band-mixes for Tony Bennett and is a contributor to ***Pro Audio Review.***

The QSC PL 9.0 Power Amp: A Technical Look at a Novel Design

ON THE BENCH

QSC PL 9.0 POWER AMPLIFIER

Testing power amplifiers as large as the PL 9.0 creates special challenges. These include large enough load resistors to take the power and a source of AC line voltage that will deliver the required current. Not having either a large enough load bank or a stiff enough AC supply, I took the logical step of testing the amp at the QSC factory. Their lab was very well equipped with all the necessary gear to do this. When I arrived, the equipment was all set up in a such a neat and orderly fashion that I was able to immediately set to work measuring the amp.

QSC has a large regulated AC power supply with remote sensing at point of use. This regulates the AC line voltage so it stays constant as a function of AC current drawn. At full power into 2-Ohm loads with both channels driven, the PL 9.0 taxed this supply to the max. By setting the no-load voltage high enough, it was possible to maintain close to 120 V at full power output, some 9 kW!

Total harmonic distortion plus noise as a function of power output and frequency in a 80 kHz measurement bandwidth is shown in Figures 1, 2, and 3 for loads of 8, 4, and 2 Ohms. Both channels were driven in this test and the results shown are for the left channel. Although distortion does rise with frequency, as is the case with the majority of amplifier designs, the overall amount of distortion is satisfactorily low and doesn't increase much for the lower impedance loads.

The PL 9.0 switching power supply's output is regulated but with a calculated amount of give under load. This helps to keep the power output more constant with AC line voltage changes for 8 and 4 Ohm loads. For instance, the amount of power attainable with 8 Ohm loads for AC line voltages of 132 and 100 V at about 0.9% distortion, roughly the visual onset of clipping, was 2.07 and 1.9 kW respectively. If the power supply was unregulated, but set to produce the 2.07 kW at 132V AC line input, the 100 V power would have dropped to roughly 1.2 kW.

Frequency response for open circuit, 8, 4, and 2 Ohm loading on the output is graphed in Figure 4. As can be seen, this amp has good load regulation in the audio band and the differences above the audio range are due to the series buffering RL network between the output stage and the output terminals. Damping factor as a function of frequency is plotted in Figure 5 for the right channel, which was the lower of the two.

The PL 9.0 behaved well on the test bench, especially for such a high power unit. One thing that impressed me was how nicely the unit clipped, even at high frequencies. There was no sticking, just smooth virtually perfect clipping behavior. Sticking is the phenomena where the wave form stays clipped beyond where it should, and then abruptly comes down with a step to become a sine wave again.

by Bascom H. King

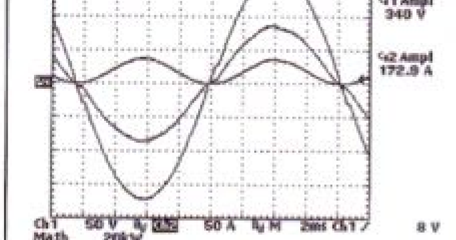
The PL 9.0 is, in my experience, a refreshing new approach to high power amplifier design. Quite a number of the circuit aspects of this design are patent pending.

Among the numerous technical innovations in the PL 9.0 is its Power Factor Correction (PFC) switching power supply. Apparently in most implementations of such supplies, a two tier approach has been used — a boost converter followed by the switcher that supplies the final power supply voltages used by the amplifier. In the power supply for the PL 9.0, this is all done in one stage, simplifying the circuitry and increasing the power supply efficiency. The control for the switching transistors in the power supply is a function of the product of a sample of the output DC voltage and the incoming AC line wave form.

This results in the AC line current being sinusoidal and in phase with the AC line voltage. Further, the DC output voltage that powers the amplifier circuitry is regulated with some designed-in "give" to promote overall stability in the prime AC supply. Even more impressive: The power supply current will follow the shape of an arbitrary input AC voltage wave form indicating that the AC input impedance of this unit is essentially resistive in nature and not some result of resonance of the 60 Hz frequency.

Power factor correction

This amp will work equally well at 50 or 400 Hz, again, with the current being in phase with the voltage. All is not theoretically perfect in this picture as the AC current at idle and low output powers tends to be more like that of a conventional power supply; current pulses drawn at the peak of the AC input voltage. As the power output from the amplifier increases, the current quickly "fills out" to a sinusoidal shape. This is logical and OK as the high efficiency and power factor corrected current is more important at high AC currents when the amp is cranking it out. An example of the AC line voltage, current, and instantaneous power, the product of the voltage and current, is shown in Figure 1 for a PL 9.0 running at 1/2 power into a 2-ohm load. In this plot, the largest wave is the AC line voltage, the next larger wave is the AC current waveform, and finally, the smallest wave, running at twice the line frequency, is the product of the current and voltage. Note the essentially sinusoidal shapes of the waves. In contrast, a similar set of waveforms for a more conventional non-power factor corrected power supply in another power amplifier is shown in Figure 2. Here, the AC line voltage is severely clipped due to



the current being drawn more at the peaks with the current wave form being typical of this conventional power supply.

Output circuitry for the PL 9.0 consists of a four quadrant full bridge topology with one side of the load grounded. Thus, the power supply for this output stage, of a single polarity without a center tap reference, could move with respect to signal ground. Each side of the bridge uses two large-geometry N channel MOSFET power devices in parallel. It is in the drive to these output devices that much of the circuit innovation of the PL 9.0 resides. Each output device is included in a servo circuit that forces its output current to be a linear function of the controlling input current. This way, the paralleled pairs of devices in each side of the bridge share current equally. The drive to each corner of the bridge is symmetrical and thus the controlled current "cells" behave in a complementary manner using output devices of the same polarity.

A current processor

One consequence of the current-operated nature of the output stage is that the

ON THE BENCH

Bench Measurement of QSC PL 9.0 Power Amplifier

OUTPUT POWER (EIA)

At clipping, 8 ohm load	2,020 W
Clipping headroom re: 1,950 W rating	0.15 dB,
Dynamic power, 8 ohm load	2020 W
Dynamic headroom re: 1,950 W rating	0.15 dB
At clipping, 4 ohm load	3,500 W
Clipping headroom re: 3,400 W Rating	0.13 dB
Dynamic power, 4 ohm load	3,916 W
Dynamic headroom re: 3,400 W Rating	0.6 dB
At clipping, 2 ohm load	4,500 W
Clipping headroom re: 4,500 W rating	0 dB
Dynamic power, 2 ohm load	6,642 W
Dynamic headroom re: 4,500 W rating	1.7 dB

INPUT CHARCTERISTICS (average of both channels)

For 1 W output, 8 ohm load	54.3 mV
For 1950 W output, 8 ohm load	3.1 V
Voltage gain, 8 ohm load	32.1 dB
Channel balance	0.06 dB
Input impedance At 1 kHz	20.0 K

COMMON MODE REJECTION RATIO

Left channel -70 dB, 20 - 500 Hz, rising to -64 dB at 20 kHz

Right channel -71 dB, 20 - 500 Hz, rising to -58 dB at 20 kHz

FREQUENCY RESPONSE

20 Hz to 20 kHz, 8 ohm load	+0.05 dB, - 0.18 dB
-3 dB points	< 10 Hz, 60 kHz

NOISE LEVELS (Input levels at maximum)

A-wtd residual (left/right)	354 uV, -78.1 dBW
339 uV, -78.4 dBW	
Wideband residual (left/right)	6.89 mV, -52.3 dBW
	7.53 mV, -51.5 dBW
A-wtd signal to noise re: 1,950 W, 8 ohm (left/right)	-111.0, -111.3 dB

TOTAL HARMONIC DISTORTION PLUS NOISE

(4 ohm loading, left channel)

At 2 W, 1 kHz, 20 Hz to 20 kHz	0.032
	< = 0.051%
At 20 W, 1 kHz, 20 Hz to 20 kHz	0.011 < = 0.10%
at 200 W, 1 kHz, 20 Hz to 20 kHz	0.015 < = 0.11%
at 3000 W, 1 kHz, 20 Hz to 20 kHz	0.01 < = 0.11%

SMPTE INTERMODULATION DISTORTION

At 1.8 kW, 8 ohm load	< = 0.005%
At 3.3 kW, 4 ohm load	< = 0.007%
At 4.0 kW, 2 ohm load	< = 0.012%

CHANNEL SEPARATION

L > R at 1 kHz, 20 Hz to 20 kHz	83.7dB, > = 82.1 dB
R > L at 1 kHz, 20 Hz to 20 kHz	84.2dB, > = 74.6 dB

DAMPING FACTOR (RE: 8 OHM LOAD)

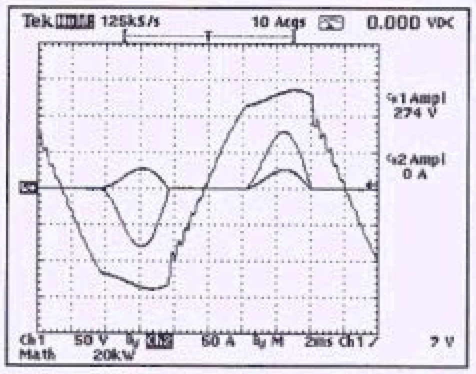
One amp RMS injected current, 50 Hz (left/right)	> = 3,500/2,800
One amp RMS injected current, 20 Hz to 20 kHz (left/right)	> = 33.1/31.8

Notes:

1. All measurements made with balanced inputs and in stereo mode unless otherwise noted.
2. Inputs terminated with 300 ohm/phase for noise and channel separation.
3. AC line current at idle, about 2.5A.
4. Dynamic power levels are at beginning of the 20 ms burst. Power levels at end of burst were somewhat less, more so with the lower impedance loads.

stage has a high dynamic output impedance. This is reduced to very low values in the overall amplifier circuit by several nested feedback loops enclosing the output stage. Another major difference in this output stage and virtually all others is that it is not self-commuting within itself. Meaning, in typical complementary-symmetry output stages, the transfer of current from one output device to the other occurs naturally using a common drive signal for both halves. In the PL 9.0, the drive signals for the four sides/corners of the bridge have the same nominal amplitude, but the polarities differ so that separate drive signals must be delivered by the preceding stage. The circuit that does this (termed a Class A to Class B current processor) takes the differential output of the preceding stage and, for a sine wave input, outputs shaped half-wave sinusoids. Thus, in the PL 9.0, the drive signals for the four corners of the bridge output stage are separate appropriate polarity but nominally equal amplitude signals of a special nature created by the preceding circuitry.

In the PL 9.0, the commutation between half cycle signals is done before the output stage. With this approach, one can define the transfer characteristics of the output stage to get the best transfer between half cycles of



the output signal for lowest distortion.

Power supply voltage for the output stage is actually arranged in four switched voltage levels, nominally 50, 100, 150, and 200 V. This is commonly called Class H. It has the distinct advantage of creating less output stage dissipation and greater overall efficiency at low to moderate output powers yet permitting much higher peak output stage levels when the signal demands it. The power supply voltage switches are four of the same type of devices used in the output stage itself. Control circuitry for switching to the higher levels of supply voltage is obviously output signal level knowledgeable. A Bessel low-pass filter in the signal input amplifier provides enough delay so that the level switching can take place in a timely manner.

More stages

The description thus far is for the main circuit block of the PL 9.0, which is arranged as a transconductance amplifier. All stage transfers are in a current mode with little voltage appearing at the various nodes except at the final amplifier output. This main portion of the circuitry is enclosed in a feedback loop to reduce output impedance and extend bandwidth. Another amplifier stage preceding this is configured to provide an integrating response (a 6 dB/octave increase in gain as frequency decreases). An overall feedback loop from the main output comes back to the inverting input of this stage.

All of this, being what I would define as the power amplifier circuit proper, is preceded by a separate front-end adjustable gain stage that accepts with equal facility either balanced or unbalanced signal signals.

Great attention to circuit layout and shielding is required in a design such as this to minimize RFI generation and to get the overall performance in terms of distortion and noise to the level desired. Not to be dismissed, but not to be elaborated upon here, are the sophisticated protection and control circuitry that help to make this all function as the innovative high power amplifier that it is.

–Bascom H. King

ON THE BENCH

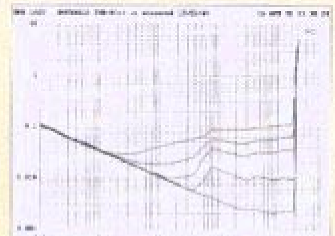


Figure 1: Total harmonic distortion versus power and frequency, 8-ohm loads. At 1 kW from bottom to top, 20 Hz, 1 kHz, 5 kHz, 10 kHz, 20 kHz.

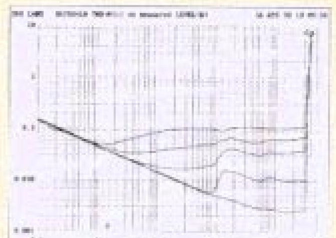


Figure 2: Total harmonic distortion versus power and frequency, 4-ohm loads. At 1 kW from bottom to top, 20 Hz, 1 kHz, 5 kHz, 10 kHz, 20 kHz.

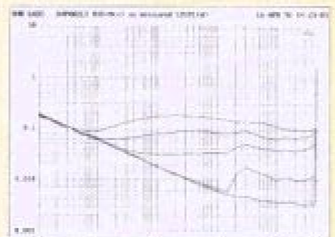


Figure 3: Total harmonic distortion versus power and frequency, 2-ohm loads. At 1 kW from bottom to top, 20 Hz, 1 kHz, 5 kHz, 10 kHz, 20 kHz.

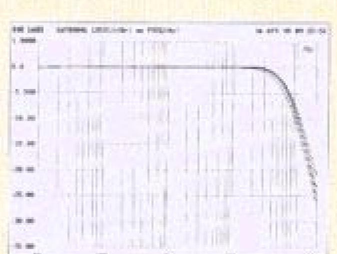


Figure 4: Frequency response for open circuit, 8, 4, and 2 ohm loads. At 100 kHz, from bottom to top, 2 ohm, 4 ohm, 8 ohm, open circuit.

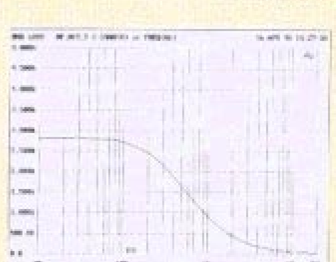


Figure 5: Damping factor versus frequency.