ATMA-SPHERE M-60 MK. II
OTL POWER AMP TEST

Reviewed by Charles Hansen, in Glass Audio, Issue 6, 1998, p.p. 64-69

The Atma-Sphere M-60 MK. II (an assembled unit supplied by Atma-Sphere) comprises a pair of 60W monoblock amplifiers, each weighing 30 lb with dimensions of 19" W X 5.25" H X 12" D. The circuitry is a patented, fully balanced, differential output-transformerless (OTL) design, using four 6SN7 drivers and eight 6AS7G low-mu dual-triode output power tubes. The tubes that arrived with the test units were Phillips JAN 6SN7WGTAs and Sovtek 6AS7Gs.

The main chassis has cooling holes located around the eight power-tube sockets to promote convective cooling air flow. The three power transformers are located under another chassis behind the 12 tubes, and a bias/DC offset meter is placed front and center on this upper chassis. Cooling louvers are in abundance on the hammertone, gray stainless steel chassis, giving it a retro industrial look.

The front panel has a main power switch with an amber indicator light, and a standby switch with a red indicator light. The main power switch energizes all the tube filaments, as well as the high voltage and bias for the 6SN7s. The standby switch provides high voltage to the output tubes, and is to be turned on at least one minute after the main power switch. The standby switch is wired in series with the power switch, so you cannot accidentally turn off the filaments and leave the high voltage on.

One pot adjusts the DC offset voltage, and another the bias current. A test switch selects between the two functions and displays the results on the aforementioned offset meter. The back panel has a pair of heavy-duty, solid-copper output binding posts, a test binding post (for DC balance and bias), a gold plated Teflon™ insulated unbalanced RCA input jack, and an XLR balanced input jack. An IEC power-cord receptacle and three fuse holders complete the rear panel. A well-marked placard gives connection and calibration instructions.

Tube-pology

The balanced XLR inputs are connected to a 6SN7 configured as a differential amplifier. In the unbalanced mode, a jumper shorts pins 1 and 3 in the XLR. This jumper changes the input stage to a grounded-grid, cathode-coupled long-tailed pair phase inverter. The cathodes are connected to the plate of a series-connected 6SN7 cascoded constant-current stage.

One pair of zener diodes sets the grid of the upper half of the cascode-current source 94V CD below ground via a high-voltage bias supply. The cathode of this stage is coupled to the plate of the lower half, whose grid is biased 94V DC above the negative-bias supply rail. Fixed resistors in the cathode of the lower half set the constant current value.

The plates of the 6SN7 differential input pair are series connected to the cathodes of another pair of 6SN7s that cascode the differential pair. The grids of the upper cascode stages are held 47V DC above ground by a zener that is bypassed by a Rel Cap film capacitor. This set of cascode 6SN7s constitutes the only gain stage in the amplifier.

The plates of the cascode sections are coupled to the grids of the last 6SN7 tube via the only capacitor in the signal path, which serves as the push-pull driver pair for the output tubes. The grid resistors, in conjunction with the Rel Cap coupling capacitors, set the Ã¢â‚¬â€œ3dB low-frequency cutoff at 0.8 Hz. The DC offset and output bias adjustment pots are incorporated into the grid bias circuit for the drivers.

Atma-Sphere uses its patented Balanced Differential Design™ rather than the Futterman OTL design. The output stage is a bridge amplifier consisting of four 6AS7G dual triodes per side, and the eight grids and cathodes of each side are connected in parallel. The left side of the bridge consists (from top to bottom) of eight plate resistors (1R1 5W), the eight triodes, then one of the floating power supplies (+ to -). The right side of the bridge consists (again from top to bottom) of the second floating power supply (- to +), the common-connected cathodes of the other eight triodes, and the other eight plate resistors.

The two bridge halves are connected in series, with the speaker connected horizontally between the negative supply sides of the two floating supplies, resulting in a parallel arrangement. The grids of output-tube bridge halves are operated push-pull from the cathodes of the 6SN7 driver, and are biased so the output tubes operate in Class A.

The speaker terminals are not grounded, owing to the bridge design (neither terminal is allowed to contact chassis ground). Feedback, only 2dB, is returned from each speaker terminal to the respective grid circuit of the 6SN7 differential input amplifier.

The two floating output-tube power supplies are fed by separate secondary windings of a massive toroidal transformer, and the full-wave rectified DC is well-filtered with two 1,500µF capacitors per winding. The plate and bias supplies for the 6SN7s are filtered by 100µF each. The power indicators are connected to the 6.3V AC filament windings which, in the case of the eight output tubes, is a hefty 20A transformer.

Measurements

In accordance with the kit instructions, I adjusted the amplifier for minimum DC offset and the output-tube bias for 0.55A DC plate current, and then operated it for three hours at idle with a resistive load, checking the settings every 15 minutes for the first hour. After the third hour, I reset the DC offset and bias and ran in the unit with pink noise at approximately 5W for another two hours. After five hours, the DC offset and bias were stable.

Both adjustments are easy to make, with good pot resolution. However, each minor division on the panel meter represents a rather large increment of DC offset. With the meter needle set to zero, the actual offset measured +65mV, with true zero being about one needle-width positive. Each minor division in the positive meter direction represented about Ã¢â‚¬â€œ140mV, and each minor division in the negative direction represented about +200mV. I was able to adjust it down to 14 mV, but it tended to wander with load.

There was no transient thump from the speakers during either turn-on or shutdown. With my ear to the speaker, I detected no hiss, only a very low-level 120Hz buzz, which was inaudible from the listening position. Hum and noise measured only 0.8mV with the input shorted. The unit runs fairly hot, especially at the right side of the chassis where the toroidal B+ transformer is located. The tube filaments alone dissipate 140W.

The M-60 Mk. II does not invert polarity, and XLR pin 2 is positive. The amplifier is unconditionally stable for any load condition. Input impedance was 98kΩ at the unbalanced input, and 199k at the balanced input. Input sensitivity for 2.83 V RMS into 8Ω was 0.181V RMS, or 23.9dB. With a 4Ω load, input sensitivity was 0.284V RMS, or 20 dB. The gain was identical for both the balanced and unbalanced input; however, any preamp used with the amp will need more gain than usual to get maximum power into 4Ω speakers.

Frequency Response

The frequency response is plotted in *Fig. 1*, with the output voltage set to 2.83V RMS at 1kHz for loads of 4Ω, 8 Ω, 8Ω paralled with a 2µF cap, and an IHF speaker load. I also measured the open-circuit response (not really "open", since the output bridge is loaded by 600Ω resistors from each speaker terminal to ground). This amplifier is stable with a leading power factor or any other load condition, with no evidence of any ringing or instability. Response with the resistive loads was within ±3dB from 10Hz to 100kHz.

Each output-tube plate is rated at 13W and 280Ω. While the composite output stage can absorb 288W, the equivalent ohms of plate resistance is rather high compared to a conventional tube amplifier with its output transformer. To illustrate the sensitivity of the OTL design to speaker impedance, I measured the output response with a fixed input signal of 180mV RMS. The results in *Fig. 2* are plotted for 4Ω, 8Ω, 8Ω paralleled with a 2µF cap, the IHF speaker load, and the open circuit. The 0dB relative (0dB rel) condition is defined at 2.83V RMS into 8Ω at 1kHz.

THD+N versus frequency is shown in *Fig. 3* at 1W into 8 Ω, 2W into 4Ω, and 2.83V RMS into 8Ω paralleled with a 2µF cap. The THD was slightly higher using the balanced input, so all measurements were made this way. The 4Ω measurements are substantially higher than those at 8Ω. Viewing the monitor output waveform (after the THD test set the notch filter) showed mainly the second through the fifth harmonics, with very little fuzz or noise, although there were higher-order harmonics at 4Ω.

MANUFACTURER'S SPECIFICATIONS (PER CHASSIS)
Power output: 60W into 8Ω or 45W into 4Ω (120V AC mains voltage)
Frequency response (1W): 1Hz-200kHz (±0.5db), 2Hz-1.5Mhz (±3dB)
Power bandwidth: (60W): 2Hz-75kHz (±0.5dB)
Slew rate: 600V/µs
Feedback: 0-2dB, hardwired
Maximum AC line power: 300W

Clipping Levels

Figure 4 shows THD+N versus output power at 1kHz into 8Ω and 4Ω. As before, the THD measured at 4Ω is significantly higher than at 8Ω. The clipping level is normally defined as that power where THD+N reached 1%, but the baseline distortion is fairly high at low power levels. The generally accepted practice for OTL and single-ended (SE) tube amps is to use 3% THD+N as the clipping point. This occurred at 23W into 8Ω and only 9.5W into 4Ω.

Maximum output power into 8Ω was 65W (5.6% THD+N) when the B+ fuse blew. The fuse blew again during the 4 ΩΩ test at 44W (8.8% THD+N). The AC line voltage was 118V AC, rather than the 120V AC at which the amplifier is rated, for 60W (8Ω) and 45W (4Ω). I detected absolutely no sound of strain or transformer hum right up to the point of maximum power. The only indication that output power had ceased was when the distortion-test set meter dropped to zero, followed by the gentle tinkle of contracting tube elements as the thermal load was removed.

Intermodulation distortion (CCIF IMD with 19kHz + 20 kHz) at 12V pk-pk into 8 Ω was 0.085%, and 0.166% into 4 Ω. The multitone IMD (9kHz + 10.05kHz + 20kHz) into 8Ω was 0.051%, and 0.049% into 4 Ω.

The spectrum of a 50 Hz sine wave at 8.5W into 8Ω is shown in *Fig. 5*. The THD+N at this load measured 1.6%, and the predominant harmonics are shown in the mark list.

The 1V pk-pk square wave at 40Hz into 8Ω showed minimal tilt, indicating good low frequency response. The 1kHz square wave is nearly perfect. Some leading-edge rounding is visible at 10kHz without any evidence of peaking or ringing. This is very good performance.

Conclusion

The Atma-Sphere M60 Mk. II test results are representative of high-end OTL and SE amplifier designs. The seemingly high distortion levels are not evident during listening tests. Frequency response is exceptionally flat, since the output tubes are connected directly to the speaker rather than being coupled through an output transformer.

The IM and square-wave data is quite good; this amplifier is impervious to instability caused by difficult output loads. Indeed, OTLs have an excellent reputation when used with electrostatic speakers. Output power, however, is extremely dependent on load impedance, and the unit just missed its specified power with the 4Ω load, albeit at 118V AC mains voltage rather than the 120V AC that Atma-Sphere recommends.

Manufacturer's response:

Thank you for the time and energy you put into this review. We appreciate the attention.

The M60 Mk. II kit is our M60 Mk. II made available to the DIYers at a reasonable price. The kit is slightly stripped down compared to the assembled version, but is the same circuit, and its performance is easily upgraded with many options. These are outlined on our web site (www.atma-sphere.com) and are both circuit and materials enhancements. There is also an independent owner's group (The Atma-Sphere Owner's Group is at http://www.audioasylum.com/forums/otl/bbs.html), where further information is available.[Note: the link has been updated. The ASOG was shut down in 2004.]

Although the amplifiers we make are OTLs, we have more in common with single-ended amplifiers and Nelson Pass' minimalist solid-state efforts than anything else. We have a philosophy of zero feedback (although the M-60 employs 2dB), ClassÃ¢â‚¬â€œA operation, and minimalist circuits in order to wring out as much performance as possible. With only a single gain stage there are less places for things to go wrong.

This amplifier has nothing in common with the old Futterman circuits and is therefore reliable and unconditionally stable. As a result of making the world's first reliable OTL, we are the oldest manufacturer of OTLs in the world (we are in our 21st year). A further benefit of the Circlotron circuit is a lowered output impedance, making for a lowerÃ¢â‚¬â€œpowered OTL that is practical on an 8Ω load. It is possible to improve the measured performance by hand-picking the tubes and other parts, since the amp relies entirely on circuit balancing and simplicity, rather than feedback, to reduce distortion.

Ralph Karsten
Atma-Sphere (1742 Selby, St. Paul, MN 55104, 612-690-2246)

Back