Since 1984

Boulder

3050

Class A Mono Power Amplifier

Technical Information

An introduction to the technology in the 3050 Mono Power Amplifier. The 3050 is the first product within the 3000 Series and is the highest performing and most powerful amplifier Boulder has ever produced.

Basic Design

The 3050 Mono Amplifier was conceived and created because of demand from existing 2050 Mono Power Amplifier owners. Since the 2050's original release, loudspeakers have grown in price and performance, yet the 2050 has never been updated or revised. Eventually, demand was such that a larger and more powerful reference product was needed to meet the demands of the market. At the time of its development, no other linear amplifier was available with the power output of the 3050 (1,500wpc).

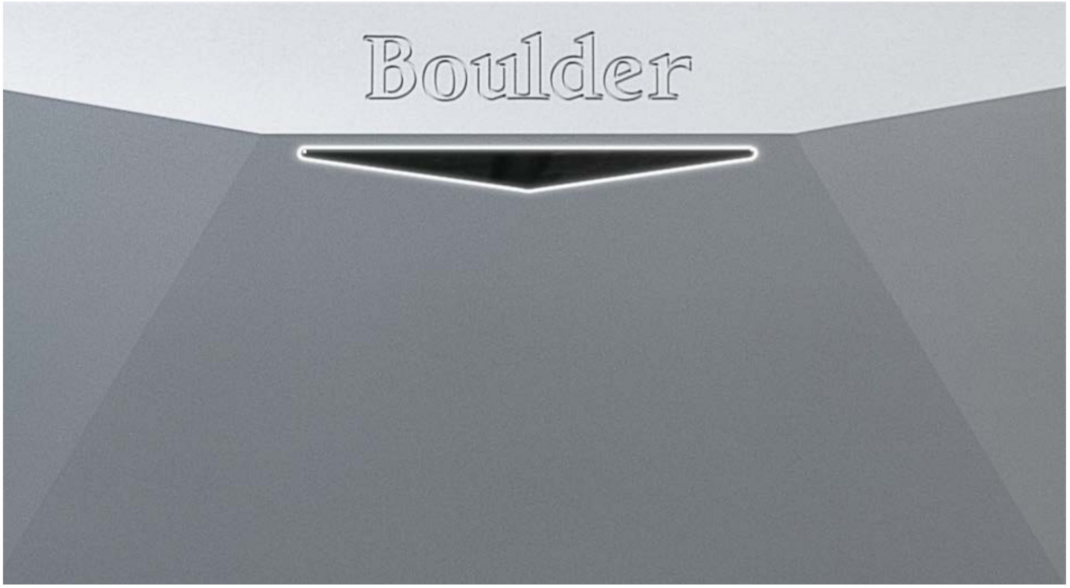
The 3050 was created from conception entirely as a monaural design. It is not a mono derivative of a stereo amplifier. The left and right chassis casework are physically symmetrical, with the pair being mirror-imaged. No metal is shared between the left and right units. All metalwork is interlocking, machined from solid billet and non-resonant to eliminate microphonic resonance distortions. At no point do exterior surfaces terminate at a 90° angle.

Gain stages within the 3050 are the new and proprietary Boulder 99H, based on the modular and discrete 993 gain stage used in Boulder's 2000 Series products. 99H gain stages are only used in 3000 Series products. The "H" in 99H signifies "high voltage." The 99H is a surface-mount, circuit board-implemented, fully-discrete, extremely high-current gain stage that provides the best possible distortion figures and exceptionally low noise.

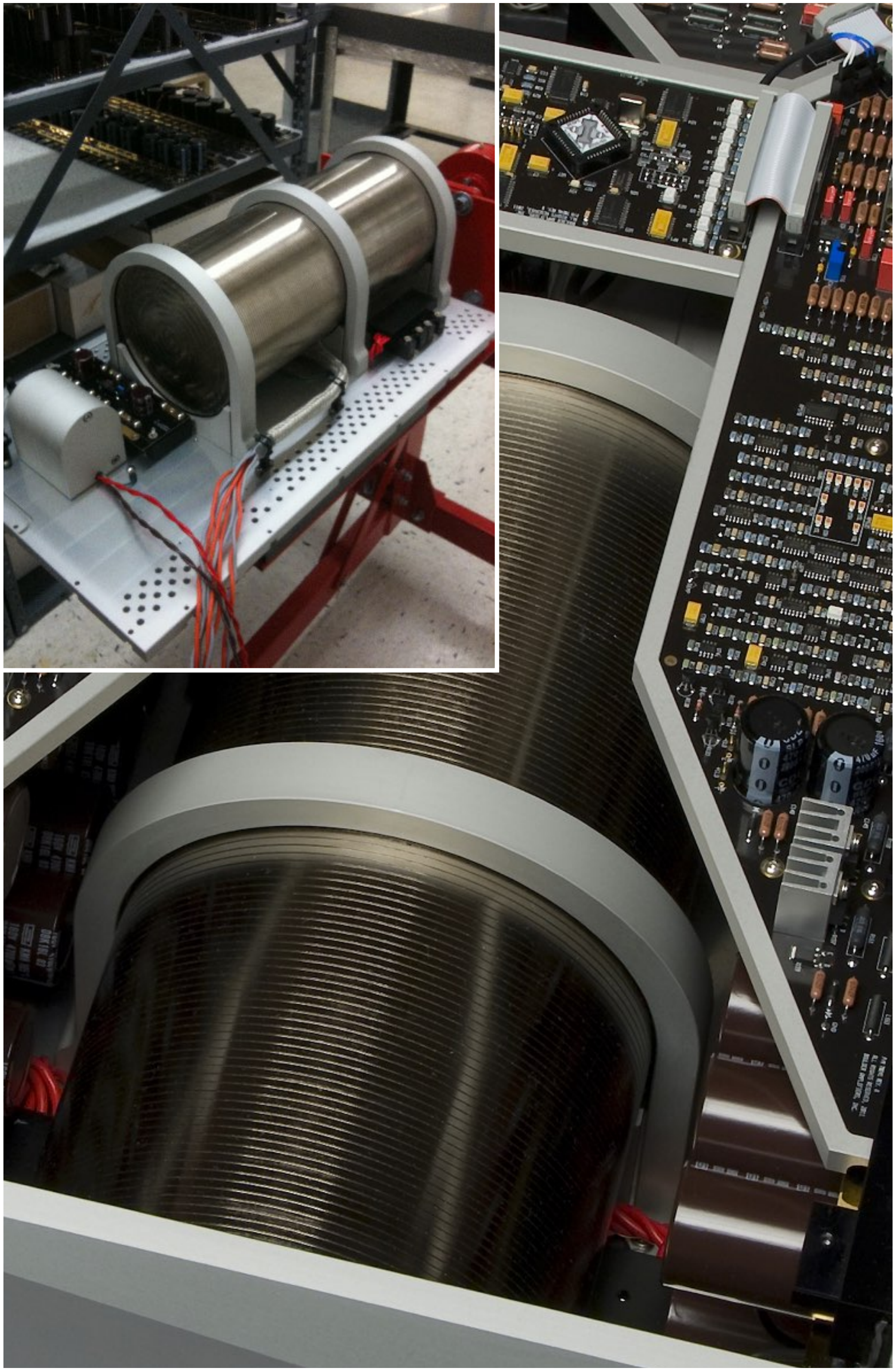
Bias operation is Class A to full rated output power. An analog bias circuit continually monitors the voltage draw, current draw and load to adjust the bias current as necessary in order to maintain Class A operation. If a musical transient requiring more bias current is detected, the circuit will raise the bias much faster than the audio signal to keep the amplifier operating within the Class A window. After the transient has passed, it will then gently lower the bias in a decreasing analog manner over a period of 28 seconds until another transient peak is detected. This has the benefit of keeping the 3050 operating in full Class A mode without the drawbacks of massive power consumption, excessive heat generation and the audible steps or "sliding" of other active bias management systems.

Power output is 1,500 watts continuous into an 8, 4, or 2-ohm load. Peak output will double to 3,000 watts into a 4-ohm load, and 6,000 watts into a 2-ohm load. The ability to deliver power under load contributes to unmatched control and dynamic impact during transients or dynamic swings and a sense of unlimited power during low frequency passages into any and all loads.

The elimination of noise and distortion were paramount in the design of the 3050. The 3050 is true differentially balanced at the inputs and outputs for optimal common-mode noise cancellation in tandem with the use of the 99H gain stage. Lower distortion, and in particular, lower noise in the form of a much lower noise floor, contribute to vastly increased resolution of fine detail.



Contents



Power Supply

The 3050 incorporates two main power supplies; a large, massive brute supply for the input and output section, and a smaller, regulated independent supply for the supervising microprocessor control section. All supplies are linear. No switching supplies are used in any Boulder product. Switch-mode supplies are generally a solution of economy rather than performance.

1. AC Mains

AC mains power to the 3050 is provided via a detachable 32-amp IEC connector. A 32A connector was selected due the amplifier's ability to draw nearly 30A peak current during high power outputs into low-impedance loads. The next greatest amperage rating for a safety approved detachable IEC connector above 20A is 32A. The 32A IEC connector incorporates low resistance, machined brass contacts for safe and ideal electrical transfer. All 3050s are built to operate at 240VAC. No lower operating voltages will be accommodated so as to guarantee full rated power output into any load and to prevent excessive current draw from the AC mains.

2. Brute Supply

The large, main brute supply features four toroidal transformers, two for each phase of output. Four transformers ensure ideal noise isolation between each phase as well as faster and more efficient operation during high output. Toroidal transformer design was specifically selected for power handling efficiency and low noise radiation. All transformers are specified and built in the USA to Boulder's standards. Transformer hum is not permitted.

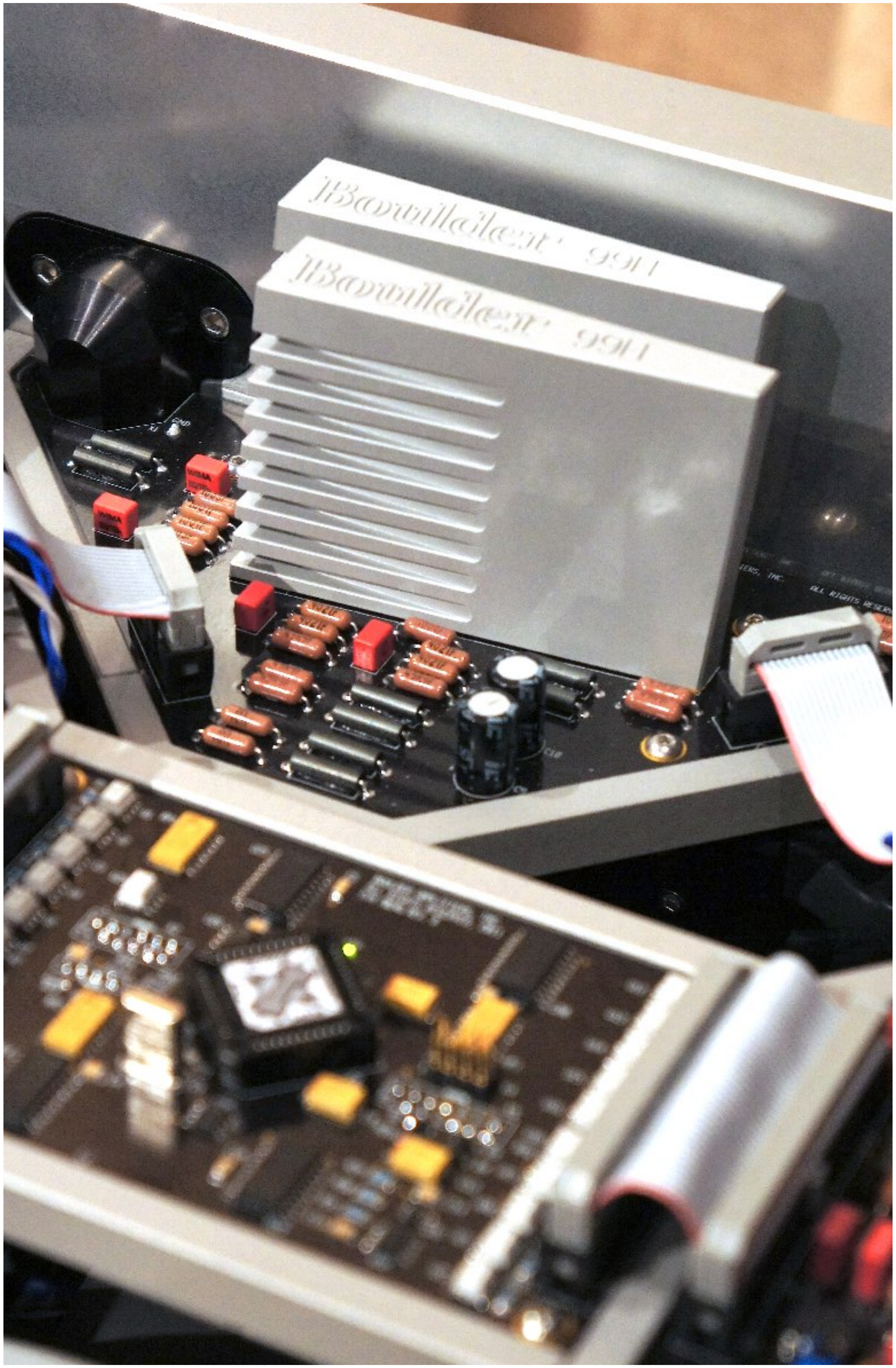
All four transformers "float" in a machined, nickel-plated, steel tube, with two transformers on either side of a separation wall within each half of the tube. The tube is magnetically shielded and high-mass encapsulated in a unique resin potting compound to eliminate any audible hum or operational vibration. The complete transformer tube weighs well over 100 lbs. (45 kg).

To prevent the transformers from buzzing or creating mechanical noise, a DC elimination circuit is utilized to block up to 3VDC from making its way to the transformers. DC is one of the primary causes of transformer hum, thus this added circuit is essential to maintain absolutely silent operation in any environment world-wide.

After bridge rectification, 48 large electrolytic filter capacitors are used to assure a low impedance supply to the output stage. The use of many distributed capacitors provides faster power delivery and recharging, as well as lower overall harmonic noise during operation, regardless of output power or load. Dynamic and transient response are thus greatly improved with no drawbacks.

3. Microprocessor Supply

The smaller supply is fully regulated and powers the microprocessor control system. It is fully independent to prevent any noise from the logic system affecting any of the analog amplification stages. The microprocessor system controls power-up, Boulder Link, thermal management, and protection circuitry.



Input Stage

4. Input Circuitry and Topology

The input circuit is a true, full-balanced, differential, three-stage instrumentation-style circuit initiated with three-pin XLR connectors. This ensures that the audio signal passes from the source to the amplifier free of distortion and noise by keeping the input impedance as high as possible in comparison to the output impedance of the source. Input impedance is a tested and verified 200k ohms (100k ohms per leg). This high input impedance ensures a much greater resistance to noise and also provides flat frequency response. The instrumentation-style input design also ensures consistent input impedance and electrical characteristics regardless of frequency or load termination.

Matched impedance or “transmission line” circuits are not used, as the frequency spectrum of audio does not present reflected waves from the signal receiver and the benefit of resistance to hum or noise is thus preferable.

Pin 2 of the XLR input connector is positive or “hot,” and the amplifier’s overall output is non-inverting.

All transistors in the input circuit are bipolar. FET-type transistors are not used to carry audio signal because of their lower reliability and much higher distortion levels. Bipolar devices are inherently more reliable as they aren't prone to static-related damage. More importantly, the circuit topologies required for FETs are awkward, with high levels of pre-distortion required to drive the outputs.

The 3050 is a direct-coupled design with a servo eliminating any DC voltage offset passed along by the front-end source. An offset of 50mV or more engages a speaker-protection circuit that immediately mutes the output.

Gain Stage

5. 99H Gain Stage

The 3050 incorporates +26 dB of gain. The gain stages in the 3050 are Boulder's proprietary 99H gain stage, a surface-mount, discretely implemented and encapsulated operational amplifier circuit and the output section. The 99H is an extremely high-current output design utilizing the benefits and low distortion of discrete implementation. Two gain stages are used in each 3050, with the majority of gain (20 dB) handled by the initial 99H stage, thus maximizing bandwidth. The remaining 6 dB of gain is handled by the output stage. The 99H operates with +/-38V rails and features exceptional headroom for ideal signal-to-noise ratio. Each 99H provides input buffering and voltage gain with a high slew rate, wide bandwidth, high current output, low distortion and low output impedance.

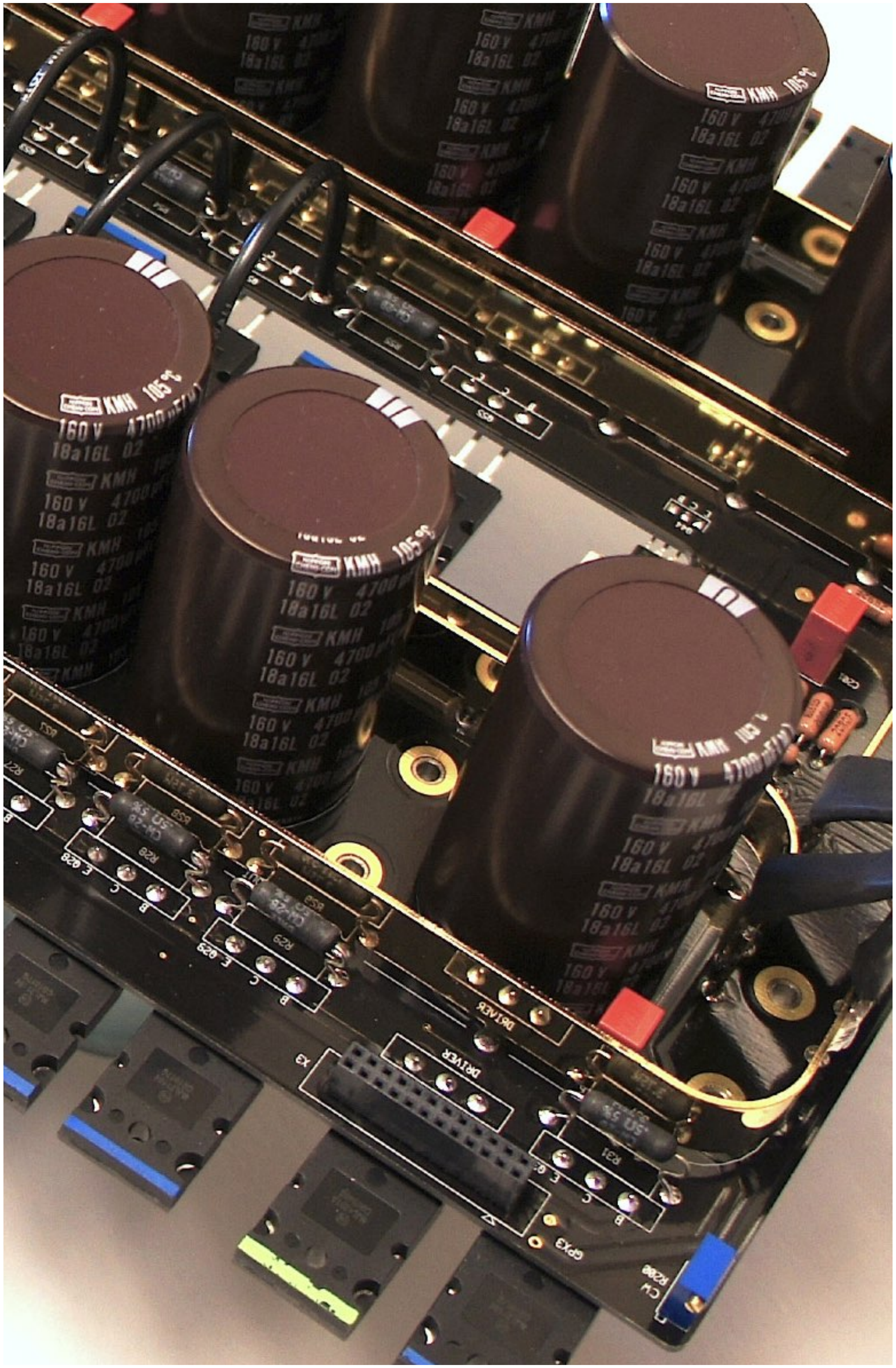
The 99H in the 3050 are implemented on small, surface-mount circuit boards which are assembled in-house on Boulder's own pick-and-place machines and board ovens. Surface mount technology allows for smaller PCB real estate (which decreases PCB capacitance) as well as elimination of lead inductance and optimized ground planing. After the circuit board assemblies pass initial testing, the boards are mounted in a custom-machined housing and potted with a proprietary mineral epoxy compound to control microphonic resonances and evenly distribute heat within the circuitry. The entire 99H assemblies (one each for positive and negative halves of the waveform) are then retested. During operation they are plugged into the input circuit board and pass the audio signal to the output sections.

6. Feedback Theory and Use

Correct and appropriate levels of feedback are used for achieving ideal operating parameters, including gain determination, constant group delay across the entire bandwidth (maximally linear phase response) and bandwidth limiting.

A hallmark of Boulder designs is a thorough understanding and *proper use* of feedback. Decades ago, feedback developed a poor reputation as designers asked the then new, integrated operational amplifiers to do something they weren't capable of due to their slow speed. Early monolithic op-amp designs were not fast enough to keep up with feedback loops in wide-bandwidth applications, resulting in horrible distortions. Designers who didn't know how to solve the problem simply tried to remove the feedback, which also resulted in further compromised sound and increased distortion.

In 1984 the Boulder' 500 showed the audio community, perhaps for the first time, that the proper use of feedback in tandem with proper operational amplifier design results in improved sound and measurably lessened distortion. The gain of the output stage can thus be reduced and its bandwidth increased. The resulting design has lower distortion than any single-stage design.



Output Section

The 3050 operates in full Class A bias mode to full rated output (1,500W). The output impedance of the 3050 is a specified and measured 0 ohms, meaning the output and operation of the amplifier is non-reactive.

The voltage rails of the 3050 operate at +/-113V. Maximum power output is 1,500 watts into 8 ohms, with peaks of 3,000W and 6,000W into 4 and 2 ohms respectively. The ability to drive any loudspeaker without dynamic range limitations was one of the primary goals of the 3050. This means no increase in distortion, even during the most demanding passages or largest transient peaks, regardless of load or impedance. To meet this goal of wide dynamic range required very high voltage capability.

Starting with the microphone and throughout the entire recording and playback process, an audio signal is stored as *voltage*, not as current, thus a greater voltage potential was required to avoid any dynamic compression and allow for continuous high power output.

The power supply and transistor complement were designed around the 1,500W output figure, regardless of impedance, guaranteeing that the 3050 will produce a minimum of the rated output power into any load.

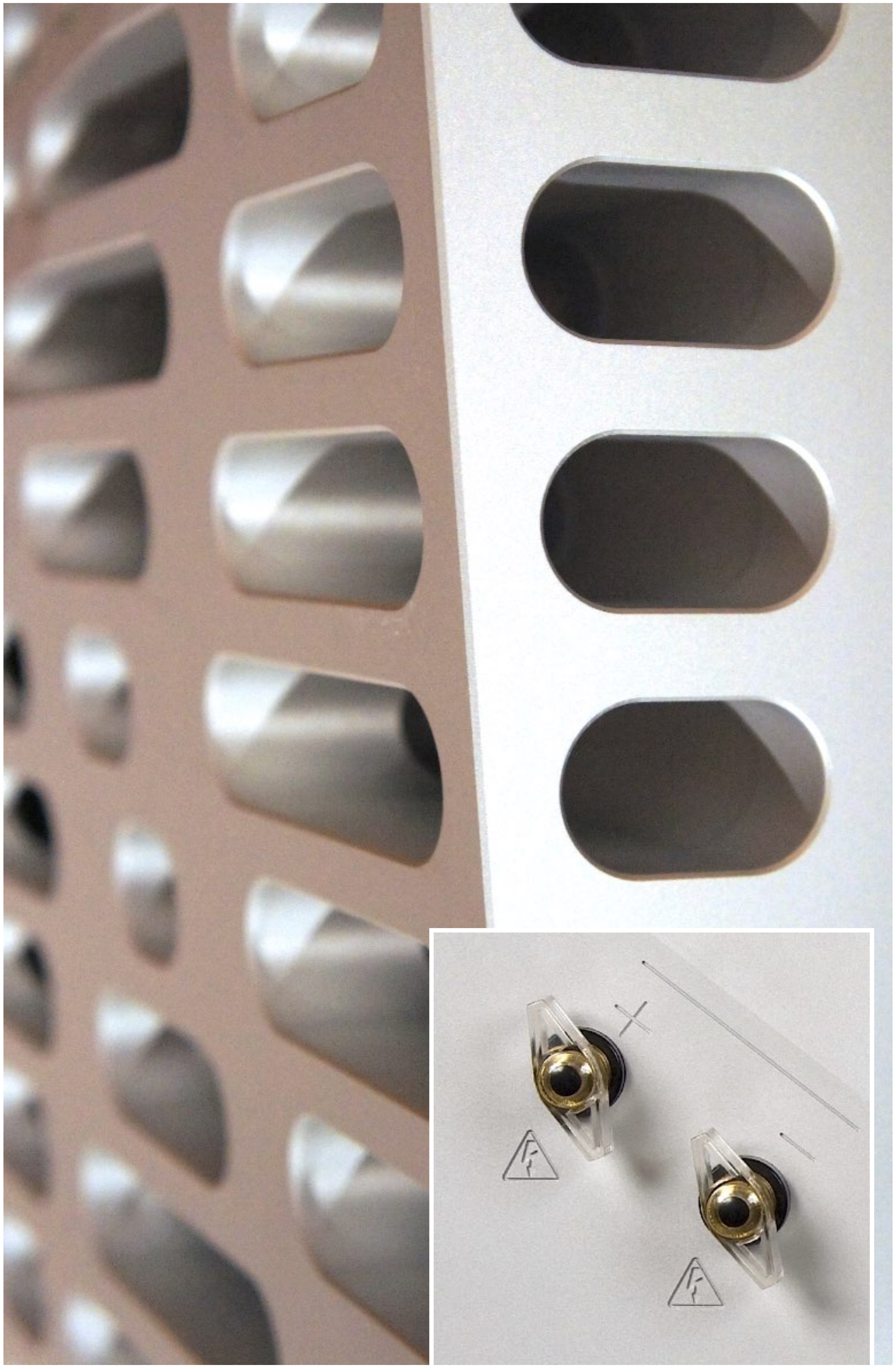
7. Output Circuit and Transistors

The output section of the 3050 is comprised of 120 bipolar output devices, with bipolar devices chosen over FET-type designs for the same reasons as the input section. Each half of the chassis amplifies either the positive or the negative half of the analog waveform as expected in a true differentially balanced design.

The use of a larger number of output devices reduces the thermal cycling range required of each individual device and the amount of stress placed upon each device during high power handling–each device is responsible for only a tiny fraction of the total output power demanded at any given time. Better distortion figures are also realized, as each device handles only a portion of its rated output power. The larger number of output devices also eliminates the effects of EMF backwaves caused by loudspeaker drivers, as the energy is divided and dissipated amongst a greater total number of transistors.

8. Clamp Bar, Heatsink and Resonance Damping

Each output device is clamped to a non-resonant heatsink via a custom CNC machined clamp bar. The unique clamping design eliminates the individual screw-down method that would secure each transistor to the heatsink via its mounting tab and keeps the clamping pressure uniform for all output devices. A special thermal transfer material between the clamp bar and the output device aids in keeping clamping pressure uniform without exposing the housing of the device to potential damage in the event of over-tightening the screw that secures the device, leading to a cracked or broken housing. The



overall benefit of this methodology is that every output device operates at a uniform temperature due to the elimination of variance in clamping pressures that occur when each device is attached to a heatsink individually.

The 3050 heatsink is cut from a 115 lb. (52 kg) solid billet of aluminum and features a variation of Boulder's familiar digital waveform pattern on the exterior surface. Standalone fins are avoided to prevent any resonant ringing. Each heatsink is resonance damped to well above the audio spectrum by securing it to chassis panels and circuitry of differing resonant frequencies. This contributes to the elimination of microphonic distortion effects leeching into the output of the amplifier by preventing any mechanical resonance from affecting the output devices that are attached directly to the heatsink.

In addition to complete elimination of microphonic resonances, the heatsink of the 3050 was also designed for efficient heat dissipation. Both left and right heatsinks minimize metal mass in order to reduce the amount of heat retention within the chassis. Vertical holes are drilled through the entire depth of the heatsink along its length to initiate convective cooling. Cooling vents are also cut into the top cover right above the output driver boards to ventilate specific areas of the internal circuitry that are temperature sensitive.

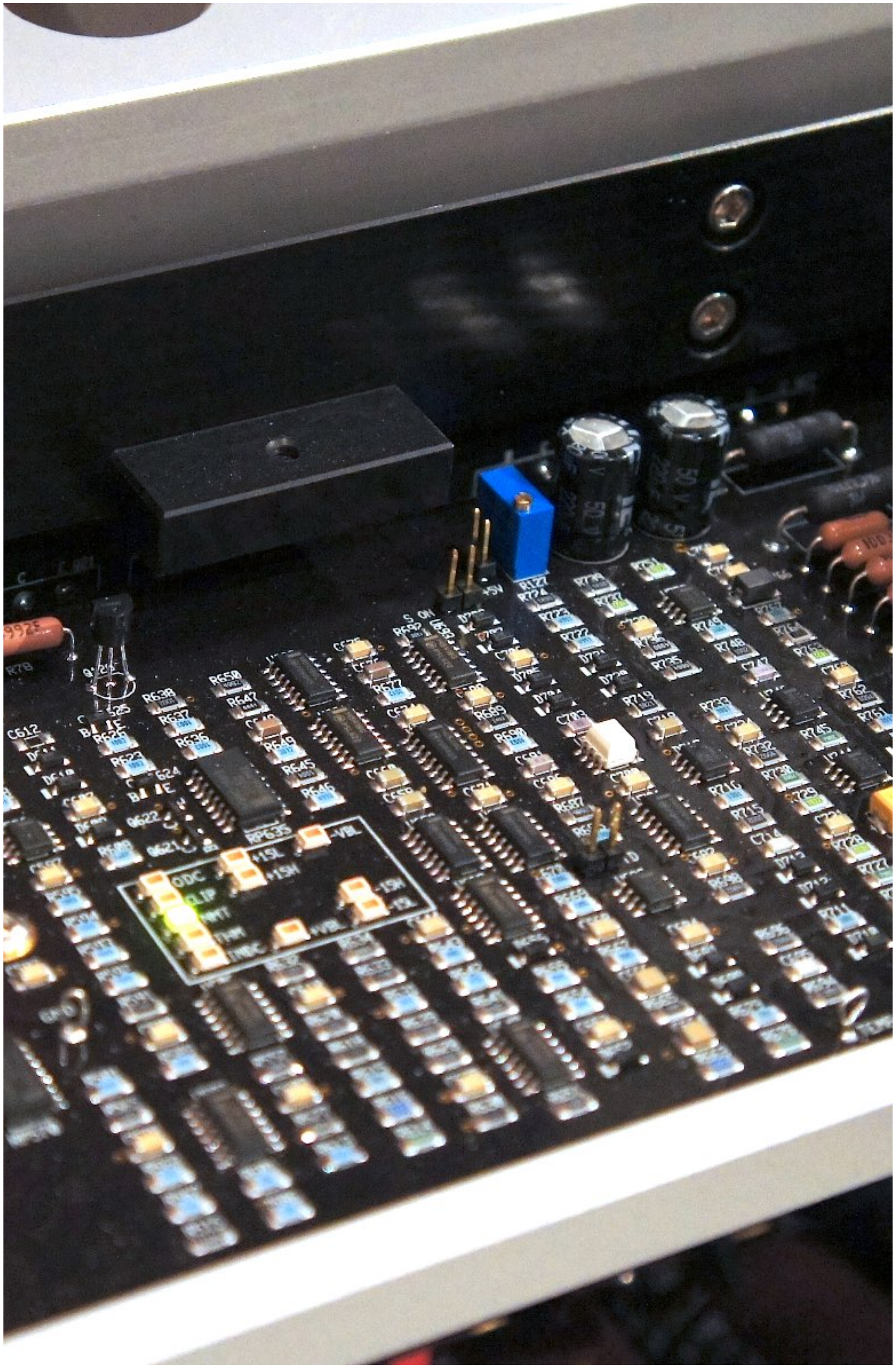
Every piece of the 3050's chassis has been machined from solid billets of 6061-T6 aerospace-grade aluminum. Machining is performed on Boulder's own CNC machining centers which operate up to 65,000 RPM, and the bead-blasted finish is performed in Boulder's own sealed blasting room prior to clear anodizing.

9. Output Terminals

Output is delivered to the loudspeaker via two pairs of custom, spade-only binding posts. Internal connection of both pairs of binding posts is parallel, so no advantage exists in connecting one set over another. A large contact area is provided to maintain the lowest contact resistance possible.

Connection options for banana plugs or bare wire are not supported. Banana plugs have been shown to decrease in spring tension over time, which in turn increases impedance through the connector and decreases reliability, and bare wire is at best a haphazard form of connection with the very real potential for shorted outputs.

At no point is the 3050 "voiced" or tuned for a specific sound or type of presentation. All engineering and testing verify numerous distortion specifications and these results are then verified by ear prior to shipment for every unit produced. All harmonic distortions (including those that produce "pleasant" though inaccurate sound) are eliminated as much as possible during the design stage.



Protection Circuitry

10. Monitoring and Protection

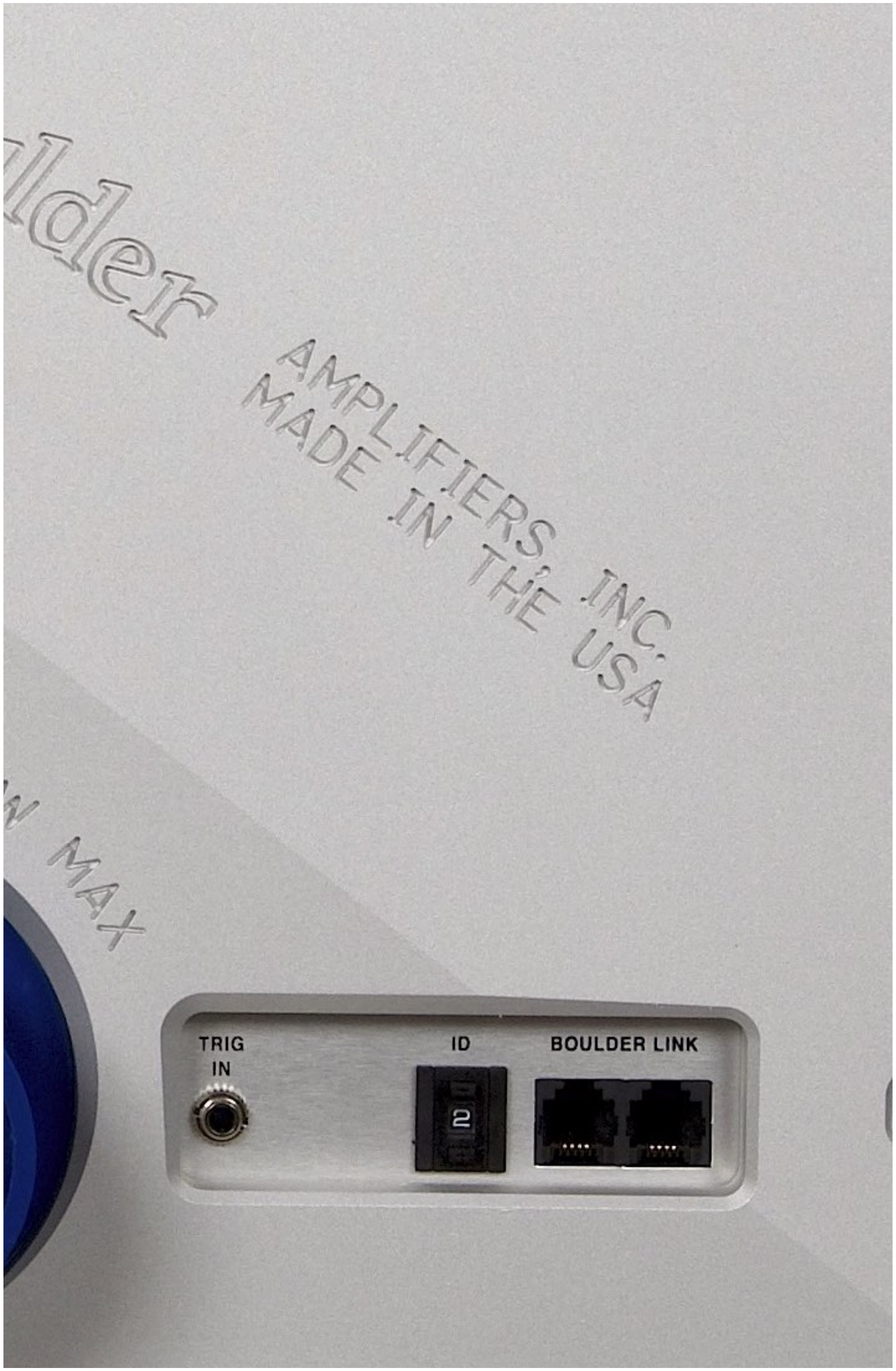
The 3050 includes a complete array of protection circuits, all intended to prevent damage to either the amplifier or loudspeakers. All protection circuits are microprocessor controlled. In the event of a microprocessor failure, the amplifier will power off.

A current limiting circuit prevents damage to the output section in the event of a shorted output or overdriving. When the current limiting circuit is engaged, the amplifier will mute output for three seconds via a timer circuit. The 3050 will then try to re-engage the outputs unless the overcurrent fault is still present, at which time the amplifier will again mute. This will continue until the source of the fault is removed.

The 3050 incorporates two DC detection circuits, one at the inputs and one at the outputs of the amplifier. In the event that DC is present on the inputs of the 3050, a servo system will null any DC offset detected. A secondary protection circuit will mute the amplifier if 50mV or more is detected. The amplifier will remain muted until the offset falls below 50mV, at which time it will again be nulled by the servo system. The amplifier will mute the outputs if any DC is detected at the outputs.

All power supplies within the amplifier are continuously monitored. In the event that any supply fails, the amplifier will power down and cannot be restarted until the problematic supply is operating correctly in order to prevent potentially damaging voltages from appearing at the output terminals.

A thermal-protection circuit is also present. This circuit monitors the temperature of the output devices and protection is triggered when the transistor cases reach 95° C. This corresponds to approximately 80° C at the heatsink. Current output will be limited until the temperature of the output device cases again falls below 95° C, at which point normal operation will resume.



External Control

11. Boulder Link and IP Control

The 3050 has been designed to be seamlessly integrated into custom home installations as well as incorporated into systems with legacy or current Boulder Linked products.

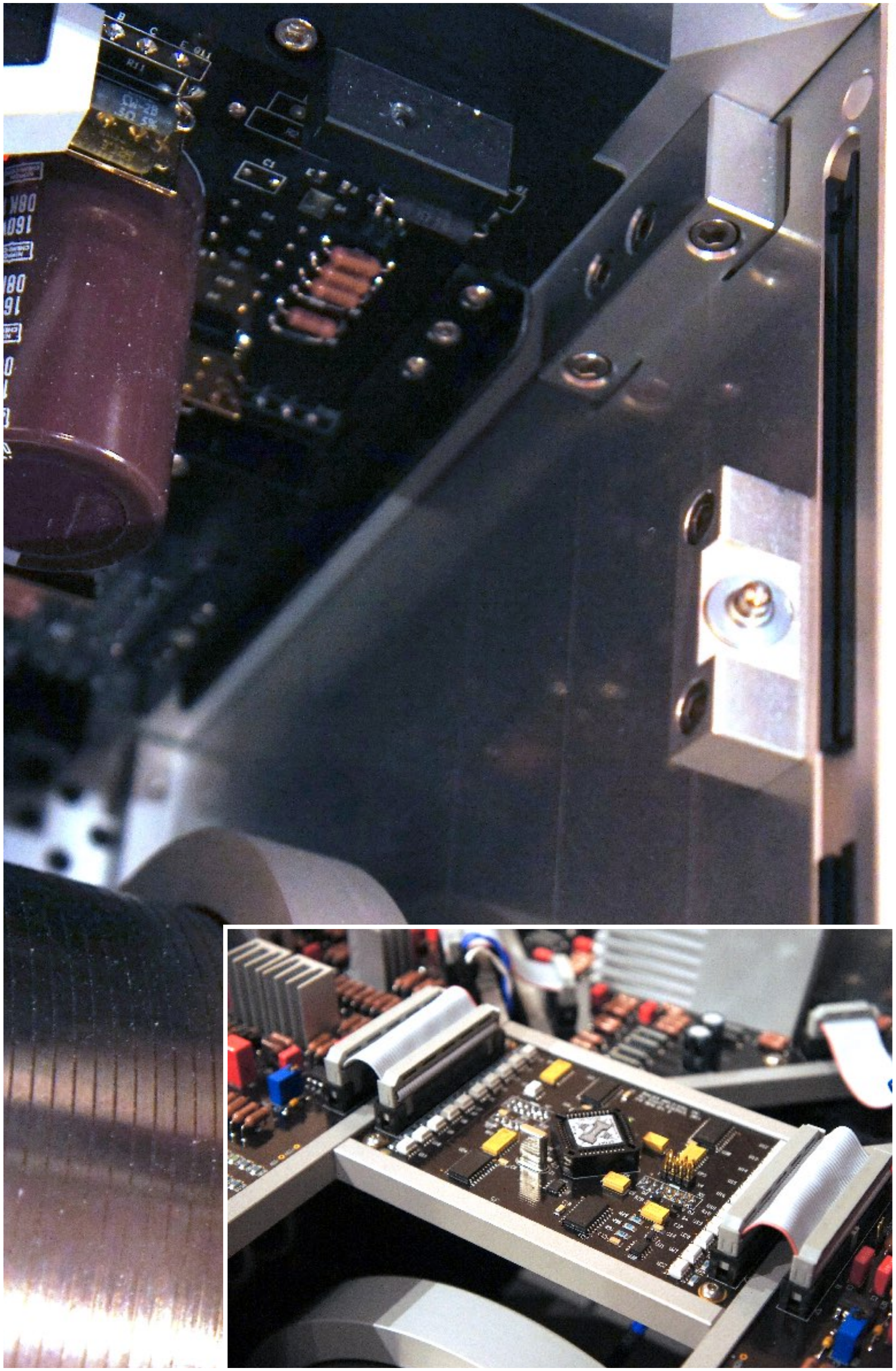
The Boulder Link system is a proprietary system of inter-component communication, specific to Boulder products. It is an RS-435-based communication system that enables a single component to behave as the "master" in a system and initiate power-up, power off and volume commands as well as transmit any protection or warning notices to any Boulder product with an alpha-numeric display. In the 3000 Series, Boulder Link is a continuously scanning system that monitors and keeps track of individual components and all of their associated protection circuits.

Upon power-up, a 3050 will detect any other 3000 Series amplifiers connected via Boulder Link. It will then logically determine the proper sequence and rate in which to turn on each amplifier so as to prevent excessive AC line current draw.

Ethernet connection options have also been made available that will allow IP (internet protocol) control of amplifier turn on and turn off.

Provisions are also available to inquire with the amplifier about the status of each protection circuit and operating parameter, which can then be fed to outside control displays, such as those from Crestron, Savant, AMX and others.

A 12V trigger via a 1/8" mini-jack connector is also available on the rear panel of the amplifier to control the standby function of the amplifier in a trigger-based system. Both pulse and continuous voltage trigger controls are supported.



Mechanical Design

The mechanical design of the 3050 was centered around three principles: elimination of mechanical resonances, efficient heat dissipation and unique aesthetic design. All casework was designed on advanced 3D CAD systems and machining tolerances are held to within 1/1000 or 3/1000 of an inch, depending on the application of the metalwork.

All exterior metalwork of the 3050 is damped, either via the use of direct application of damping materials or by adjoining one subassembly to another in order to significantly raise the resonant frequency of the compound assembly.

All brute supply transformers within the chassis are potted and DC filtered to eliminate mechanical resonances. The smaller microprocessor transformers are housed in a separate machined enclosure and damped and floated to prevent mechanical vibration from affecting the amplifier's output.

12. PCB Mounting

All circuit boards within the amplifier are slid into custom machined frames designed to fit perfectly around each individual circuit board. Circuit board assemblies are not screwed down onto standoffs or to sheet metal plates. A non-conductive damping foam material is then sandwiched between the circuit board and the frame assembly in order to prevent any vibration, either air- or chassis-borne, from inducing any microphonic distortions.

13. Interlocking Structure and Damping System

All chassis parts are interlocking and are attached via stainless steel screws and/or hardware to prevent corrosion in harsh or salt air environments. The interlocking chassis component design has been utilized to eliminate chassis resonances through harmonic cancellation. When bolted together, the individual harmonic resonances of each chassis part will raise the overall resonant frequency of the entire structure to well outside the audio bandwidth. The heatsinks contain no fins or resonant tongs. The top cover utilizes constrained layer damping by way of a layer of damping material sandwiched between the cover and a plate of stainless steel screwed to the underside of the cover. The top cover itself fits into the chassis with a tongue-in-groove system on one end and lowers into the chassis with nylon bumpers that prevent rattling and keep the spacing equal on all sides. Once in place, the top cover is held in place via stainless steel screws that are accessed through the top cover's ventilation holes.

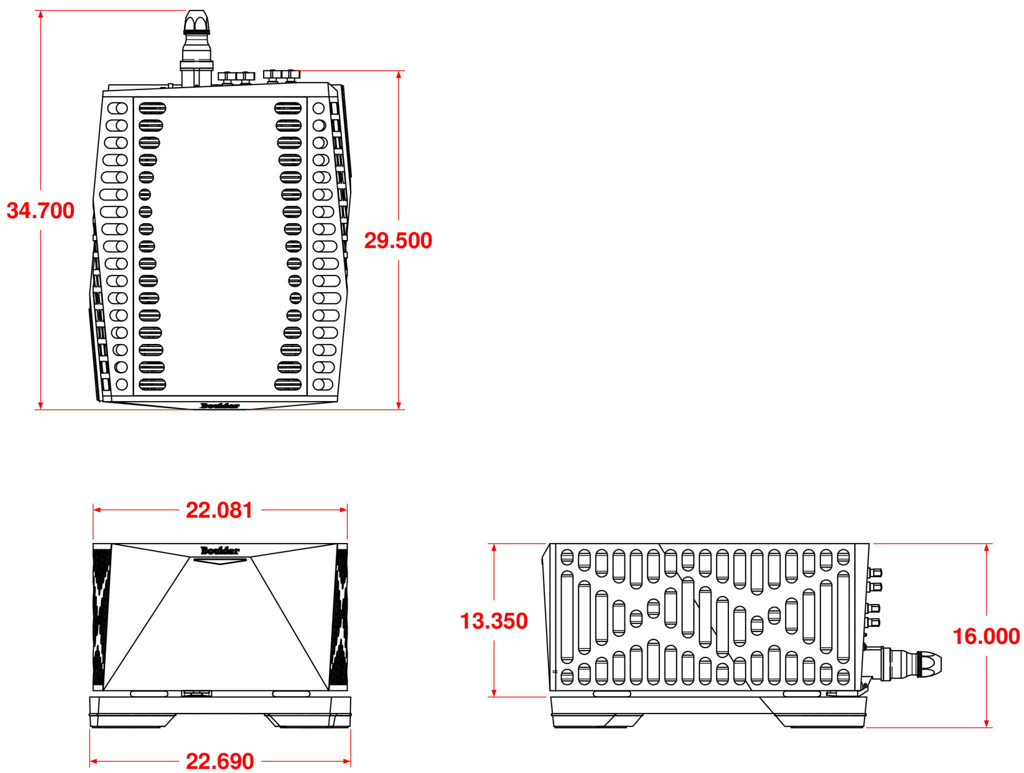
The chassis is supported on feet comprised of a three-layer system of damping and shock absorption. Each foot is made of a machined and polished stainless steel disc that incorporates two layers of damping material (one firmer and one softer) in a constrained layer damped arrangement, isolating the amplifier from any direct coupling of the chassis to the surface on which it is placed. This eliminates any need for specialty racks, shelves, or accessory isolation devices.

14. Granite Base
A cut and polished granite base is provided with each 3050. This base is cut from Colorado-mined Absolute Black Zimbabwe granite and features a layer of polished stainless steel between the main plate and the feet of the base. The edges of the base are cut and polished to match the exterior angles of the amplifier.

These bases serve two purposes, the first being to further isolate the amplifier chassis from the surface on which it is placed. The second is to alleviate any need for custom platforms or stands, which may need to be constructed in order to support the weight of the 3050. In many instances, a suitably strong stand may not be available.

Specifications

15. Dimensions



16. Technical Specifications

THD at Continuous Power, 20 Hz to 20 kHz	0.0005%
THD at Continuous Power, at 20 kHz	0.0017%
Continuous Power, 8Ω	1,500W
Continuous Power, 4Ω	1,500W
Continuous Power, 2Ω	1,500W
Peak Power, 8Ω	1,500W
Peak Power, 4Ω	3,000W
Peak Power, 2Ω	6,000W
Magnitude Response, 20 Hz to 20 kHz	+0.00, -0.04dB
Magnitude Response, -3dB at	0.015 Hz, 200 kHz
Voltage Gain	26dB
Signal to Noise Ratio (re: 500W/8Ω)	-135dB, Unweighted, 20 to 22 kHz
Input Impedance	Balanced: 200kΩ
Common Mode Rejection (Balanced Only)	
Input	3-pin Balanced XLR, Pin 2 Hot
Output Connectors	2 Sets 6mm/0.25” Wingscrews
Power Requirements	240VAC, 50-60Hz, 300W Nominal, 6000W at Maximum Output

All specifications measured at 240VAC mains power

Boulder Amplifiers
255 South Taylor Avenue
Louisville, CO 80027
Tel: 303-449-8220
e-mail: sales@boulderamp.com
web: www.boulderamp.com