Mark Levinson №53 Reference Monaural Power Amplifier

Technology Background

Overview

Mark Levinson was founded in 1972 to produce the first solid-state electronics that sonically outperformed the finest tube electronics of the era. In 1993, the Mark Levinson №33 Reference Monaural Power Amplifier was hailed by audiophiles and music lovers around the world as the ultimate power amplifier. Now, the Mark Levinson №53 debuts – the first switching technology amplifier to sonically outperform the finest Class A or AB amplifiers.

Cosmetically similar to its predecessor, the №53 is the first Mark Levinson Reference Monaural Amplifier to incorporate multi-stage very high speed switching amplifier technology, dispensing with the conventional Class AB power output stage in favor of Interleaved Power Technology (IPT), which features a patented[1] circuit design that provides significant advantages over prior switching amplifier topologies.

PWM Limitations

Switching amplifiers aren't new (the earliest design originated back in 1932 and was vacuum tube-based), and offer significant advantages over conventional designs in terms of thermal and power efficiency, and operational stability. However, while they are popular in industrial electronics and professional sound reinforcement applications, switching amplifier technology had yet to be refined enough to be on par with the best conventionally configured audiophile power amplifiers.

Challenges that needed to be addressed include high frequency noise components that are a result of the PWM process. Analogous to digital audio quantization noise, these high frequency residual components need to be filtered with a sharp slope brickwall filter, which can have unwanted consequences such as phase alteration and high frequency ripple in the audio passband.

In-band distortion can also be higher than desirable, especially compared to reference class audiophile amplifier designs.

Another area of concern is a limited frequency response range, an important consideration in the era of modern wideband high resolution audio formats, including SACD, Dolby TrueHD and DTS-HD Master Audio. These formats support up to 192 kHz sampling, allowing an audio passband that extends to over four times that of standard resolution formats such as CD.

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[1] Covered under one or more U.S. patents, including #5,657,219, #6,297,975 B1, #6,504,348 B2, #6,556,053 B2, #6,909,321 B2

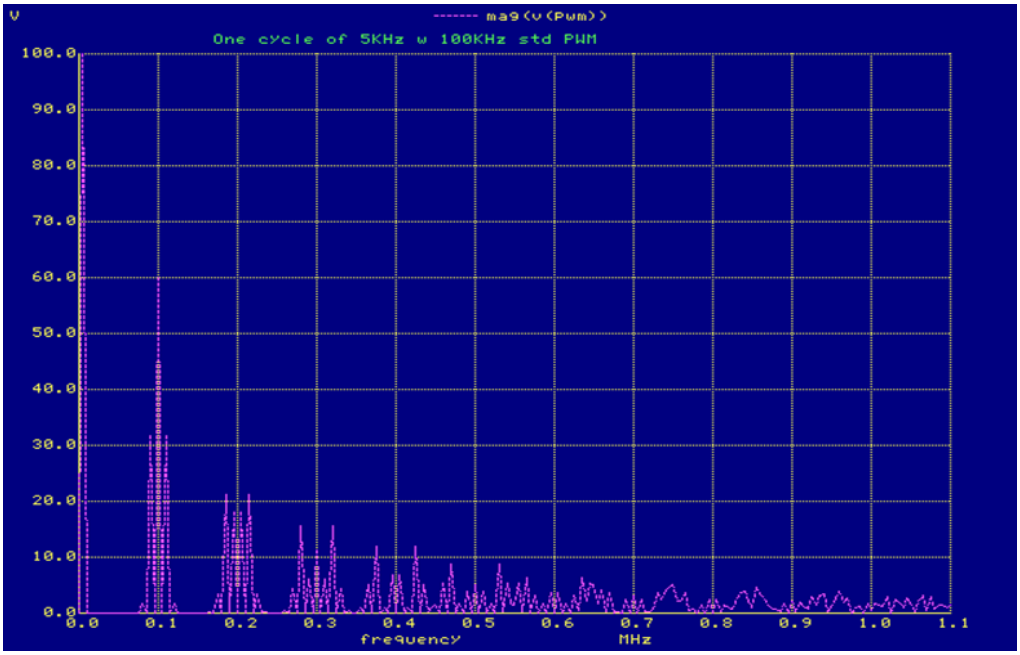
New Class I Interleaved Output Stage

Our engineers set out to develop a new PWM output stage design that would overcome these limitations, based on improvements made to earlier designs employed in pro sound reinforcement and automotive audio applications.

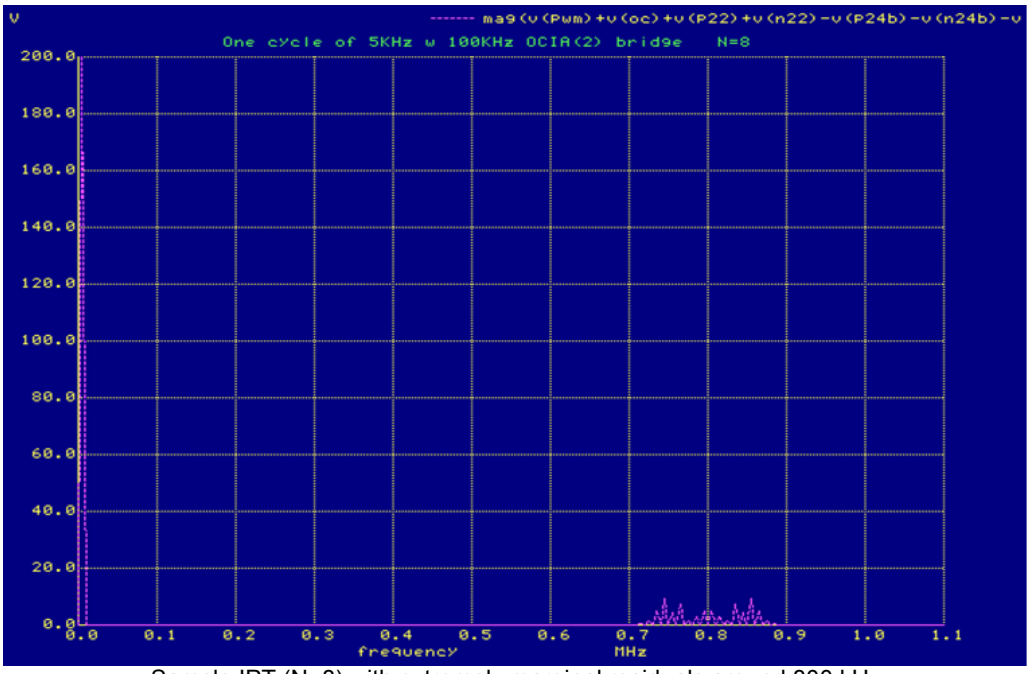
With conventional switching amplifier designs (Class D and other variants), the output stage is theoretically limited to a single interleaving topology, which limits the audio passband frequency range, and results in high order distortion products that must be filtered out with brickwall filter types, which can introduce phase errors and other in-band artifacts. Care must be taken to ensure timing accuracy, as dead time (brief moments where neither the positive or negative stages are conducting current between pulses) and overlap (brief moments where both positive and negative output stages are simultaneously conducting current, which is a catastrophic condition that can cause amplifier failure) must be thoroughly addressed.

With our Interleaved Power Technology, there are eight half bridges (N=8) working synchronously to achieve a much higher PWM switching frequency (4 MHz). The modulation circuitry also features propriety refinements to ensure that there is absolutely zero dead time between pulses, as well as completely preventing the possibility of overlap.

The charts below detail the tremendous improvements in bandwidth and low distortion provided by our Interleaved Power Technology (N=8), compared to conventional Class D (N=1) techniques.



Sample Standard Class D output (N=1) 100 kHz, sidebands and odd harmonics are all present



Sample IPT (N=8) with extremely marginal residuals around 800 kHz

With Interleaved Power Technology (N=8), the comparably much smaller byproducts of the PWM switching process are easily filtered out using a simple high frequency notch filter, which has no deleterious effect on sound quality, compared to brickwall filter types.

And, the broad frequency response provided by our Interleaved Power Technology system is ideal for the latest wideband high resolution audio formats, with extended response all the way out to 95 kHz (-3dB, 8 ohms).

№53 Configuration & Construction

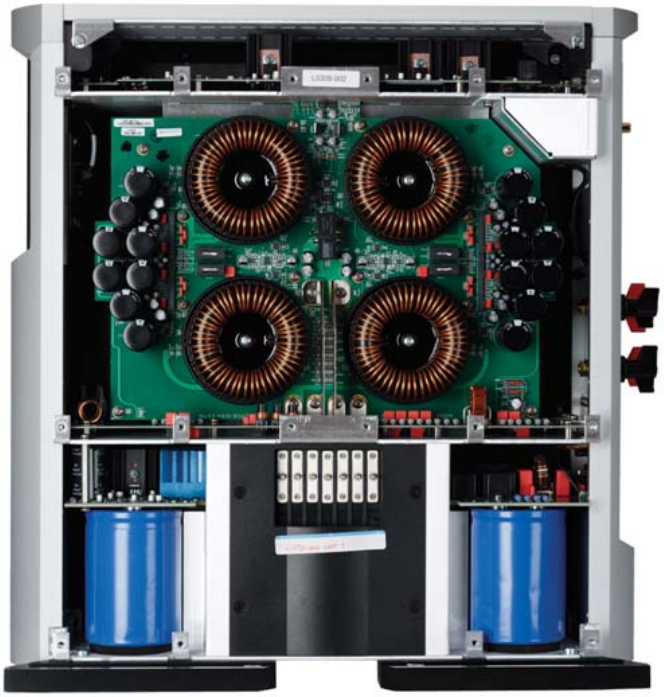
Within the №53, there are essentially four major sub-sections, including analog, modulation, amplifier and power supply sections.

The analog input stage features both single-ended (unbalanced) and balanced (XLR) inputs. Single-ended inputs are converted to true balanced configuration, and remain balanced through the entire amplifier and on to the bi-wiring compatible speaker terminals.

The modulation section incorporates the heart of the Interleaved Power Technology, and features a six layer PCB with approximately 1,500 parts, and contains four isolated modulator sections. As well, the modulator board includes communication support for our Link2 and MLNet system control functions, along with most of the amplifier's protection circuitry.

№53 Six layer modulator PCB contains about 1,500 parts

The output stage features multiple high voltage, high current, high frequency vertical MOSFET output devices, as well as eight air core inductors (four on each of the two amplifier boards). As the high current, low inductance coils are air core (as opposed to ferrite core) types, there is virtually no problem with saturation at high current levels, a problem with standard (and less costly) ferrite core inductor types.



Side view of №53 showing modulator board at top, one of two amplifier boards at center, and main power supply at bottom. Note the large air core inductors, which are custom wound specifically for the №53.

The power supply includes a large capacity toroidal power transformer (pictured at bottom center in the photo above), which carries a raw power capacity rating of 2.8 kVA. For the №53, the power transformer is conservatively de-rated to a more reasonable 1.065 kVA, to ensure long term operational stability and lower thermal operational limits to conform to electrical safety compliance requirements.

In addition to 188,000µF of local capacitance in the main power supply section, the №53 power amplifier boards feature an additional 105,600µF of local capacitance, for a total of 293,600µF capacitance (146,800µF per voltage rail), for a combined storage capacity of approximately 680 Joules.

With the high power output amplifier sections, combined with the main and local power supply capacities, the №53 is capable of tremendous power output. Rated at 500 watts continuous into 8 ohm loads and 1,000 watts continuous into 4 ohm loads, the tremendous headroom of the №53 allows for substantial short term power output bursts, including peak (dynamic power) bursts of up to 2,000 watts into very low 2 ohm loads.

The amplifier's output impedance is also quite low, which provides for very high damping factor (~8,800 at 20 Hz and ~5,500 at 40 Hz). This high damping factor lets the driving loudspeaker "see" a virtual short circuit path back to the amplifier, limiting the effects of back EMF (Electro Motive Force), which provides for the tightest deep bass response with full range audiophile loudspeakers.

The №53 also boasts greatly increased thermal efficiency, compared to conventional Class AB designs. As much less of the power going through the output devices is converted to heat, the amplifier runs cooler, and in fact needs no forced air cooling, which is almost always the case with high power Class AB designs. Arrayed along the №53's chassis sides are four massive heat sinks directly coupled to the vertical MOSFET power output devices, and they collectively provide over 14.5 square feet of radiating surface area. Even after extended high volume listening at elevated power output levels, the heat sinks are merely warm to the touch, allowing side-by-side configuration in multiple amp rack setups and greater installation flexibility.

Operational Stability

With conventional Class AB designs, reactive loudspeaker loads can result in shifts in phase between output current and voltage, which can necessitate the amplifier's protection circuitry kicking in at lower than ordinary levels to limit output current. The №53 is not bound by this constraint, as it will only limit current without caring about voltage, regardless of phase.

The current output capability of the №53 is indeed prodigious. For example, 500 watts into an 8 ohm load equates to a current flow of just under 8 amps. At 1,000 watts into 4 ohms, the figure doubles to just under 16 amps. Due to the tremendous power reserves and the robustness of the output stages, the №53 is capable of delivering short burst current peaks of around 70 amps, and around 50 amps peak over time. This ensures

real world operational stability with the widest range of loudspeakers, including models that feature lower than normal impedances over portions of the frequency range.

Listen Testing & Evaluation

At each stage of the №53's development, extensive listen testing and thorough measurements ensured that our goal of Mark Levinson Reference Class performance was attained. In addition to multiple rounds of in-depth critical listen-testing over a period spanning many, many months, a differential amplifier comparison methodology was also employed. A low power, mostly passive reference amplifier design was programmed with the №53's transfer function, and differentially (subtractively) compared against the №53 itself. By subtracting the signal output from the №53, and comparing against the reference transfer function design, our engineers were able listen to any differential components between the two, and evolve the №53's design to improve sound quality even further.

Efficiency

Our Interleaved Power Technology provides substantial benefits in terms of electrical efficiency, in addition to the lower operational thermal characteristics described earlier. Compared against an equivalently powerful conventional Class AB amplifier, the №53 provides significantly reduced energy consumption:

Power Output	№53 power consumption	Equivalent Class AB amplifier
500 watts into 8 ohms	785 watts	995 watts
1,000 watts into 4 ohms	1,465 watts	2,085 watts

This increased electrical efficiency provides greater installation flexibility, especially in multi-channel amplifier configurations, reducing the number of dedicated AC outlets that may be required. Note that with actual audio program material, the average power draw over time will typically be much, much lower for both amplifier types – the above test bench examples simply illustrate the improved efficiency of the №53.

Summary

Mark Levinson was established in 1972 with the singular goal of producing reference class solid state audiophile components that would be the first to provide superior audio quality, compared to that era's vacuum tube-based audiophile components that were favored by audiophiles and reviewers at the time.

Each of the company's first three products – phono preamplifier, stereo preamplifier and Class A power amplifier – were hailed as breakthrough designs, and were quickly adopted by audiophiles and reviewers around the world as the ultimate in reference class components.

The following decade saw Mark Levinson approach digital audio with the goal of achieving true audiophile reference class performance, with the introduction of the №30 digital audio processor and the №31 digital CD transport. Both of these were “from the ground up” designs, as opposed to numerous competitive offerings at the time that were merely massaged-over models that originated from mass brand products.

Over the course of nearly four decades, Mark Levinson products have consistently been rated as absolute best-in-class, and now, the Mark Levinson №53 sets new standards in performance, reliability and audiophile sound quality.

Featuring our proprietary Interleaved Power Technology, and combining tremendous power headroom with prodigious peak current delivery capabilities, the №53 provides superb sound quality, operational stability, improved electrical and thermal efficiency, along with substantially reduced chassis mass, and is the first audiophile class PWM power amplifier that provides improved sonic performance, compared to conventional class A/AB designs.

Designed for no-compromise music and multi-channel home theater surround sound systems, the №53 redefines the state of the art in power amplifier design and performance.