

REX 500 White Paper

There is a consistent philosophy and common architecture behind every product developed by Balanced Audio Technology. You will see these common architectural elements referred to in our product descriptions. This common approach is grounded in solid engineering principles developed and refined over nearly thirty years in business. Balanced Audio Technology believes that there are solid principles that lead to building a product for the ultimate in sound performance. What are these common principals or architectural elements?

Balanced Circuit Design

First and foremost, our products rely upon balanced circuit design. We staked our reputation on this architectural decision from the day that Balanced Audio Technology was founded. Electrical engineers have known for decades that given a similar implementation; a balanced circuit will always sound better than a single-ended one. Some manufacturers still claim that balanced topology is not an improvement; that "it isn't necessary". The reasons for these claims become clear once you realize that they come from the makers of single-ended products. While it is true that balanced topology requires greater expertise, the main stumbling block has always been cost. When implemented incorrectly, a balanced circuit doubles the component count of a single-ended one. Many manufacturers are unable to break this cost barrier. Others are reluctant to throw away old "working" solutions.

The best way to demonstrate the improvement that balanced topology brings to audio reproduction is by setting up a good balanced system: source, preamp, power amplifier. Listen to it first and then switch into single-ended mode. Most equipment will allow you to do this by simply changing the interconnect cables or by using RCA-to-XLR adapters. You will hear an easily detectable change. Go back and forth several times – same source – same preamplifier – same power amplifier. The balanced connection always yields a more palpable and realistic sound.

Attempts have been made in various publications at explaining the sonic superiority of balanced topology. For lack of a better handle, authors concentrated on the enhanced noise immunity and high common mode rejection ratio (CMRR) of such circuits. All our experience indicates that this is a great oversimplification. Such explanations do not even begin to clarify why the *overall sound quality* improves from switching to balanced, not just the noise aspects. There is still no reliable evidence that the CMRR is *the reason* for the balanced topology's virtues in audio systems. In fact, some fine balanced amplifiers do not possess even an average CMRR, while still sounding exceptionally good.

Then, how do we know that balanced is superior? We listen. We believe it is better to admit that we don't understand something than to provide a pseudo-scientific explanation. We build better and better balanced circuits and hear into the music ever more deeply.

Still, we believe that some explanation is required. In our opinion balanced topology simply provides a *complete signal representation*. Something magical happens when you free yourself

from the limitations of the single-ended structure with its *half-signal processing*. If a one-handed craftsman can be very good, imagine what he could do with two hands.

The Low Restriction Signal Path

The circuit topology of any BAT product is consistent with our philosophy of utmost simplicity in implementing a clean, unobstructed signal path. However, the unique design of our products goes significantly beyond simply reducing the number of gain stages.

Every gain stage introduced into a circuit should perform a useful function. Unfortunately, every gain stage (be it active or passive) will also restrict the signal flow to some degree. The more restriction it imposes, the stronger the negative effects such as loss of detail, anemic bass and lackluster dynamics. Some of the elements that make the signal path more restrictive are more intuitive to understand than the others. For instance, the negative effect of a high number of gain stages is easy to understand. On the other hand, the effect of the gain stage's quiescent current, or gain stage power dissipation, is not always appreciated. In reality, however, if one asks a gain block, running at 2mA quiescent current, to deliver 1mA current to its load, then it is easy to imagine that such a weak gain block will struggle. In the same way that we do not expect a one hundred pound weight lifter to set the world record in the heavy weight category, we shouldn't expect an anemic gain stage to drive its load with ease.

Many products today, unfortunately, employ such anemic gain stages – often running at 2mA to 4mA of quiescent current. This weak design approach is easily understood once you consider that increasing the quiescent current automatically means an increase in the power required as well. This increase in power calls for bigger and more expensive power transformers and filter components.

Balanced Audio Technology's REX 500 amplifier, for example, contains a gain stage running at an extremely high - some might say insanely high - current of 200mA per channel. This hallmark of Balanced Audio Technology design continues today in all of our products. The gain stage in the VK-90 preamplifier runs at an astonishing 100mA per channel!

Signal stage power has been confirmed as a predictor of sonic goodness by a significant amount of experimentation performed by Balanced Audio Technology. This experimentation has provided a firm foundation for our innovative decisions, as applied to both preamplifier and power amplifier design. All BAT products employ low restriction gain stage(s). These high-power gain stages operate with uncommonly high drive capability to achieve an unprecedented level of sonic transparency. These high-power circuits also allow us to avoid the use of popular cathode followers that further compound the sonic deficiency of many designs.

Zero Feedback Topology

There is another aspect to designing a low restriction gain stage – the elimination of negative feedback. Put simply, high feedback circuits are restrictive circuits. Empirical evidence confirms this to be the case.

In any zero-feedback configuration, the user listens to the unique voices of each individual component. These voices come through totally free and uncorrected, like solo dancers in a ballet theater. As with solo dancers, these components also must meet the most demanding performance requirements. The proper choice and application of each component are now of paramount importance. The individual parts selected for all BAT products, from the signal capacitors to output devices and output transformers are well qualified for such a mission. Their characteristics are linear and well controlled.

In order to evaluate the effects of negative feedback on sound characteristics, a prototype BAT amp was equipped with feedback controls that provided an adjustment range from 3 dB to 10 dB. We soon discovered that as little as 3 dB of negative feedback was detrimental to the sound. The insertion of negative feedback generally reduces the sound stage as well as lessens the air around the reproduction of the human voice. The sound becomes constricted - no longer breathing like the live event. Thus, notwithstanding the improvements that negative feedback brings to an amplifier's measured performance, every listener preferred the zero feedback position.

Only Two Gain Stages

Balanced Audio Technology's power amplifiers follow the same philosophy of elegant simplicity in their design. The REX 500 power amplifier has only two gain blocks with zero global feedback in a purely symmetrical design. The theoretical ideal for any power amplifier would be to have only one gain block, but this has been achieved only with the limitation of low power output. Thus, the REX 500 is at the simplicity ideal for any modern high-power amplifier design.

What does all this mean in practical terms? If a customer uses a BAT VK-90 preamplifier (one gain stage) combined with our REX 500 power amplifier, the signal will pass through a total of three gain blocks from start to finish - with no global feedback applied. The benefit of this approach is that it provides the ultimate simplicity of amplifying the incoming signal as few times as possible, while using no global feedback to double-back on the straight-through integrity of that signal. Imagine telling a joke to your friends and telling them to "*pass it on*".... Pass it on enough times and you won't recognize the joke. Pass the music through too many gain stages, and you'll no longer recognize the inherent beauty of your favorite recordings.

N-channel Mosfet devices used

The REX 500 circuit is based entirely on N-Channel MOSFET devices. It is customary in high power amplifiers to use the complementary N- and P-Channel devices in the output stage. Such configurations are easier to build, but they all suffer from one important drawback: the P-Channel devices are inherently inferior to their N-Channel brethren. They are simply much slower. Pairing the faster N-channel devices with the slower P-channel devices is like pairing Ginger Rogers with her horse on the dance floor – instead of Fred Astaire. You will never get perfect symmetry when using devices with such a wide discrepancy in speed. In the REX 500 power amplifier, both sides of the waveform are handled by identical devices - in identical circuit configuration, assuring ultimate symmetry of the resulting signal.

Massive Power Supply

(or why there is no substitute for cubic inches)

Since the power supply is usually a major contributor to the overall cost of a component (often as high as 30% to 50%) it is understandable, but not excusable, that many so-called high-end products cut where it hurts. Often, when you take the cover off a very expensive product, you will find a disappointingly small power transformer of "cost effective" design and just a few small filter capacitors serving both channels. More often than not, it will be followed by a solid state voltage regulator in an attempt to make it measure tolerably, if not sound good.

Some things never lose their truthfulness. There is still no substitute for cubic inches. Yes, you can take a very small motor and put a turbo charger on it. It *will* make it better. Such a car will have a respectable top speed. Even the 0-to-60 numbers may not look too bad. Until one day you meet Lamborghini's 50th anniversary Aventador V-12 at a traffic light. Then you know it is over.

You will never find a designer who believes that a small, underpowered supply will improve the sound of an amplifier. But when the bottom line talks, they have no choice. The engine size is cut. Then the turbocharger (voltage regulator) is bolted on. When trying to sell you the virtues of a regulated supply the manufacturers usually don't mention the fact that this regulator often costs just a few dollars, including the heat sink. In addition, a voltage regulator introduces substantial negative feedback to a gain stage.

On the other hand:

- i. Incorporating a bigger and better power transformer
- ii. Using one transformer per channel
- iii. Switching to better quality toroidal transformers
- iv. Beefing up the filter capacitors
- v. Using separate power cords for true dual mono construction (REX 500)
- vi. Adding custom oil capacitors

Any of such changes could easily add substantial cost to each unit. Yet these are the very ingredients you'll find in products from Balanced Audio Technology.

It isn't at all surprising that the same designers who put a small, cheap power supply in their products will in their spare time build the "dream amplifier" for their home systems according to quite a different approach. There you will see all the *right stuff*. It *will* have separate supplies for each channel. It *will* have large high quality transformers, most likely toroidal. It *will* have a huge bank of filter capacitors. Virtually every article on improving the sound of an existing product (be it a preamplifier, power amplifier, DAC, etc.) begins with the subject of beefing up the power supply! We know why: this is the foundation for good sound.

Every Balanced Audio Technology product is designed to bring you much closer to this "designer-builds-it-for-himself" model. The Balanced Audio Technology REX 500 power amplifier contains 1200 joules of energy storage. This is enough stored energy to lift an adult over one meter from the ground. *We call this BAT levitation!*

The basic idea behind the BAT SuperPak

There are many possible ways of designing a power supply for a gain stage. Among them are:

1. A simple unregulated supply based upon resistors and capacitors or RC filters.
2. A regulated supply with or without the final capacitor.
3. An Active filter supply (C-multiplier) with or without additional RC stages. This is our approach.

Since the power supply is a part of the gain stage, we can say that if we design our gain stages to be zero feedback, then the design of the power supply should follow that rule as well. For this reason, BAT believes that a regulated supply is not the best choice - as a regulated supply inherently relies heavily upon negative feedback.

In addition to being zero feedback, our gain stages are also balanced, which means that signal-induced current fluctuations are substantially reduced, thereby also reducing their demand on the power supply.

There are two basic needs for the proper design of the power supply, and they each rely upon a different choice of components. One need is for power-line frequency ripple reduction. This is typically done through voltage regulators, or large value electrolytic capacitors. C-multiplier circuits can also be used successfully in this regard.

The second requirement is the ability to handle the fine elements of the sound - usually associated with the higher frequency components.

Since electrolytic capacitors are generally deficient in this regard, they are often bypassed with higher quality capacitors - usually of some film type.

However, there are different schemes for accomplishing this bypass. The simple paralleling of large capacitors with small film parts does not work very well, because it goes against the more insightful approach that states that it is the LAST capacitor in the chain that matters most. In other words, *it is the last capacitor that the circuit should go to first* for its current needs.

Making the circuit rely on that "good cap" means it can't simultaneously be a "small cap". The 1,000uf electrolytic capacitor combined with a 1uF film bypass cap is the common example of this flawed approach. Such common bypass capacitors are typically too low in value to provide the gain stage any meaningful electrical benefit. That LAST capacitor must be of substantial energy storage to perform its task.

This is the reason behind the immense size of the BAT SuperPak. The SuperPak in all BAT products provides both a sizable as well as a high quality capacitor bank that keeps the gain stage happy, and it is properly decoupled from the main energy storage. The REX 500 SuperPak for example, contains 800uF of energy storage via high quality capacitors. Moreover, each 50uF capacitor is of a hybrid construction that contains a silver foil oil capacitor as well. This means that the REX 500 contains a total of sixteen silver foil oil capacitors just in the power supply! This is an example of the passion for excellence that makes BAT's engineering approach special.

What the ear hears as a result of this approach to massive high-quality *unregulated* power supply design is exactly what one hears from zero feedback design in principal – a more open, free-breathing sound. In this zero-feedback universe, the quality and size of the power supply both matter, and the SuperPak is allowed to work its magic.

The new "Push" BAT-PAK

Most solid state amps from Balanced Audio Technology incorporated some forms of BAT-Pak - the extended power supply energy storage. The REX 500 power amplifier continues that tradition, but brings it to new level.

In earlier generation products BAT-Pak worked simply as an extension to the on-board energy storage. The higher power rating of REX 500 dictated new approach to its architecture. In earlier models the raw power from the power supply entered the output stage via a single route. While more than sufficient in less powerful models, this limited the output stage potential.

In order to provide freer power delivery, a second path for power was introduced, this one through the BAT-Pak with its own on-board power rectifiers. With that architecture the BAT-Pak becomes the additional power source, in essence pushing the power into the output stage, hence the new name.

Electronic Protection

The REX 500 power amplifier incorporates a new protection circuit that eliminates the need to replace internal fuses. Many of us have dropped a needle on a record with the volume set too high or inadvertently shorted speaker leads when changing speaker cables or moving a speaker. If you make a mistake, all you need to do is reset the REX 500 by pressing a rear panel button. This will restore normal operation. That's it. The elimination of internal fuses also permits the REX 500 to handle much higher currents without impeding the circuit's operation. Indeed, the best sounding fuse is no fuse at all.

Final Tuning

Just as a supercar chassis and drive train might involve final tuning based on professional driver experience and telemetry from the Nurburgring, the REX 500 is tuned based on listening for continuous sonic improvement from design to design.. The silver foil in oil SuperPak capacitor, for example, involved hundreds of hours of listening to over a dozen prototypes before the final design was approved. In this listening, detail retrieval alone can be thought of as a cheap trick. A polypropylene capacitor that rings at 3kHz will yield a forward presentation that can contribute to a false sense of detail - but make orchestral string tone sound harsh and fatiguing. The goal is to retrieve musically consonant detail – to hear deeper into the music and achieve greater relaxation and joy at the same time.

Summary

From its extraordinary power delivery to the use of sixteen hybrid silver foil in oil capacitors, and the peace of mind provided by the elimination of fuses, the REX 500 stands as the pinnacle of BAT solid-state design. Add these design elements to the simplicity of a circuit that features only two gain blocks, zero feedback, and the pure symmetry afforded by using only superior N-channel devices for amplification, and you can understand why this statement product is unique in the marketplace. A timeless industrial design that was first launched as part of BAT's 25th anniversary celebration complements the engineering excellence within.

The REX 500 is truly an instrument worthy of being the first BAT solid-state design to wear the REX badge.

REX 500

Features & Specifications

500W/channel into 8 Ohm load
1000W/channel into 4 Ohm load

Fuseless Protection Circuit

Third generation SuperPak⁺

New "Push" BAT-Pak

Two-stage signal path

True dual-mono design
(With individual power cords for each channel)

Fully differential from input to output

Wide bandwidth: 3 Hz to 250 KHz

High slew rate: 200V/uS

Symmetrical Design
(Only N-Channel MOSFET's used throughout)

Zero global feedback

High-Current differential driver stage

Dimensions: 19" x 10" x 23.5"

Weight: 140 lb

Note: All features and specifications listed are for the stereo version.

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