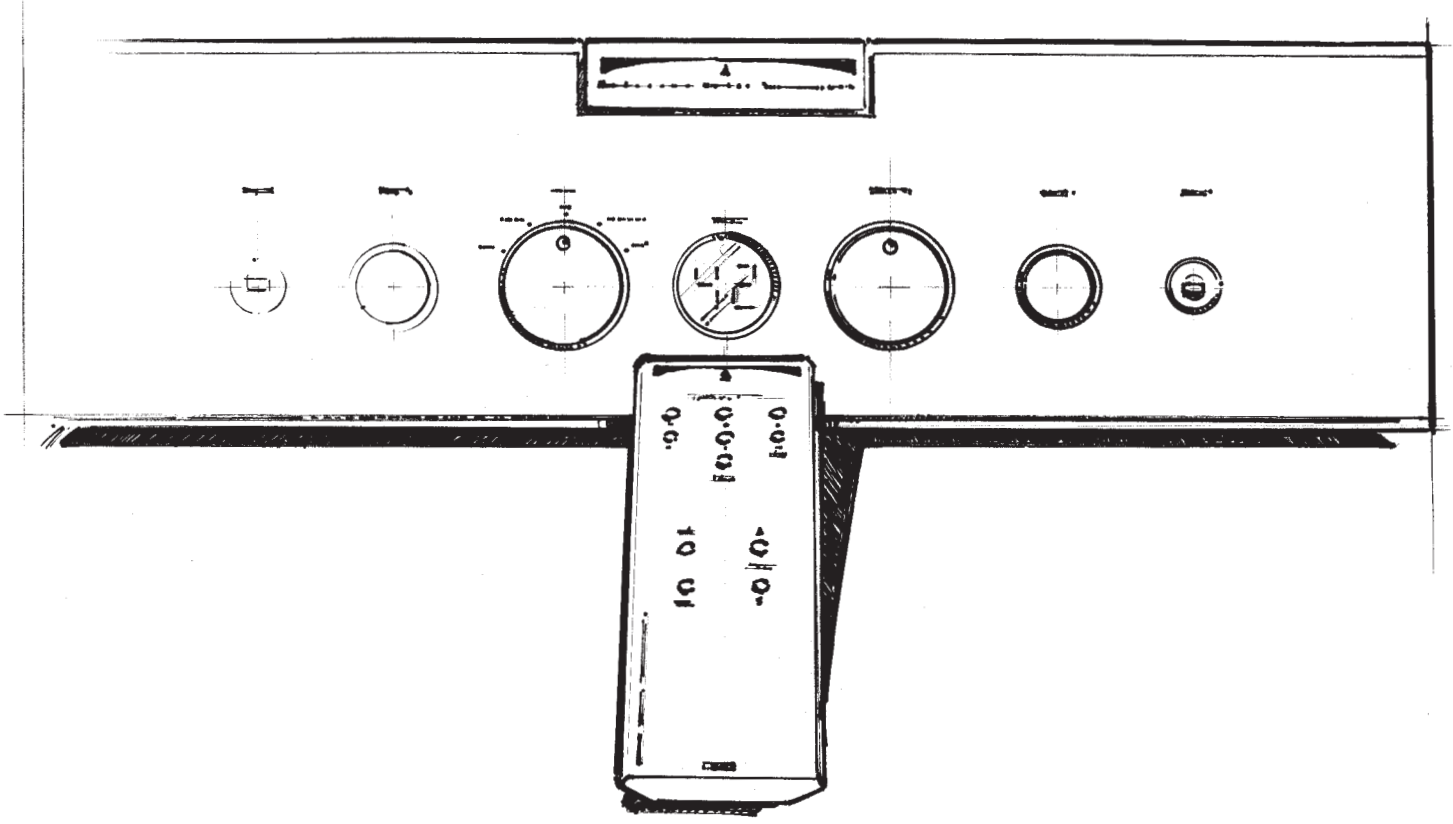


**B a l a n c e d A u d i o T e c h n o l o g y**

# *i*·Series

W h i t e P a p e r



## Introduction

This technical brief provides an overview of the design approach, reasoning and philosophy behind the creation of the new *i-series* preamplifiers from Balanced Audio Technology. It augments the technical information provided in the VK-5 white paper, as the *i-series* reflects an improvement in key aspects of the VK-5 and VK-3 preamplifiers architecture and not a departure from the fundamental excellence of these designs. Indeed, the stellar performance of the VK-5 and VK-3 preamplifiers presented an inviolate benchmark against which to judge changes contemplated for the *i-series*. The fact that the VK-5*i* and VK-3*i* improve upon the sonic performance of their forebears is a tribute to the perseverance of the Balanced Audio Technology engineering team. Numerous design alternatives were explored over an extensive development cycle before arriving at the ingenious solutions incorporated into these new benchmarks in reference preamplification.

## The *i-series* Design Objectives

The design objectives for the *i-series* were:

1. To provide remote control capability for the VK-5 and VK-3 preamplifiers that does not degrade their sound.
2. To consolidate circuit improvements and parts upgrades based upon years of experience with the existing products.
3. To incorporate a modern and convenient user interface as well as fresh styling.
4. To offer a cost-effective *i-series* upgrade option for our customers.

We are pleased that the *i-series* not only meets all these objectives but establishes a sonic improvement over the VK-5 and VK-3 as well.

Prior to understanding how Balanced Audio Technology surpassed these design objectives, it may be helpful to better define the nature of the problem that makes achieving a sonically transparent remote volume control so difficult.

## Remote Control: High End Achilles Heel

Remote control of volume has rightfully been given a bad name in high-end audio due to numerous preamplifiers that offer such capability with mediocre sonic performance. In fact, remote convenience is often synonymous with sonic compromise. The customer is caught in the middle trying to decide how to balance these apparently conflicting goals.

Since remote control is available in receivers sold for as little as \$200, the issue is not one of cost alone but a tradeoff of cost versus quality. Indeed, given the limited engineering resources of most high end firms, many find themselves resorting to the same off the shelf solutions used in “low end audio”. These are generally integrated circuits (IC’s) with devices such as low

quality op amps placed directly in the signal path. Such implementations are very inexpensive, as witnessed by their presence in many low priced products.

Therefore, we have been surprised to see such solutions appear in high end preamplifiers retailing for well over \$10,000. Another high end tube manufacturer uses a similar integrated circuit based volume control in their vacuum tube preamplifiers. Thus, even tube designs that have garnered favor for the purity of their approach to amplification find themselves corrupted by this desire for a quick-turn solution to the remote conundrum.

## The *i-series* Investigation

Balanced Audio Technology undertook a careful investigation of remote volume control implementations. Our experience with the development of the VK-5’s shunt volume control taught us that the volume control implementation played a critical role in determining the ultimate performance of a preamplifier. The volume control can be thought of as a gateway or gatekeeper within a preamplifier since any

information lost by the volume control is lost forever to the succeeding gain block(s). Thus, we used our ears to tell us if our theories were correct about the purity of alternative volume control implementations. In all cases, the existing VK-5 preamplifier’s Vishay™ shunt volume control was used as the benchmark for listening comparisons. Without further ado, here is what we learned.

## Digital Volume Controls

Digital volume attenuators are becoming increasingly common within high end audio. These are packaged as integrated circuits that rely upon a digital interface to set volume levels. Depending upon the specific chip employed, a variety of op amps or other solid-state devices are usually found directly in the signal path. Resistive elements used inside these chips are

diffusion-type integrated components that have unpredictable sonic characteristics. The advantage of such an implementation is that, as a packaged solution, it can be plugged into an existing preamplifier design relatively easily. Such parts also have very good electrical specifications (e.g. dynamic range, distortion, range of attenuation).

This allows the designer to build a very convenient and friendly user interface. The parts functionality, coupled with quick availability and low cost, make this a very tempting proposition. We tried this solution with the VK-5 as our investigation into remote volume control began.

The result confirmed our fears about such an implementation. Almost every sonic parameter of the VK-5 was affected.

The air and breath of life that the VK-5 brings to music was replaced by a more congealed and flattened perspective. Instrumental attack was softened and instrumental decay was truncated. It was as if we inserted a lesser preamplifier in-between the source and the VK-5. Referring back to the volume control as a gateway, its easy to understand why. Based on these observations, an integrated circuit digital volume control implementation was rejected for our reference products.

## Multiplying DAC Volume Control

Another popular integrated circuit implementation is the so-called Multiplying Digital-to-Analog Converter, or MDAC. As the name implies, the output of the MDAC represents the product of two input variables: one being a binary number on the digital port and the other – the reference analog voltage. When using an MDAC as a volume control, the audio signal is connected to the reference voltage input. Changing the digital input will modulate the signal output, allowing for a very convenient way of changing volume.

Most of the concerns mentioned in the previous discussion on digital volume controls apply here as well. The internal

resistive ladder that is the very heart of complicated DAC integrated circuits, is comprised of silicon diffusion-based resistors and not, for example, metal film resistors, normally used in high end components. In addition, such DAC's usually require that an external operational amplifier (used as a current-to-voltage converter), another complex solid state component, be inserted directly in the signal path.

Our listening evaluations confirmed a striking similarity to the sound of the digital volume control. Our search continued.

## Motorized Volume Control

In contrast to the two solutions described previously, in the motorized volume control the motor and its electronic drive circuitry are not part of the signal path. You can still use your favorite volume potentiometer and, therefore, preserve the original sound of your product. You can buy an integrated motor/potentiometer package or create your own. Existing units can be upgraded by simply adding the motor and control board.

This convenience comes with some penalties. First of all, any moving mechanical component in your system is bound to be one of its most troublesome elements. Potentiometers, even the best ones, will suffer from the resistive element wearing out and its moving parts breaking down. The same is true for the motor and gears. In addition, there is something exceedingly old-fashioned and antiquated about this solution.

The choice of motor is a very painful exercise. Low cost models, of the type usually found in inexpensive receivers, are of inferior quality for use in high end components (although they are still used by some companies). High quality motors and gears, worthy of a high-end product, can be very expensive.

Implemented within the VK-5 prototype, the motor was driving the four-section high-quality plastic conductive potentiometer that is used in a shunt attenuator configuration. This should be differentiated from a traditional motorized volume control that does not incorporate the Vishay Bulk Metal® foil resistors as a pass-through element (see pg. 8 of the VK-5 white paper for more detail).

As expected, this solution did not have a negative effect on the sound of the VK-5. Nor was there a positive improvement. The biggest problem with such a solution is that it is a crude architectural dead end. With this implementation, repeatable setting of volume level is practically impossible (unless one embarks on a full-blown closed-loop design with potentiometer position sensor in the feedback loop) and such niceties as being able to offer a unity gain function are also eliminated.

This became our solution of last resort. Although it satisfied many of our objectives, we felt that Balanced Audio Technology should set the highest standard possible in all aspects of design. Our third objective of providing a modern convenient user interface would not be satisfied by this somewhat crude approach. We continued our search.

## BAT Electronic Shunt Volume Control

At this point in the investigation, it was clear that a markedly different approach had to be undertaken. The vision of Balanced Audio Technology's volume control began taking shape with the following key attributes:

1. The new volume control would continue to be based on the shunt configuration. The Vishay Bulk Metal Foil resistors would remain at the heart of the VK-5*i*.
2. It would provide a substantial improvement in overall sound quality due to elimination of the plastic element potentiometer from the signal path.
3. It would be a fully electronic volume control, alleviating any reliability concerns associated with the deterioration or breakdown of a motorized control.
4. It would use only the highest quality parts, such as precision low noise metal film resistors.
5. It would be digitally controlled using an onboard microprocessor. This would allow us to design a convenient user interface and provide an easy future upgrade path - requiring only the change of one chip in the field to accomplish any such upgrade.
6. The stepped attenuator would have a broad range of adjustment. The steps should be small enough in size to maintain the feel of a continuously-variable potentiometer.
7. The solution would be fully retrofittable to allow the owners of even the oldest units to get the full benefits of this latest upgrade.

The step size for the attenuator was chosen to be 0.5dB over most of its adjustment range. This provides an essentially continuous feel and ease of predictable gain setting, without becoming burdensome in cost.

The choice of switching element in any stepped attenuator is a critical one. While relays are being used in some high end products, we found them to be undesirable for several reasons. An effect best described as relay chatter becomes annoying on some products when changing the volume. In addition, the usual questions about the reliability of electromechanical components remain. All this meant that carefully selected electronic switches had to be found for this application.

Through extensive circuit analysis and simulation, the proper choice of components and their placement in overall circuit topology were determined. These findings were later confirmed in our listening tests.

Up until this time, we believed the VK-3 and VK-5 preamplifiers to be the most transparent units on the market. Somewhat surprisingly, the *i-series* remote volume implementation removes a slight opaque film from the presentation of music. Transient reproduction and detail resolution are all improved. Needless to say we are very pleased with the sonic improvement.

## The *i-series* User Interface

The microprocessor controlled volume attenuator of the *i-series* makes possible some delightful convenience features. For example, in addition to the common Mute function, the VK-3*i* and VK-5*i* remote controls incorporate a very useful FADE button, allowing for a gradual reduction in volume. Few of us enjoy the abrupt termination of music caused by using a Mute switch. So, while the Mute switch is still available, now you can also enjoy a soft gradual fade - convenient for gracefully handling the common interruptions to listening to music.

The *i-series* volume control allows for an instant recall of up to 6 preset volume positions. You can use this feature to preprogram your favorite volume positions or to compensate for signal differences in various source components. Or simply hop from volume to volume in 10 or 20 step increments.... The number 6 preset position is reserved for the UNITY GAIN setting. Please note that in this position the signal is still routed through the preamplifier active circuit.

## ***i-series* Feature Summary**

In summary, the *i-series* represents a major improvement over the industry leading VK-3 and VK-5 in numerous aspects of their design, improving upon these standard-bearing preamplifiers in the following significant areas:

1. Implementing an electronic version of the original shunt attenuator that is sonically superior to the already high standard achieved by the VK-3's and VK-5's shunt volume control.
2. Providing a digital display of volume level for precise repeatable control of this critical function.
3. Offering 100 discrete steps for precise adjustment of volume level.
4. Delivering an optional wireless remote control housed in a substantial machined case that offers not only the convenience of remote control of volume and mute but the sophistication of setting preset volume levels as well as such niceties as a gentle fade-to-silence button.
5. Replacing signal path resistors with an improved set of metal film resistors that yield a noticeably lower noise floor.
6. Incorporating a sophisticated auto-balance circuit in the VK-5*i* to maintain perfect internal DC balance independent of tube aging and varying line voltage.
7. Providing a modern update to the VK-3 and VK-5 front panel that maintains the classic appeal of Balanced Audio Technology's industrial design.
8. Incorporating a new back-panel on the VK-3*i* that offers a mix of XLR and RCA connectors.
9. Including a provision for a plug-in phono module on the VK-3*i*.
10. Offering full upgrades for both remote control as well as additional upgrades for older units that protect the customer's investment in their VK-3 and VK-5.
11. Establishing a factory direct only upgrade program to maintain the tightest possible control of quality and to maximize customer satisfaction with BAT.

## **Conclusion**

The *i-series* represents Balanced Audio Technology's groundbreaking effort at combining superb convenience without sonic compromise in our reference preamplifiers. For new customers, we're confident that the VK-5*i* and VK-3*i* will bring great joy to the experience of listening to music. For existing customers, we are equally confident that you'll be

just as pleased with the VK-5*i* or VK-3*i* as the day you first brought one home. We believe that you'll also appreciate Balanced Audio Technology's exemplary position of protecting your investment in BAT with these exciting new product releases.

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