Pass Laboratories

Aleph 0s Owner's Manual

Introduction

The Aleph 0s is a single ended Class A audio power amplifier sharing the same basic design as the Pass Labs Aleph 0, except that the hardware resources of the Aleph 0 are split between two channels to form a stereo amplifier rated at 40 watts per channel.

This power amplifier design flows from a commitment to create the best sounding product: a simple circuit with the most natural characteristic. The Aleph 0s integrates power Mosfet devices and single ended Class A operation in a simple topology in order to deliver natural sound, the reference for naturalness being taken as the acoustic characteristic of air.

Consuming four times the rated output power, single ended, or Asymmetric Class A makes ordinary push-pull circuits appear comparatively efficient. This inefficiency has been a deterrent to designers, limiting this "king" of Class A circuits to preamps and input stages.

I feel that in specialized and demanding applications, the energy penalty is worth the purity of performance obtainable from single ended Class A operation. This purity delivers the most musicality and listening satisfaction per watt of any operating mode.

Over the years I have remained fascinated by the characteristic sound of the single ended topology, but until now I did not have the opportunity to bring such a product to market . The Aleph 0s is the second product to come from Pass Laboratories reflecting this design vision.

A very few people are involved in the production of this product. I supervise all phases of the construction, and I test and listen to each amplifier myself. If you have questions, comments, or problems, please feel free to contact me directly.

Thank you for purchasing this amplifier. It is my sincere hope that you will enjoy its sound as much as I do.

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Nelson Pass

Serial # ____________________

Date: ____________________

Next page: Distortion curve of your particular amplifier into 8 ohms versus output watts.

Setup

The amplifier has three sets of connections and one switch:

The first connection and switch is the AC line power system. The amplifier's voltage and current rating are indicated on the bottom panel. It will be either 240 volt with a 6 amp fuse, a 120 volt with a 6 amp fuse, or a 100 volt with a 6 amp fuse. The frequency rating of the AC line source is 50 to 60 Hz. On the rear panel is an AC line power switch used to turn the amplifier on and off. A blue Led lamp mounted in the front panel indicates power.

Your amplifier is provided with a standard AC power cord which fits into the line receptacle located just below the power switch. The amplifier is equipped for operation with an earth ground provided by the AC outlet. Do not defeat this ground. The chassis of the amplifier is connected directly to this earth ground, and the audio circuit ground is connected to the chassis and earth through a power thermistor, which gives a ground connection but helps avoid ground loops.

While the amplifier is equipped with an AC inrush suppresser, the turn-on AC draw will peak (half cycle) at roughly 50 amps on a 120 volt system and 25 amps on a 240 volt system. The fuse on the amplifier is a 3AG fast blow type rated at 6 amps. It is in series with the AC power line.

The second connection is at the input, which is a standard female XLR connector. It is configured for balanced input, and if you wish to run the amplifier from an unbalanced source, you may configure it for unbalanced source using an adapter as described later in this manual. On this connector, pin 1 is grounded, pin 2 is the positive signal input, and pin 3 is the negative signal input. In balanced mode, the input impedance is nominally 25 Kohm, and the unbalanced input impedance of the amplifier is nominally 10 Kohm.

The amplifier is shipped with a shorting plug between pins 1 and 3 of the XLR input connector. Remove this plug and save it if you are using a balanced connection to the source. If you are using an RCA connection to the source, you may operated the amplifier with or without this shorting plug. Use of the shorting plug will give 26 dB of gain, and without will give 20 dB of gain. You may operate it either way as you prefer.

The third connection is the amplifier output connection. Connect the 5-way output connectors to loudspeaker plus and ground, using the cable of your choice. The polarity of the red output connectors is +, and the black connectors are ground. Although they are at ground, It is not recommended that you attach the black output connectors to anything other than the loudspeaker terminals.

The amplifier will drive any known loudspeaker load which dips as low as 2 ohms. Do not drive the amplifier into a direct short. If distortion or fuse blowing accompany an attempt to operate the amplifier, please disconnect the loudspeaker first and check for a shorted circuit. As the amplifier does not use a current limiting protection circuit, quite a large amount of power can flow from the amplifier. The design has been tested to survive external short circuits, but the possibility exists for failure under these conditions. Such failure is covered by your warranty.

At rated power, the amplifier draws approximately 250 watts from the wall, and during idle operation most of this energy will appear as heat on the heat sinks. Good ventilation is vital to the proper operation of the amplifier. It has been adjusted for optimal performance at room temperature, but will work well between 50 and 90 degrees Fahrenheit (10 to 33 Celsius). You should leave at least six inches clearance on the sides and top. The amplifier should not be placed in a closed cabinet which does not have forced air ventilation.

This amplifier runs hot. The heat sinks will warm up in about an hour to a temperature which will not be particularly comfortable to touch, which is 120 to 130 degrees Fahrenheit (50 to 55 degrees Celsius). This is normal, and there is a thermal shut off system which will shut down the amplifier at internal temperatures in excess of 75 deg. C. If the over temperature protection system is activated, it will shut down the amplifier until the thermal sensor has cooled. If you find that the amplifier has shut down, turn it off and investigate the cause before attempting to use it further.

It takes at least an hour of warm up time to get the best performance out of the amplifier. It will take that long to reach operating temperature and exhibit lowest DC offset voltage at the output. However, prior to warm up, the amplifier will meet measurable performance specifications except DC offset voltage.

The amplifier does not require any maintenance. While the design is conservative, this is a hard running amplifier, as single ended Class A operation is the least efficient operating mode. In fifteen years the electrolytic power supply capacitors will get old. Depending on usage, you will begin to have semiconductor and other failures between 10 and 50 years after date of manufacture. Later, the sun will cool to a white dwarf, and after that the universe will experience *heat death*.

Product Philosophy and Design Theory

When I started designing amplifiers, solid state amplifiers had just achieved a firm grasp on the market. Power and harmonic distortion numbers were king, and the largest audio magazine said that amplifiers with the same specs sounded the same.

We have heard Triodes, Pentodes, Bipolar, VFET, Mosfet, TFET valves, IGBT, Hybrids, THD distortion, IM distortion, TIM distortion, phase distortion, quantization, feedback, nested feedback, no feedback, feed forward, Stasis, harmonic time alignment, high slew, Class AB, Class A, Pure Class A, Class AA, Class A/AB, Class D, Class H, Constant bias, dynamic bias, optical bias, Real Life Bias, Sustained Plateau Bias, big supplies, smart supplies, regulated supplies, separate supplies, switching supplies, dynamic headroom, high current, balanced inputs and balanced outputs.

Apart from digitally recorded source material, things have not changed very much in twenty five years. Solid state amplifiers still dominate the market, the largest audio magazine still doesn't hear the difference, and many audiophiles are still hanging on to their tubes. Leaving aside the examples of marketing hype, we have a large number of attempts to improve the sound of amplifiers, each attempting to address a hypothesized flaw in the performance. Audiophiles have voted on the various designs with their pocketbooks, and products go down in history as classics or are forgotten. The used market speaks eloquently: Marantz 9's command a high price, while Dyna 120's are largely unwanted.

There has been a failure in the attempt to use specifications to characterize the subtleties of sonic performance. Amplifiers with similar measurements are not equal, and products with higher power, wider bandwidth, and lower distortion do not necessarily sound better. Historically, that amplifier offering the most power, or the lowest IM distortion, or the lowest THD, or the highest slew rate, or the lowest noise, has not become a classic or even been more than a modest success.

For a long time there has been faith in the technical community that eventually some objective analysis would reconcile critical listener's subjective experience with laboratory measurement. Perhaps this will occur, but in the meantime, audiophiles largely reject bench specifications as an indicator of audio quality. This is appropriate. Appreciation of audio is a completely subjective human experience. We should no more let numbers define audio quality than we would let chemical analysis be the arbiter of fine wines.   Measurements can provide a measure of insight, but are no substitute for human judgment.

As in art, classic audio components are the results of individual efforts and reflect a coherent underlying philosophy. They make a subjective and an objective statement of quality which is meant to be appreciated. It is essential that the circuitry of an audio component reflects a philosophy which address the subjective nature of its performance first and foremost.

Lacking an ability to completely characterize performance in an objective manner, we should take a step back from the resulting waveform and take into account the process by which it has been achieved. The history of what has been done to the music is important and must be considered a part of the result. Everything that has been done to the signal is embedded in it, however subtly.

Experience correlating what sounds good to knowledge of component design yields some general guidelines as to what will sound good and what will not:

1) Simplicity and a minimum number of components is a key element, and is well reflected in the quality of tube designs. The fewer pieces in series with the signal path, the better. This often true even if adding just one more gain stage will improve the measured specs.

2) The characteristic of gain devices and their specific use is important. Individual variations in performance between like devices is important, as are differences in topological usage. All signal bearing devices contribute to the degradation, but there are some different characteristics are worth attention. Low order nonlinearities are largely additive in quality, bringing false warmth and coloration, while abrupt high order nonlinearities are additive and subtractive, adding harshness while losing information.

3) Maximum intrinsic linearity is desired. This is the performance of the gain stages before feedback is applied. Experience suggests that feedback is a subtractive process; it removes information from the signal. In many older designs, poor intrinsic linearity has been corrected out by large application of feedback, resulting in loss of warmth, space, and detail.

High idle current, or bias, is very desirable as a means of maximizing linearity, and gives an effect which is not only easily measured, but easily demonstrated: Take a Class A or other high bias amplifier and compare the sound with full bias and with bias reduced. (Bias adjustment is easily accomplished, as virtually every amplifier has a bias adjustment pot, but it should be done very carefully). As an experiment it has the virtue of only changing the bias and the expectations of the experimenter.

As the bias is reduced the perception of stage depth and ambiance will generally decrease. This perception of depth is influenced by the raw quantity of bias current.

If you continue to increase the bias current far beyond the operating point, it appears that improvements are made with bias currents which are much greater than the signal level. Typically the levels involved in most critical listening are only a few watts, but an amplifier biased for ten times that amount will generally sound better than one biased for the few watts.

For this reason, designs which operate in what has been referred to as "pure" Class A are preferred because their bias currents are much larger than the signal most of the time.

As mentioned, preamp gain stages and the front ends of power amplifiers are routinely single ended "pure" Class A, and because the signal levels are at small fractions of a watt, the efficiency of the circuit is not important.

4) Given the assumption that every process that we perform on the signal will be heard, the finest amplifiers must employ those processes which are most natural. There is one element in the chain which we cannot alter or improve upon, and that is the air. Air defines sound, and serves as a natural benchmark.

Virtually all the amplifiers on the market are based on a push-pull symmetry model. The push-pull symmetry topology has no particular basis in nature. Is it valid to use air's characteristic as a model for designing an amplifier? If you accept that all processing leaves its signature on the music, the answer is yes.

One of the most interesting characteristics of air is its single ended nature. Sound traveling through air is the result of the gas equation

$$PV^{1.4} = 1.26 \times 10^4$$

where P is pressure and V is volume, and whose curve is illustrated in fig. 1. The small nonlinearity which is the result of air's characteristic is not generally judged to be significant at normal sound levels, and is comparable to the distortion numbers of fine amplifiers. This distortion generally only becomes a concern in the throats of horns, where the intense pressure levels are many times those at the mouth, and where the harmonic component can reach several per cent.

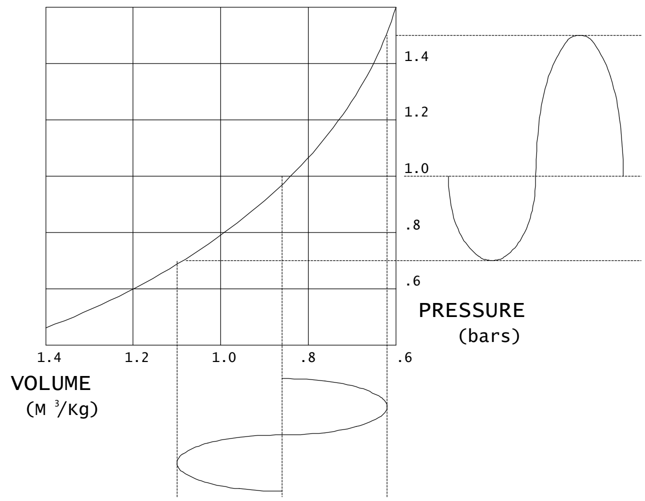

FIG 1 CHARACTERISTIC OF AIR

Fig. 1 shows the single ended nature of air. We can push on it and raise the pressure an arbitrary amount, but we cannot pull on it. We can only let it relax and fill a space as it will; the pressure will never go below "0". As we push on air, the increase in pressure is greater than the corresponding decrease when we allow air to expand. This means that for a given motion of a diaphragm acting on air, the positive pressure perturbations will be slightly greater than the negative. From this we see that air is phase sensitive.

As a result of its single ended nature, the harmonic content of air is primarily 2nd order, that is to say most of the distortion of a single tone is second harmonic. The phase of this distortion reflects the higher positive pressure over the negative.

Air's transfer curve also shows also that it is monotonic, which is to say its distortion products decrease smoothly as the acoustic level decreases. This is an important element that has often been overlooked in audio design and is reflected in the poor quality of early solid state amplifiers and D/A and A/D converters. They are not monotonic: the distortion increases as the level decreases.

The usual electrical picture of an audio signal is as an AC waveform, without a DC component. Audio is represented as alternating voltage and current, where positive voltage and current alternates with negative in a reciprocal and symmetric fashion. This fiction is convenient because it lends itself to the use of an energy efficient design for amplifier power stages known as push-pull, where a "plus" side of an amplifier alternates operation with a "minus" side. Each side of a push-pull amplifier handles the audio signal alternately; the "plus" side supplying positive voltage and current to the loudspeaker, and the "minus" side supplying negative voltage and current.

Problems with push-pull amplifier designs associated with crossover distortion have been discussed elsewhere at length, and one of the primary results is non-monotonicity. Class B and many AB designs have distortion products that dramatically increase with decreasing signal. This is reduced greatly by Class A mode, but crossover distortion remains as a lower order discontinuity in the transfer curve.

For reproducing music as naturally as possible, push-pull symmetric operation is not the best approach. Air is not symmetric and does not have a push-pull characteristic. Sound in air is a perturbation around a positive pressure point. There is only positive pressure, more positive pressure, and less positive pressure.

Push-pull circuits give rise to odd ordered harmonics, where the phase alignment reflects compression at both positive and negative peaks and crossover nonlinearity near the zero point.

Only one linear circuit topology delivers the appropriate characteristic, and that is the single ended amplifier. Single ended amplification only comes in pure Class A, and is the least efficient form of power stage you can reasonably create, typically idling at four times the rated output power.

Single ended operation is not new. It is routinely found in the low level circuitry of the finest preamplifying stages and in the front end circuits of the finest power amplifiers. The first tube power amplifiers were single ended circuits using a single tube driving the primary of a transformer.

In 1977 I designed and published in Audio Magazine a single ended Class A amplifier using bipolar followers biased by a constant current source. A considerable number of amateurs have built the device, rated at 20 watts output, and many have commented on its unique sonic signature.

Single ended Class A operation is generally less efficient than push-pull Class A. Single ended Class A amplifiers tend to be even bigger and more expensive than their push-pull cousins, but they have a more natural transfer curve.

The "purity" of Class A designs has been at issue in the last few years, with "pure" Class A loosely defined as an idling heat dissipation of more than twice the maximum amplifier output. For a 100 watt amplifier, this would be 200 watts out of the wall at idle.

Designs that vary the bias against the musical signal will generally have bias currents at or below the signal level. This is certainly an improvement from the viewpoint of energy efficiency, but the sound reflects the lesser bias point.

You might note that I authored the first patent on the dynamically biased Class A amplifier in 1974, however I have not used the technique for the last 15 years. The reason is that I found the quality of sound associated with an efficient Class A operating mode inferior in depth and less liquid at high frequencies, simply because it operates at reduced bias at low levels. Given the plethora of cool running “Class A” amplifiers on the market, you might say I opened a Pandora’s box.

Until the output current reaches its single ended bias point of the Aleph 0s, it is considered a single ended Class A amplifier as the bias is provided by a constant current source attached to the negative power supply. Beyond the single ended bias point to 40 watts peak it will operate as a push-pull Class A amplifier in the conventional (pure) sense, leaving Class A at twice the bias point. As with other pure Class A amplifiers, it will continue to operate push-pull at yet higher power levels (25 amps) but with shutoff occurring in the unused half of the output stage.

A very important consideration in attempting to create an amplifier with a natural characteristic is the selection of the gain devices. A single ended Class A topology is appropriate, and we want a characteristic where the positive amplitude is very, very slightly greater than the negative. For a current gain device, that would mean gain that smoothly increases with current, and for a tube or field effect device a transconductance that smoothly increases with current.

Triodes and Mosfets share a useful characteristic: their transconductance tends to increase with current. Bipolar power devices have a slight gain increase until they hit about an amp or so, and then they decline at higher currents. In general the use of bipolar in a single ended Class A circuit is a poor fit.

Another performance advantage shared by Tubes and Fets is the high performance they deliver in simple Class A circuits. Bipolar designs on the market have between four and seven gain stages associated with the signal path, but with tubes and Mosfets good objective specifications are achievable with only 2 or 3 gain devices in the signal path.

Yet a third advantage tubes and Mosfets have over bipolar devices is their greater reliability at higher temperatures. As noted, single ended power amplifiers dissipate comparatively high wattages and run hot.

In a decision between Triodes and Mosfets, the Mosfet's advantage is in naturally operating at the voltages and currents we want to deliver to a loudspeaker. Efforts to create a direct coupled single ended triode power amplifier have been severely limited by the high voltages and low plate currents that are the province of tubes. The commercial offerings have not exceeded 8 watts or so, in spite of hundreds of dissipated watts.

Transformer coupled single ended triode amplifiers are the alternative, using very large gapped-core transformers to avoid core saturation from the high DC current, but they suffer the characteristic of such a loosely coupled transformer as well.

The promise of the transconductance characteristic in power amplifiers in providing the most realistic amplified representation of music is best fulfilled in Mosfet single ended Class A circuitry where it can be used very simply and biased very high.

The Aleph 0s uses International Rectifier Hexfet Power Mosfets exclusively for all gain stages. These Mosfets were chosen because they have the most ideal transfer curve for an asymmetric Class A design. Made in the United States, they have the highest quality of power Mosfets we have tested to date. We match the input devices to each other to within 0.3% and the output devices to within 2%. The smallest of these, the input devices, are capable of peak currents of 2 amps. The largest are capable of peaks of 25 amps each.

The power Mosfets in the Aleph 0s have chip temperatures ratings to 150 degrees Centigrade, and we operate them at small fractions, typically 20% of their ratings. For extended life, we do not allow chip temperatures to exceed 80 degrees C.

Regardless of the type of gain device, in systems where the utmost in natural reproduction is the goal, simple single ended Class A circuits are the topologies of choice.

While it will not leave Class A on a positive signal, a single ended Class A design would ordinarily clip at negative currents greater than the bias point, and for this occurrence the Aleph 0s has a proprietary pull element in the output stage which gives a smooth transition to push-pull Class A operation at negative currents beyond the bias point. This design is capable of peak current of 25 amps on both positive and negative peaks, and will operate with complete stability into 2 ohms with any phase angle of reactance. This new topology has been designed to source greater negative current than previous amplifiers with single ended bias, in the belief that push-pull Class A operation is preferable to clipping.

It is a very simple topology, which is a key part of the sound quality. Other solid state amplifier designs usually have five to six gain stages in the signal path in order to get enough gain to use feedback to provide adequate performance. In this amplifier, we get greater linearity by providing much more bias through three gain stages: a differential input stage, a cascoded voltage gain stage, and the output transistors. The Aleph 0s uses Mosfet power transistors throughout. The input stage uses power Mosfets and biases them at eight to ten times the amount of current usually running through front end circuitry. The result is significantly greater linearity and greater drive capability from simple circuitry.
Mosfets provide the widest bandwidth of solid state power devices, however they were not chosen for this reason. The design of the Aleph 0s does not seek to maximize the amplifier bandwidth as such. The capacitances of the Mosfets provide a natural rolloff in conjunction with the resistive impedances found in the circuit, and the simplicity of the circuit allows for what is largely a single pole rolloff characteristic.

The slew rate of the amplifier is about 50 Volts/uS under load , which is about 10 times faster than the fastest signal you will ever see, and about 100 times faster than what you will be listening to. In and of itself, the slew rate is an unimportant factor when evaluating tube and simple Mosfet designs. It becomes more important with complex circuit topologies where there is heavy dependence on feedback correction, but even then its importance has been overstated.

On the other end of the spectrum, the amplifier has full DC response, and is perfectly usable as a DC power supply. There are no capacitors in the gain path of the circuit. After warm-up, the DC offset in the amplifier is about .05 volts. While warming up, the amplifier will have higher DC offset, but not so much as to present a performance problem.

It is important to note that full DC response brings with it the potential that DC can be fed to the loudspeaker if the source has a DC component to it. Exercise caution in this regard to prevent damage to the loudspeaker. The warranty coverage for this amplifier does not include damage to loudspeakers. If there is any question that DC might be present at the output of the amplifier, an inexpensive voltmeter will prove a wise investment. You can check for DC offset with the source connected and on and the amplifier on, but with the loudspeaker disconnected. If there is any question, contact your dealer or the factory.

For the lowest possible operating noise in any environment, the amplifier is equipped with balanced inputs featuring a common mode noise rejection of about 60 dB. Balanced operation is accomplished through a passive network tied directly into the input stage of the amplifier, not with additional active input circuitry as in other products. This assures that the noise benefits of balanced operation are not accompanied by the degradation of more semiconductors in the gain path.

The input of the amplifier is flexible and can also be operated with unbalanced sources. The input system will exhibit full common mode noise rejection with passive balanced sources, where the negative input is connected to ground at the source through the appropriate source impedance. This allows adaptation of unbalanced sources to balanced operation with passive cable connections in a manner that achieves the noise rejection of active balanced sources.

Fig. 2 shows the equivalent network we are using when operating in balanced mode. On a differential amplifier with this network, there are three ways of looking at the input impedance: the common mode input impedance, the positive input impedance, the negative input impedance, and the differential input impedance. The common mode input impedance, seen by signals and noise which are identical at the two inputs is 10 Kohm. This input impedance is seen individually at both inputs for common mode signal and noise. At the positive input, the input impedance is 10 Kohm in unbalanced mode, and the balanced differential input impedance is 25 Kohm.

There is an alternate way to drive this network, which is also shown in Fig. 2. The positive input is actively driven by the source circuitry of whatever preamp you might choose to use. The negative input is passively terminated at the source to ground through whatever impedance matches the output impedance of the active source. In the case of Fig. 2 the source has an output impedance of 100 ohms, so a 100 ohm resistor is used. This gives full value to the noise rejection capability of the balanced input, and avoids having to drive a low impedance negative input. This circuit is well suited to adapting unbalanced sources to the balanced input, as it will retain the desired rejection figures when the negative input is terminated at the source.

To operate the amplifier with a single unbalanced input, a male adapter should be used which brings the signal into pin 2 and grounds pins 1 and 3. Failure to ground the pin 3 negative input will result in 6 dB of loss of voltage gain, but will not otherwise cause difficulties.

The maximum short term output current is about 25 amps, which corresponds to about 600 watts peak into 1 ohm. The AC line fuse will probably blow after a several second duration of 25 amps. Over the longer term, the thermal protection will possibly activate on heavy non-musical continuous . These conditions are very unlikely when the amplifier is used for amplifying music. The amplifier does not incorporate short protection, and there is the possibility of damaging the output stage if you drive a short circuit, so we advise taking care with regard to your speaker cable connections to avoid this.

Please feel free to contact the factory for information or advice when considering difficult loads or unusual circumstances.

The amplifier is indifferent to the reactance of the load. As a single ended Class A device, the worst dissipation case is idle, and current flowing into a reactive load does not particularly alter the dissipation. Current flowing into a resistive portion of a load will generally make the amplifier run cooler. A reactive load will not increase the distortion of the amplifier, in fact it typically will reduce the distortion slightly.

The amplifier is powered by a toroidal transformer which charges .125 Farad capacitance to 150 Joules. This unregulated supply feeds the output transistors only with a full power ripple of about .25 volt. The front end circuitry is passively decoupled from the main rails for low noise.

The chassis of the Aleph 0s is made entirely of machined aluminum; no sheet metal is employed. We mill the chassis components ourselves from aluminum stock on four computer controlled vertical milling machines. We also do the chassis engraving on the milling machines, which we built ourselves. The pieces are grained and anodized at the finest plating house on the West Coast.

The Aleph 0s is warranted by Pass Laboratories to meet performance specifications for 3 years from date of manufacture. During that time, Pass Laboratories will provide free labor and parts at the manufacturing site. The warranty does not include damage due to misuse, abuse, or modification to the amplifier and also does not include consequential damage.

Performance Specifications

Gain	20 dB balanced, 20 or 26 dB unbalanced
Freq. Response	0 dB @ DC -3 dB at 100 KHz
Power Output	40 watts @ 8 ohms, 80 watts @ 4 ohms
Distortion	< 1% @ 40W, 8 ohms
Maximum Output	25 amps, 30 volts (peak)
Output Impedance	.025 ohm @ 1 KHz @ 8V @ 8 ohm
Balanced Input	26 Kohm, nominal differential
Common mode rejection	typ. 60 dB @ 1 KHz @ .1V input common ground
Output Noise	.6 mV unweighted
Crosstalk	-80 dB @ 1 KHz
DC offset	<100 mV after warm-up, balanced mode
Power Consumption	250 watts at 40 watts output/ch
Operating Temperature	50 degrees C.
Dimensions	12 " W x 12 " D x 10.5" H
Shipping Weight	63 lb.

Pass Laboratories
21555 Limestone Way
Foresthill CA 95631

tel (916) 367 3690
fax (916) 367 2193