Constant Power Sum Pan Potentiometer with Sonic Imagery Labs 312A Discrete VCA Amplifier

Richard Ian Doporto
Design Engineer
October 2013

The 312A VCA module is a very high performance device offering wide range exponential control of gain and attenuation with very low audio program signal distortion. The 312A VCA module is a powerful and versatile building block with applications ranging from radio AGC to microprocessor controlled faders and its application is merely limited to the designers imagination.

Simple Panning Application:
Having the ability to move the apparent position of one microphone input between two output channels often is required in typical recording studio mixing consoles. Such a circuit is called a panning circuit (short for panoramic control circuit) or a pan pot. **FIGURE 1**. Illustrates a simple topology in which one pot is used to control the panning control. The Model 312A VCA-EGC modules are configured as voltage-in/voltage out devices. The upper 312A VCA's EGC control port is configured to be positive voltage gain control and the lower 312A VCA's EGC control port is configured to be negative voltage gain control. Normally panning requires two oppositely wired control pots ganged together. However the circuit shown in **FIGURE 1. and 2**. provides accurate panning with only one linear taper potentiometer. With the wiper of R1 at center position, 0 volts is applied to the VCA's inputs and each of the outputs are at unity gain. As the wiper is moved to the positive direction, channel 1's gain increases at a rate of 20dB/volt.

Conversely channel 2's gain is reduced at the same 20 dB/volt rate. Moving the wiper to the negative end of the pot, channel 1's gain decreases at a 20dB/volt rate while channel two's gain increases at the same rate. The circuit as shown in **FIGURE 1.** is more akin to a vibrato or tremelo because as the gain is reduced in one channel, it increases in the other channel beyond unity. FIGURE 1. could make for an interesting musical effect but is not a true panning circuit.

A standard stereo or mixing board panning circuit is required to have unity gain at each extreme of control (pot) travel. All input signal is delivered to one output channel with the other channel at full attenuation. Additionally both channels should have -3dB gain from each output with the pan-pot at center position. (Equal power at each output.) **FIGURE 2**. does not achieve the -3dB gain from each output requirement but does retain the single linear potentiometer as the control input. U1 and U2 are configured as inverting and non-inverting gain of 2.5 clamp at 0 volts op-amps.

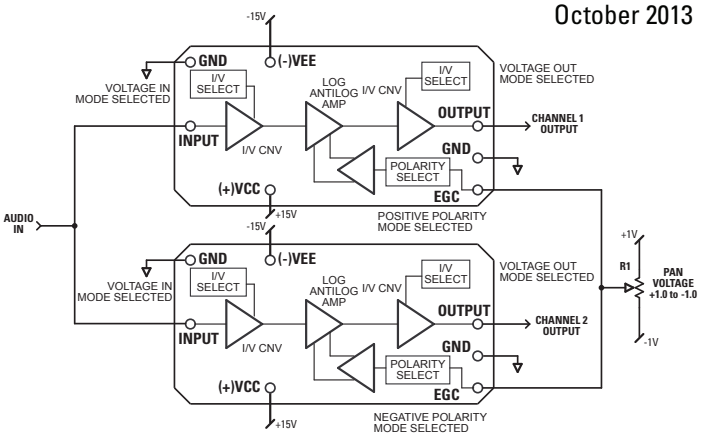

FIGURE 1. Basic topolgy for a two channel panner.

The gain of 2.5 provides approximately 50dB attenuation at the extreme ends of the pan pot travel. The gain could be increased or decreased depending on the application and designers needs. With the pot at the full negative direction, U2's output goes positive and clamps at 0V (unity gain for CHANNEL 1) and U2 will be at -2.5V (-50dB attenuation). Conversely, with the pot at full positive direction U2's output will go negative (attenuation for CHANNEL 1) and U1 will be at 0V (unity gain for CHANNEL 2).

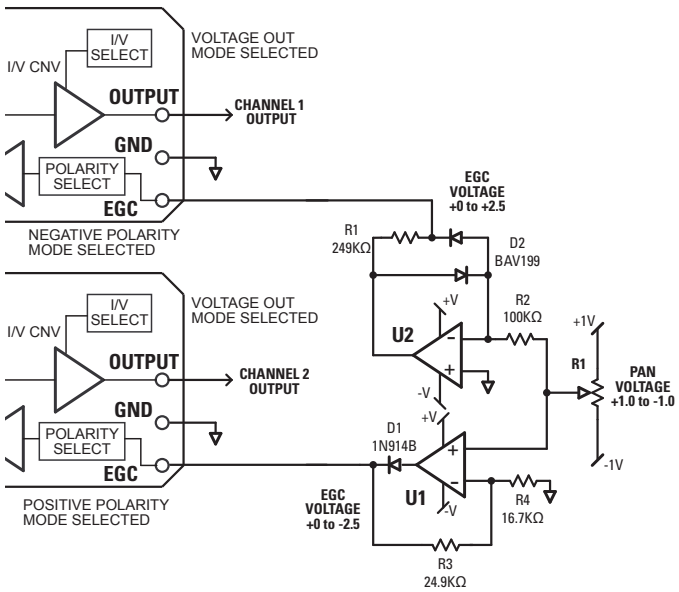

FIGURE 2. Clamp at unity circuit for a two channel panner.

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Constant Power Panning Application:

To achieve a constant power sum of the two output channels a standard stereo or mixing board panning circuit is required to have unity gain at each extreme of control (pot) travel. Additionally both channels should have -3dB gain from each output with the pan-pot at center position. (Equal power at each output.) "Digital pots" introduce significant amounts of zipper noise and have limited adjust ability. Short of adding a motor to a logarithmic taper potentiometer, automating a mechanical pot can be a daunting task in itself.

The intent is to yield a constant power sum of the two channels as the pan pot is swept. The response to achieve this correctly is close to a logarithmic taper. For a constant power sum pan pot control this would require a sin versus cosine taper response.

The circuit shown in FIGURE 3 illustrates how a precision electronic pan circuit can be implemented. The sine-cosine law of the control is achieved by a nonlinear circuit with two gain break points. U2a and U2b are the control voltage buffers for the Sonic Imagery Labs Model 312A VCA-EGC modules (U5 and U6). One VCA is driven with its EGC port set as inverting while the other is configured as non-inverting. This allows a single polarity control signal to increase the gain of one VCA while decreasing the gain of the other. U1a and U1b are used for breakpoint generation.

U2a scales and offsets the 0-5 V pan control signal so that at zero volts, U5's gain is 0db, and as the control voltage increases, the gain is reduced. U2b performs the same scaling, but R10 offsets the control voltage signal so that U6 VCA is essentially off at a control voltage of zero, but increases to a gain of 0db when the control voltage is 5 volts.

U1b is the breakpoint generator. U1a scales and offsets the 0-5 volt pan control voltage to approximately ± 0.6 volts, as well as inverting the polarity. It is easiest to analyze the breakpoint circuitry by examining one half of the circuit at a time. While the 0-5 volt pan control signal is below 2.5 volts, the output of U1b is negative, and D1a is off. Since the inverting input of U1b and the inverting input of U2a are both at zero volts, there is no current thru R5 and R11, and the output of U2a is purely a function of the 0-5 volt pan control signal via R12 and R13.

As the 0-5 volt pan control signal goes above 2.5 volts, the output of U1b goes positive, D1a conducts, and the breakpoint generator begins to affect the output of U2a. While the output of U1a is significantly more positive than ~0.5 volts, the gain of U1b is two, and its effect on the EGC port of the VCA is to approximately double the slope of the control signal. As the output of U1a continues to approach ~0.6 volts, D2a begins to turn on, and the gain of U1b begins to increase rapidly. This results in the second breakpoint.

The operation of the other half of the circuit is the same, but all of the breakpoints occur below 2.5 volts at the input. Additionally, summing the output of an additional differential output op-amp at the inverting inputs of U2a and U2b, a designer can simply add an independent fader / volume control port.

The graph shown in FIGURE 4, shows the gain of the channel 1 and 2 outputs which correspond to U5 and U6 VCA's as a function of pan control signal input.

For real world applications, the designer should generate a stable and accurate negative reference for the negative offsets. (R10 and R3). Additionally, to eliminate the potential for instability, the usual precautions apply: use a low noise, wide band amplifier for the pan control port buffer, minimize noise modulation into the EGC ports of the VCAs', and bypass supplies of the op-amps.

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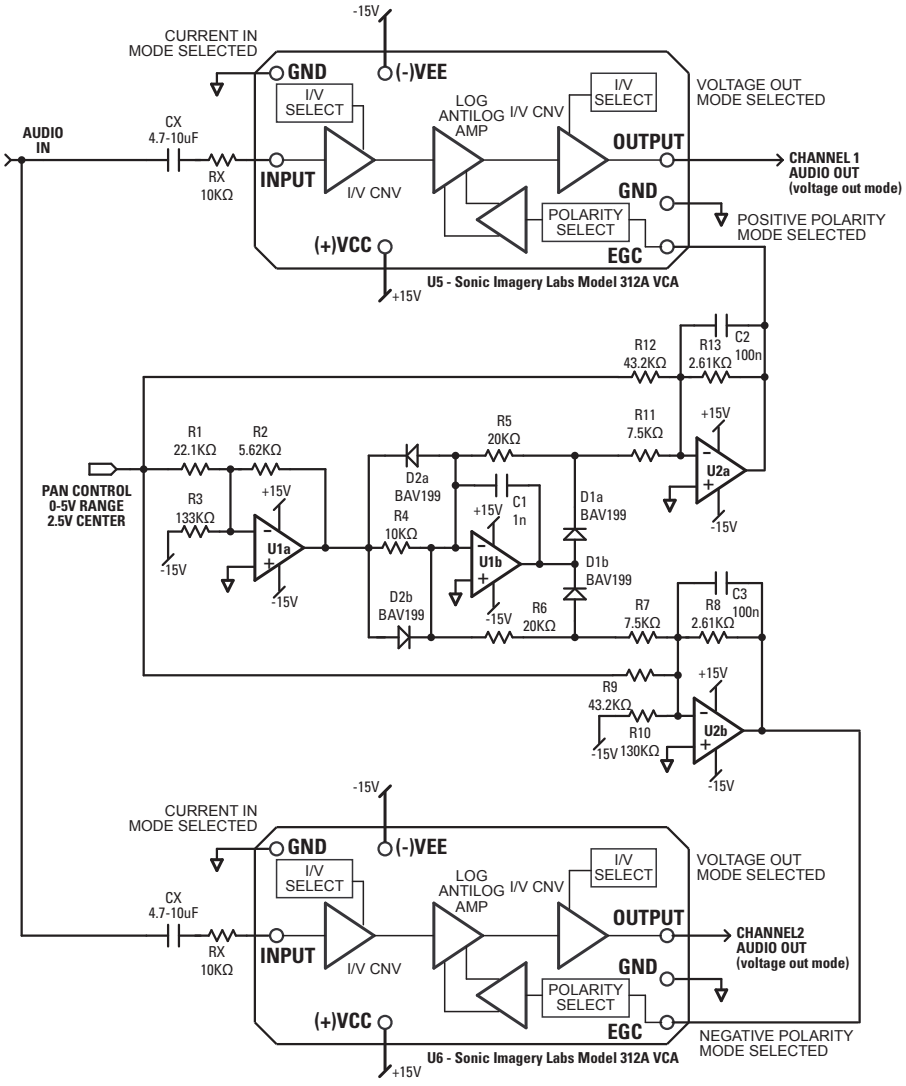

FIGURE 3. Constant Power Sum Pan circuit for a two channel panner.

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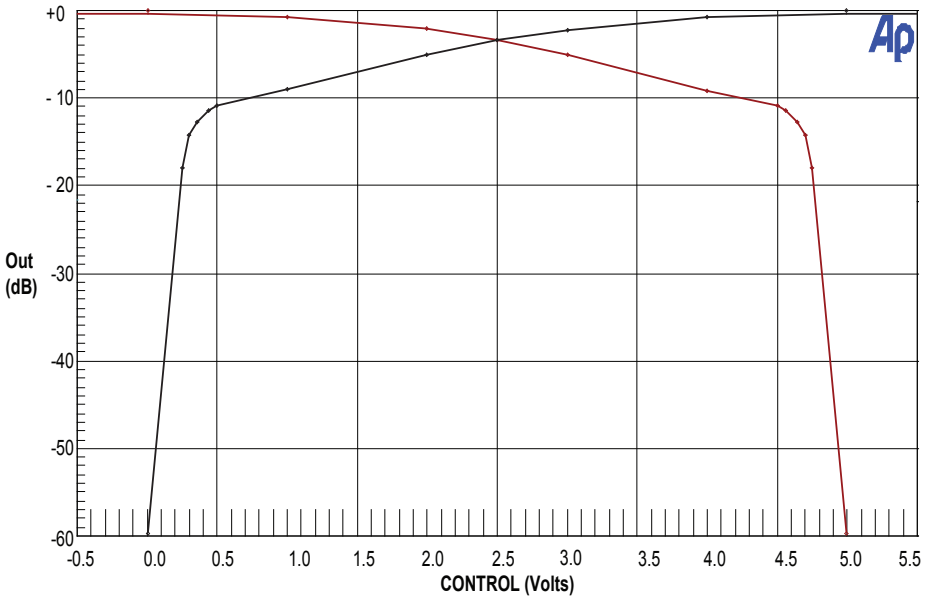

FIGURE 4. Channel 1, Channel 2 gain as a funtion of control circuit illustrated in FIGURE 3.

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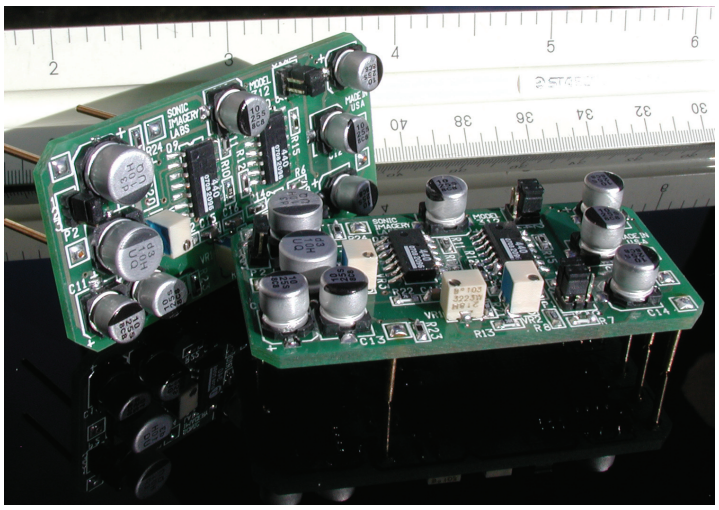
Model 312A Discrete Voltage Controlled Amplifier Module

PRODUCT BRIEF

The Model 312A voltage controlled amplifier is a high-performance voltage controlled amplifier or electronic gain control (VCA-EGC) designed for audio or instrumentation applications where low distortion, low noise, low control-voltage feed through and exceptional gain control characteristics are of primary importance. The 312A approaches immeasurably small intermodulation and total harmonic distortion independent of gain, input, or output levels. The 312A has been designed using precision matched pair discrete SMD component technology, resulting in outstanding performance, high reliability, temperature stability and wide dynamic range. It is pinned out for industry compatibility.



The gain versus control voltage characteristics of the 312A are an exponential function (20db/volt) allowing the designer to easily and accurately program the gain in decibels. The all discrete VCA core boasts a gain-bandwidth product of better than 50Mhz, resulting in full audio bandwidth at 60dB of gain without slew rate distortion error.

The Model 312A can be shunt jumper configured to be a current in-current-out, voltage in-current-out device, voltage in-voltage-out or current in-voltage-out device. Additionally, the gain control input of the Model 312A can be shunt jumper configured to allow either positive or negative (inverting or non-inverting) gain control voltage to control the device.

The Model 312A VCA-EGC module can be utilized in voltage controlled automation consoles, filters, gates, compressors, oscillators, test instrumentation, radio AGCs and any other signal modifier circuits where voltage controlled amplification is required.

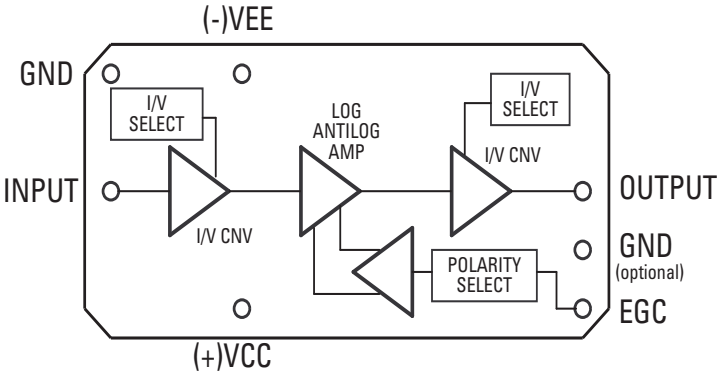
Features:

- Ultra Low Total Harmonic Distortion, 0.005 THD+N @ 1kHz
- Ultra Low Noise <4.4nV/rtHz typical
- Wide Dynamic Range >100dB typical
- Wide Gain Range
- Simplified Standard Retro/Upgrade Footprint
- Operates over ±12V to ±16V supply rails
- Low Control-Voltage Feedthrough
- I-In, I-Out or V-In, V-Out Selectable Operation
- Selectable Gain Control Operation (pos/neg)
- Particular emphasis on audio performance
- Designed, assembled and produced in the USA
- 3 Year Warranty

Applications:

- Voltage Controlled Faders and Panners
- Voltage Controlled Filters and Equalizers
- Gates and Expanders
- Compressors and Limiters
- Voltage Controlled Oscillators
- Automatic Gain Control (AGC)

Connection Diagram (Top View)



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Model 995FET-Ticha Discrete Operational Amplifier

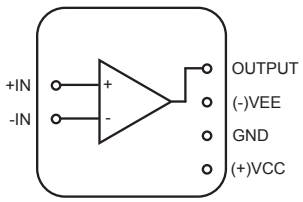
PRODUCT BRIEF

The 995FET-Ticha is a high performance discrete operational amplifier designed for professional audio applications and areas where ultra-low noise and extremely low distortion is required. A true matched monolithic FET input stage is incorporated to provide superior sound quality and speed for exceptional audio performance. This, in combination with high output drive capability and excellent dc performance, allows use in a wide variety of demanding applications. In addition, the 995FET's wide output swing, allows increased headroom, making it ideal for use in any audio circuit.

The 995FET-Ticha can be operated from ±10V to ±24V power supplies. Input cascode circuitry provides excellent common-mode rejection and maintains low input bias current over its wide input voltage range, minimizing distortion. The 995FET discrete op amp is unity-gain stable and provides excellent dynamic behavior over a wide range of load conditions.

The all-discrete design uses an ultra-precision differential matched FET pair specifically designed to meet the requirements of ultra-low noise and ultra-low THD audio systems. In addition to the enhanced input stage, the 995FET uses high performance temperature stable current sources, dual matched pair temperature stable current mirrors and an enhanced low distortion high performance Class-A output driver stage.

Connection Diagram:



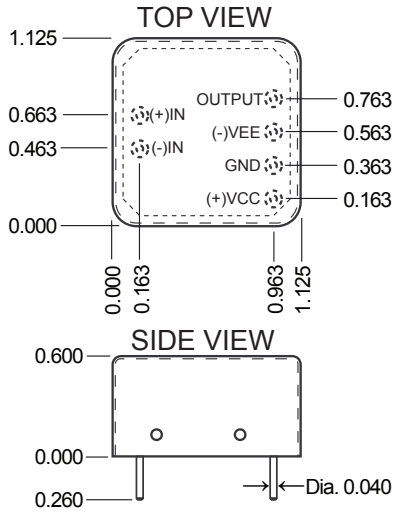
Features:

- Ultra Low Total Harmonic Distortion, 0.00055 THD+N @ 1kHz
- Ultra Low Noise, 1.1nV/rtHz
- High Current Output Drive (250mA into 75 ohms)
- +26.5dBu Output Levels (into 600 ohms)
- Standard Gain Block Footprint
- Operates over ±10V to ±24V supply rails
- Lower output offset voltage than existing counterparts
- Lower input leakage current than existing counterparts
- Class A Output Drive
- Particular emphasis on audio performance
- Designed, assembled and produced in the USA
- 3 Year Warranty

Applications:

- High Input Impedance Line Amplifiers and Drivers
- High Input Impedance Buffer
- Active Filters and Equalizers
- Summing/Mixer Amplifiers
- High Performance High Input Impedance Microphone Preamplifiers
- High Performance A/D front end preamplifier
- High Performance D/A back-end driver

Package Diagram:



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Model 990Enh-Ticha Discrete Operational Amplifier

PRODUCT BRIEF

The 990Enh-Ticha is a high performance discrete operational amplifier designed for professional audio applications and areas where ultra-low noise and low distortion is required. It was designed as an enhanced specification upgrade replacement. The pinouts conform to the 990/2520 package, allowing direct replacement. See **Table 1.** below for additional discrete opamps which can be upgraded. Complete specifications datasheet for the 990Enh-Ticha can be downloaded from www.sonicimagerylabs.com

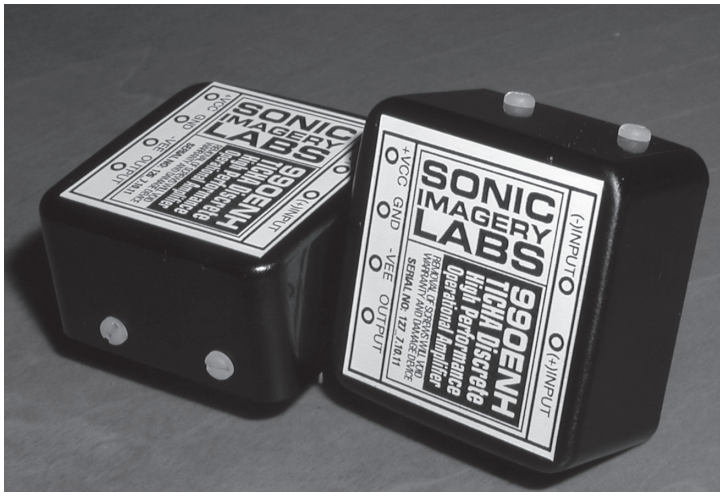
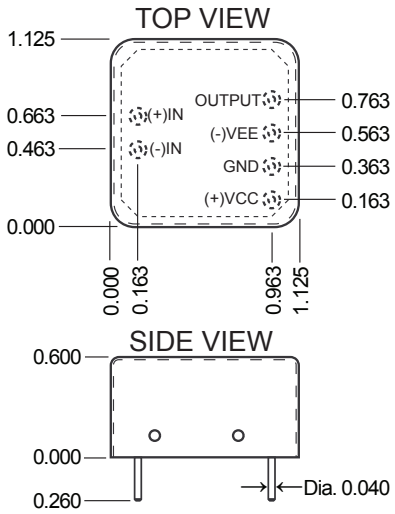


Table 1. Compatible Upgrade Table

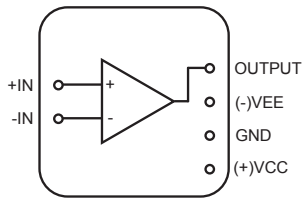
The Model 990Enh-Ticha can be used to upgrade and/or replace these obsolete or end-of-life discrete operational amplifiers. This list is by no means comprehensive. Contact Sonic Imagery Labs for additional information.

Jensen JE990 Series
Automated Processes Inc. API-2520, 2520H, 2525
John Hardy Co. 990A-990C
FiveFish Studios DOA series
Avedis Audio 1122
Seventh Circle Audio SC10, SC25, SC99
Sound Skulptor SK25, SK99, SK47
Yamaha NE80100, NE80200
TOA PC2011
ProTech Audio Model 1000
Purple Audio KDJ3, KDJ4
Modular Devices 1731, 1757
Modular Audio Products (MAP) 5000 Series, 1731 1731A
Melcor 1731
JLM Audio 99V
Inward Connections SPA690
BTI OA400
FAX Audio FA-100
Analog Devices 111

Package Diagram:



Connection Diagram:



Features:

- Ultra Low Total Harmonic Distortion, 0.00045 THD+N @ 1kHz
- Ultra Low Noise <1nV/rtHz (890pV/rtHz typical)
- High Current Output Drive (250mA into 75 ohms)
- +25dBu Output Levels (into 600 ohms)
- Standard Gain Block Footprint
- Operates over ±10V to ±24V supply rails
- Lower output offset voltage than existing counterparts
- Lower input leakage current than existing counterparts
- Particular emphasis on audio performance
- Designed, assembled and produced in the USA
- 3 Year Warranty

Applications:

- Low Impedance Line Amplifiers and Drivers
- Active Filters and Equalizers
- Summing/Mixer Amplifiers
- High Performance Microphone Preamplifiers
- High Performance A/D and D/A front end Preamplifier

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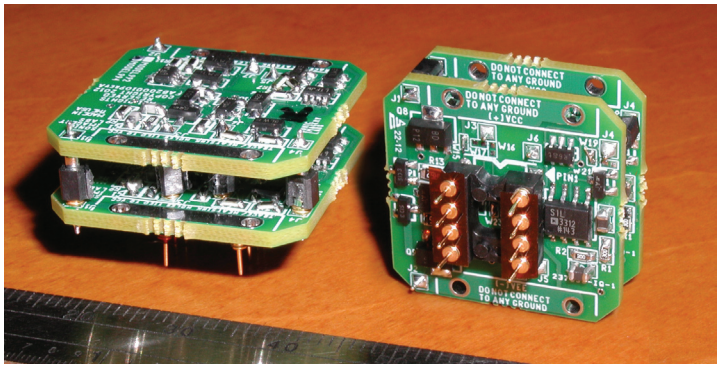
Model 994Enh-Ticha Dual Matched Discrete Operational Amplifier

PRODUCT BRIEF

The 994Enh-Ticha is a dual high performance discrete operational amplifier designed for professional audio applications and areas where ultralow noise and low distortion is required. It was designed as an enhanced upgrade replacement universal dual op-amp gain block. The pinouts conform to the standard 8 pin dual in-line monolithic IC package, allowing direct replacement.

The all-discrete SMT design utilizes an ultra-precision differential matched monolithic transistor pair specifically designed to meet the requirements of ultra-low noise and ultra-low THD audio systems. In addition to the enhanced input stage, the 994Enh-Ticha uses high performance temperature stable current sources, dual matched pair temperature stable current mirrors, dual matched pair active current loads and an enhanced low distortion Class-A output driver stage. Each amplifier is matched for noise, offset and distortion to within 0.1% of each other and both amplifiers meet or exceed published specifications over temperature and operating voltage range.

Because of the 994Enh high current drive capability, supporting circuitry impedances can be scaled down within the application circuit. This can reduce the overall system noise, without increased distortion.



The 994Enh-Ticha op amp is a true bipolar op amp and behaves as such. It does not require a flying ground lead as do other designs on the market. Because the 994Enh is a true op amp, It can also be operated in single supply applications as long as external biasing has been implimented correctly.

See Also:

Sonic Imagery Labs **Model 992Enh-Ticha**- Discrete Op Amp DIP8
Sonic Imagery Labs **Model 995FET-Ticha**- FET Discrete Op Amp 990/2520
Sonic Imagery Labs **Model 990Enh-Ticha**- Discrete Op Amp 990/2520

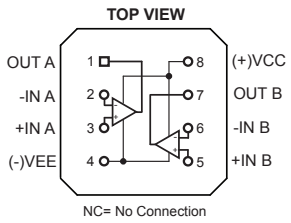
Features:

- Ultra Low Total Harmonic Distortion, 0.00045 THD+N @ 1kHz
- Ultra Low Noise 0.89nV/rtHz typical
- High Current Output Drive (100mA into 600 ohms @ ±24V supply)
- +26dBu Output Levels (into 600 ohms @ ±24V supply)
- Standard 8 pin DIP Footprint
- Operates over ±7.5V to ±24V supply rails
- Lower output offset voltage than existing counterparts
- Lower input leakage current than existing counterparts
- Particular emphasis on audio performance
- Designed, assembled and produced in the USA
- 3 Year Warranty

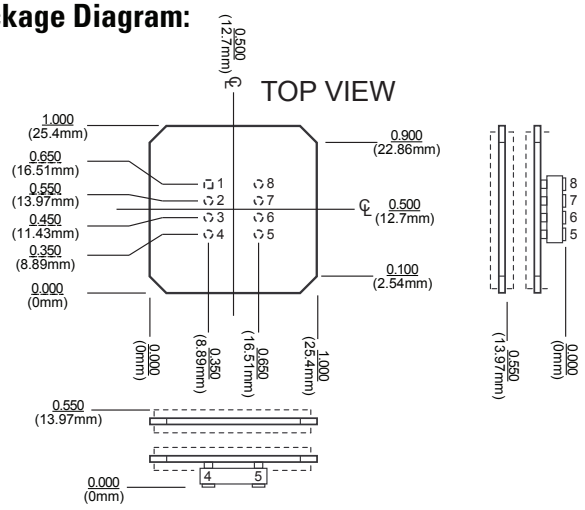
Applications:

- Low Impedance Line Amplifiers and Drivers
- Active Filters and Equalizers
- Summing/Mixer Amplifiers
- High Performance Microphone Preamplifiers
- High Performance A/D and D/A front end Preamplifier
- High Performance D/A I-V convertors
- High Current Buffer Amplifier

Connection Diagram:



Package Diagram:



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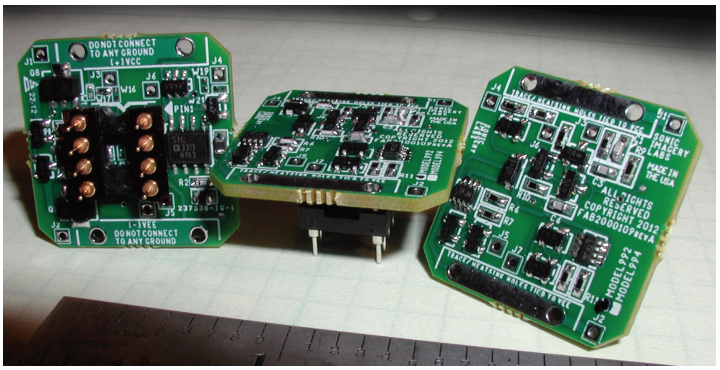
Model 992Enh-Ticha
Discrete Operational Amplifier

PRODUCT BRIEF

The 992Enh is a high performance discrete operational amplifier designed for professional audio applications and areas where ultralow noise and low distortion is required. It was designed as an enhanced upgrade replacement universal op-amp gain block. The pinouts conform to the standard 8 pin dual in-line monolithic IC package, allowing direct replacement.

The all-discrete SMT design utilizes an ultra-precision differential matched monolithic transistor pair specifically designed to meet the requirements of ultra-low noise and ultra-low THD audio systems. In addition to the enhanced input stage, the 992Enh-Ticha uses high performance temperature stable constant current sources, dual matched pair temperature stable current mirrors, dual matched pair active current loads and an enhanced low distortion Class-A output driver stage.

Because of the 992Enh high current drive capability, supporting circuitry impedances can be scaled down within the application circuit. This can reduce the overall system noise, without increased distortion.



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See Also:
Sonic Imagery Labs **Model 994Enh-Ticha**- Dual Discrete Op Amp DIP8
Sonic Imagery Labs **Model 995FET-Ticha**- FET Discrete Op Amp 990/2520
Sonic Imagery Labs **Model 990Enh-Ticha**- Discrete Op Amp 990/2520

Features:
- Ultra Low Total Harmonic Distortion, 0.00045 THD+N @ 1kHz
- Ultra Low Noise 0.89nV/rtHz typical
- High Current Output Drive (100mA into 600 ohms @ ±24V supply)
- +26dBu Output Levels (into 600 ohms @ ±24V supply)
- Standard 8 pin DIP Footprint
- Operates over ±7.5V to ±24V supply rails
- Lower output offset voltage than existing counterparts
- Lower input leakage current than existing counterparts
- Particular emphasis on audio performance
- Designed, assembled and produced in the USA
- 3 Year Warranty

Applications:
- Low Impedance Line Amplifiers and Drivers
- Active Filters and Equalizers
- Summing/Mixer Amplifiers
- High Performance Microphone Preamplifiers
- High Performance A/D and D/A front end Preamplifier
- High Performance D/A I-V convertors
- High Current Buffer Amplifier

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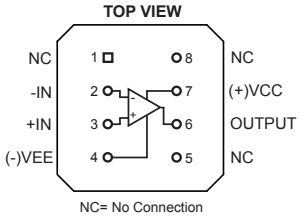

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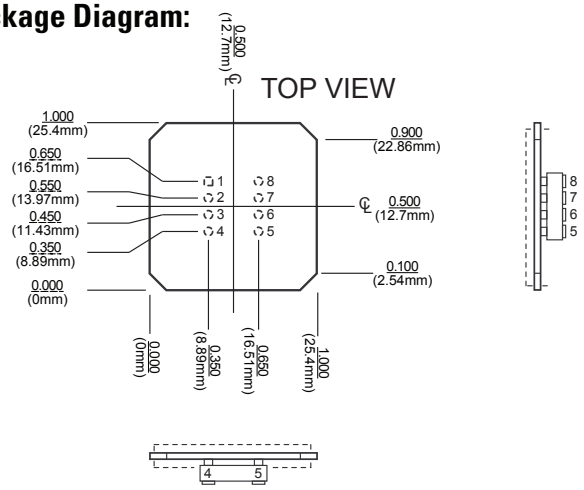

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