Interfacing Sonic Imagery Labs Discrete OpAmps to DACs

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MARCH 2012

The 990Enh-Ticha and the 995FET-Ticha are high performance discrete operational amplifiers designed for professional audio applications and areas where ultra-low noise, low distortion and high output drive current is required. The design of the current to voltage convertor for audio DACs is very important in order to actually realize the high S/N ratio of which 16 and 24bit DACS are capable. This is because noise and distortion that are generated in this area are not negligible. Dynamic performance such as the gain bandwidth, settling time, and slew rate of the operational amplifier affects the audio dynamic performance of the I/V section.

The Sonic Imagery Labs 99X-Ticha series discrete opamp is the heart of the current to voltage convertor amplifier shown in Figure 1. The analog output of a DAC may be a voltage or a current. In either case it may be important to know the output impedance. If the voltage output is buffered, the output impedance will be low. Both current outputs and unbuffered voltage outputs of DACs will be high(er) impedance and may well have a reactive component specified as well as a purely resistive one. Some DAC architectures have output structures where the output impedance is a function of the digital code on the DAC—this should be clearly noted on the data sheet.

In theory, current outputs should be connected to zero ohms at ground potential. In real life they will work with non-zero impedances and voltages. Just how much deviation they will tolerate is defined under the DACs data sheet heading "compliance" and this specification should be heeded when terminating current-output DACs.

Most DACs suitable for high performance audio, have current outputs which are designed to drive source and load-terminated amplifiers as shown in this application note. For instance, a 10-mA current output DAC can develop 0.5 V across a 49.9-Ω load. Modern current output DACs usually have differential outputs, to achieve high common-mode rejection and reduce the even-order distortion products. Fullscale output currents in the range of 2 mA to 30 mA are common. In many cases, both true and complementary current outputs are available. The differential outputs can drive the opamp directly. This method will often give better distortion performance at high frequencies than simply taking the output signal directly from one of the DAC current outputs and grounding the other.

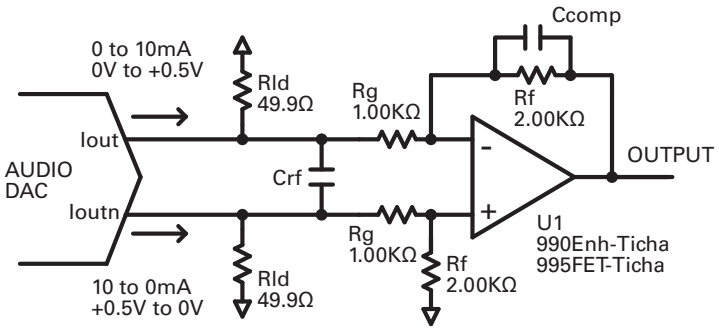

Figure 1. Differential DC Coupled Output Using the Sonic Imagery Labs 99X-Ticha Series discrete Op Amp

A Sonic Imagery Labs 99X-Ticha discrete opamp connected as a differential to single-ended converter can be used to obtain a single-ended output when frequency response to dc is required. In Figure 1 the 99X-Ticha op amp is used to achieve high bandwidth and low distortion.

The current output DAC drives balanced 49.9-Ω resistive loads, thereby developing an out-of-phase voltage of 0 to +0.5 V at each output. This technique is used in lieu of a direct I/V conversion to prevent fast slewing DAC currents from overloading the amplifier and introducing distortion. The Sonic Imagery Labs 99X-Ticha discrete opamp in Figure 1 is configured for a gain of 2, to develop a final single-ended ground-referenced output voltage of 2-V p-p. Rf and Rg set ac voltage gain of the op-amp. Whereas, Rf/Rg=Av, 20logAv=Gain_dB. Other values can be chosen depending on gain desired. Note that because the output signal swings above and below ground, a dual-supply op amp is required.

The Crf capacitor forms a differential filter with the equivalent 100-Ω differential output impedance. This filter reduces any slew-induced distortion of the op amp, and the optimum cutoff frequency of the filter is determined empirically to give the best overall distortion performance. A starting point value can be calculated; $f_{3db} = 1/2\pi \bullet 100\,\Omega \bullet Crf$.

The Ccomp capacitor provides phase-lead compensation and sets the upper frequency -3dB bandwidth cutoff point. In addition, the differential amplifiers Crf combined with Ccomp properly selected provide a low-pass filter function.

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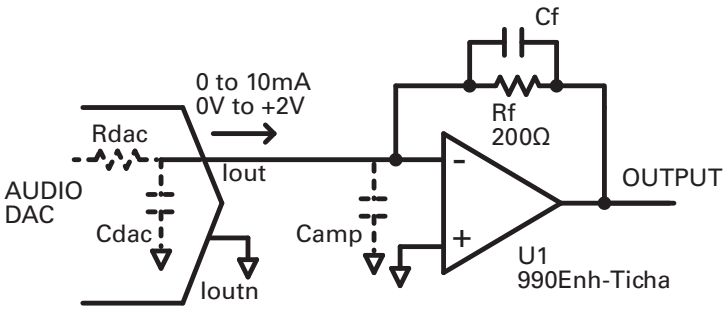

Figure 2. Single-Ended I/V 990Enh-Ticha Op Amp Interface

Single-ended current-to-voltage conversion is easily performed using a single op amp as an I/V converter, as shown in Figure 2. The Sonic Imagery Labs 990Enh-Ticha series discrete opamp is perfectly suited for this application. The 10-mA full scale DAC current from the DAC develops a 0 to +2 V output voltage across the 200-Ω RF resistor.

Driving the virtual ground of the Sonic Imagery Labs 990Enh-Ticha op amp minimizes any distortion due to nonlinearity in the DAC output impedance. In fact, most high resolution DACs of this type are factory trimmed using an I/V converter.

It should be recalled, however, that using the single-ended output of the DAC in this manner will cause degradation in the common-mode rejection and increased second-order distortion products, compared to a differential operating mode.

The CF feedback capacitor should be optimized for best pulse response in the circuit. The following equations should only be used as starting points and confirmation of pulse response should be confirmed.

If Rdac= Rf, make Cf= Rdac * (Cdac+Camp)/Rf

If Rdac > Rf, make Cf= $\sqrt{}$ (Cdac+Camp/2π * Rf * fu opamp)

Camp for 990Enh opamp is approximately 23pf

Low leakage film capacitors with high-quality dielectric (polypropylene or COG-NPO ceramic) should be used. Low-ESR power supply bypass capacitors with a small resistance in series with the power supply rails are essential for low noise operation. Precision low noise 1% metal film resistors should always be used. Since these components can represent high impedance, lead length and trace lengths should be minimized. Assembled circuits and PCB's should be carefully cleaned of flux residue to prevent leakage paths or other spurious behavior.

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Model 995FET-Ticha Discrete OpAmp Application Note AN-12

Richard Ian Doporto
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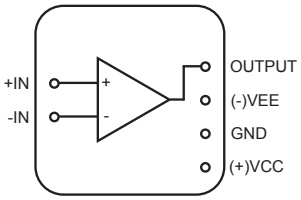
MARCH 2012

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 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 995FETs 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:



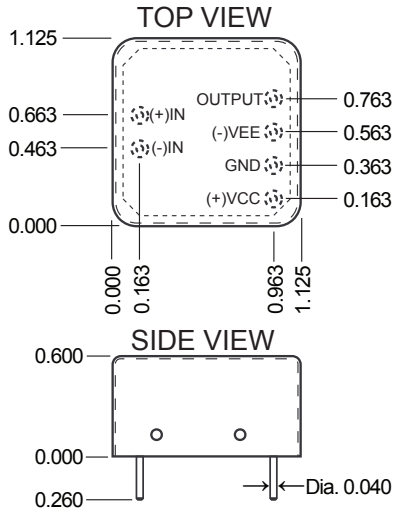
Features:

- Ultra Low Total Harmonic Distortion, <0.00045 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 OpAmp Application Note AN-12

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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

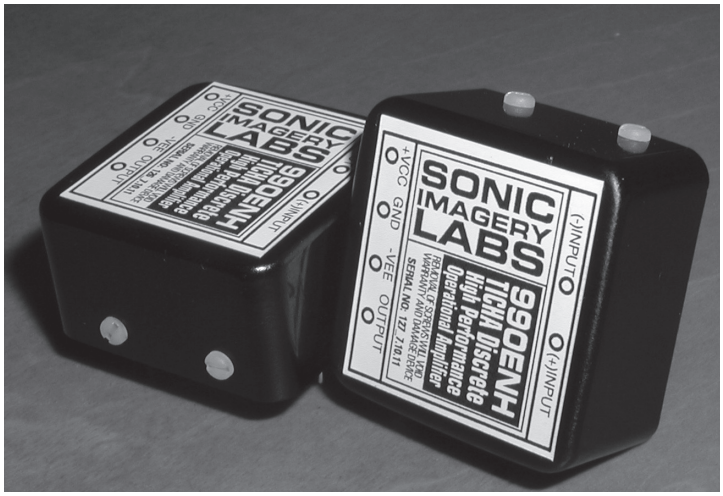
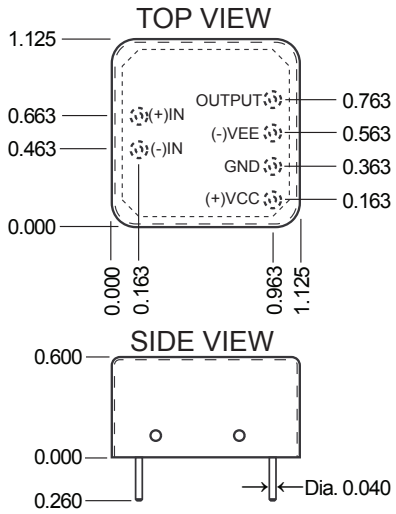


Table 1. Compatible Upgrade Table

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:



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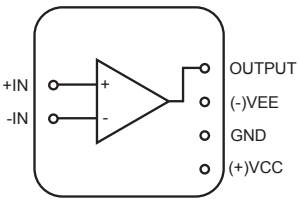

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