



## Model 990Enh-Ticha Discrete OpAmp Application Note AN-11

Richard Ian Doport  
Design Engineer  
JANUARY 2012

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.

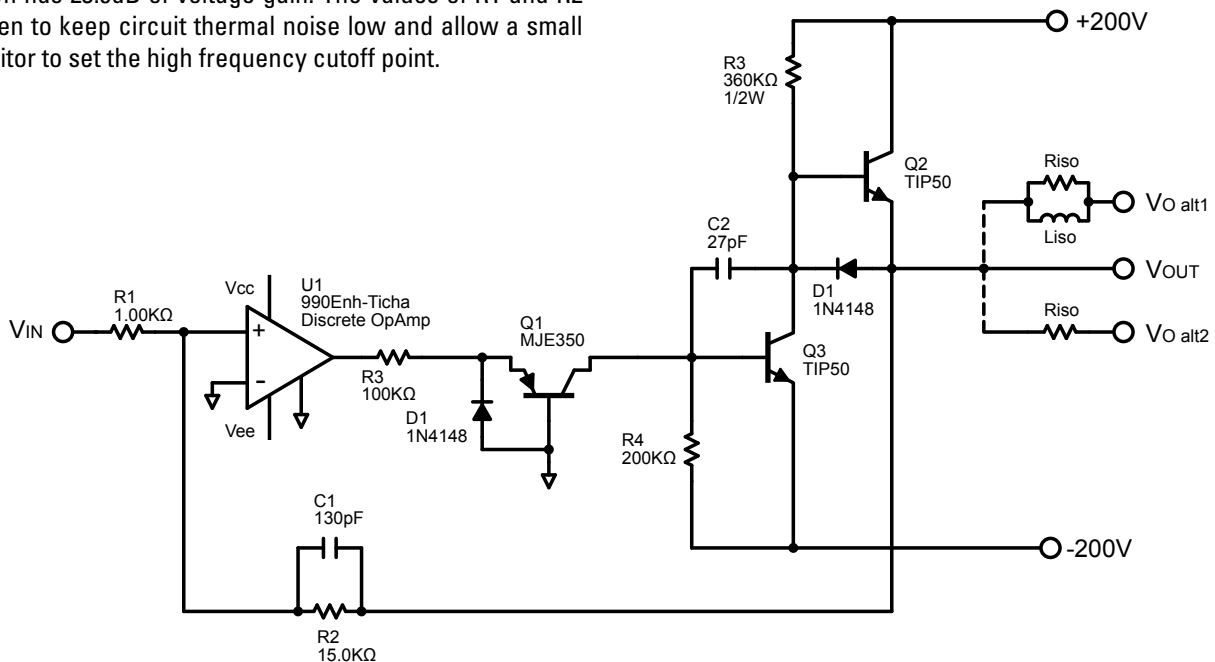
The 990Enh-Ticha discrete opamp is the heart of the high voltage front-end amplifier shown in **Figure 1** below. This application was designed to drive a valve based output stage running on high voltage supply rails. The reader is encouraged to examine **Sonic Imagery Labs AN-10** to gain insight on how one can also provide Vcc and Vee to the 990Enh-Ticha discrete opamp from high voltage supply rails without the need to add additional low voltage power supplies to support front-end circuitry.

The output of the 990Enh-Ticha discrete operational amplifier (U1) creates a proportional current drive through the common base connected transistor Q1 to the base of Q3. Transistor Q3 forms a Class A amplifier with bias resistor R5, and transistor Q2 is simply an emitter follower used for output current boost. Overall voltage gain of this stage is set by the ratios of R2 divided by R1. In this case, the circuit shown has 23.5dB of voltage gain. The values of R1 and R2 were chosen to keep circuit thermal noise low and allow a small value capacitor to set the high frequency cutoff point.

C1 and C2 set the the upper bandwidth 3dB point at 175kHz. There will be 1-2 dB of peaking at 100-120kHz but careful tweaking of C1 and C2 could flatten this out. C1 and C2 should have high working voltages. Polypropylene or COG/NPO dielectric type capacitors are recommended since they have low voltage coefficients, good dissipation factors, and low dielectric absorption.

Riso/Liso or simply Riso may be necessary to prevent oscillation caused by the capacitive loading on the output of the amplifier.

Power supply decoupling capacitors are not shown in the circuit diagram for operational clarity. Low ESR electrolytic capacitors on the supply rails to ground are highly recommended. The 990Enh-Ticha opamp has 0.1uF capacitors at its VCC and VEE pins internally.



**Figure 1. ±200 Volt Low Noise Operational Amplifier**

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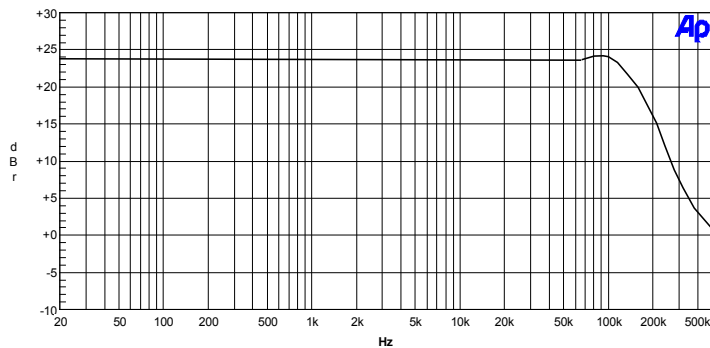


Figure 2. Frequency response of the  $\pm 200$  Volt Low Noise Operational Amplifier

Frequency and phase response plots are shown in Figures 2. and 3. Additional consideration should be given to the closed loop frequency response of U1 if the designer is to radically increase or decrease the overall gain of this stage.

A final note. The voltages used in this circuit are high and can be quite dangerous. A certain level of situational awareness should be exercised at all times to maintain personal safety and prevent damage to components and test equipment.

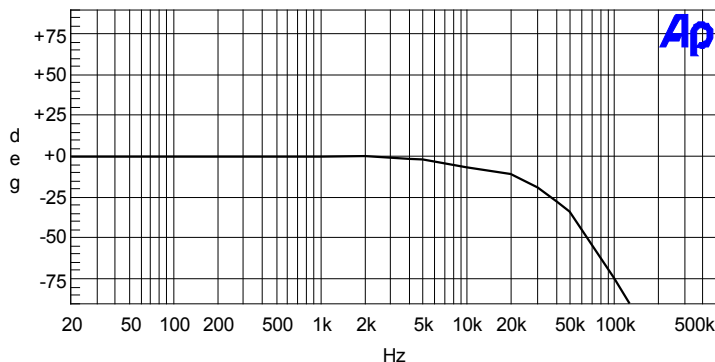


Figure 3. Phase response of the  $\pm 200$  Volt Low Noise Operational Amplifier

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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](http://www.sonicimagerylabs.com)



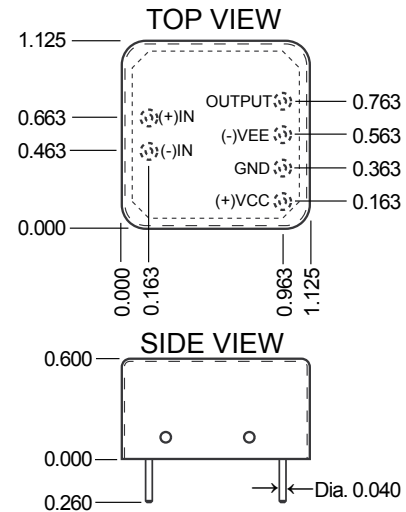
### Table 1. Compatible Upgrade Table

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.

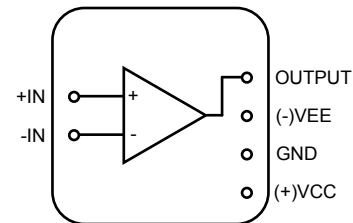
- Jensen JE990 Series
- Automated Processes Inc. API-2520, 2520H, 2525
- John Hardy Co. 990A-990C
- FiveFish Studios DOA series
- Avedis Audio 1122
- Seventh Circle Audio SC10, SC25, SC99
- Sound Skulptor SK25, SK99, SK47
- Yamaha NE80100, NE80200
- TOA PC2011
- ProTech Audio Model 1000
- Purple Audio 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

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Specifications subject to change without notice  
**REV B, 3.10.15**

### Package Diagram:



### Connection Diagram:



### Features:

- Ultra Low Total Harmonic Distortion, 0.00055 THD+N @ 1kHz
- Ultra Low Noise 0.89nV/rtHz
- High Current Output Drive (250mA peak)
- +25dBu Output Levels (into 600 ohms)
- Standard Gain Block Footprint
- Operates over  $\pm 7.5V$  to  $\pm 24V$  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