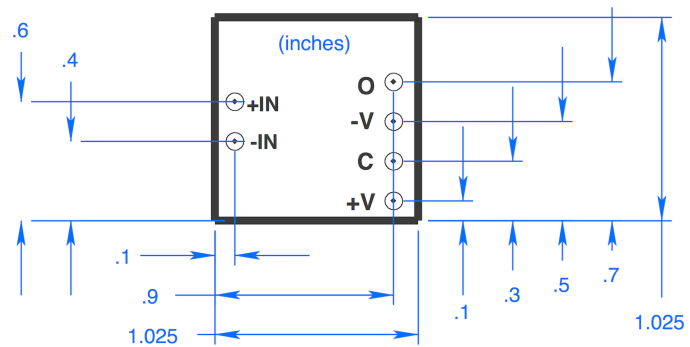
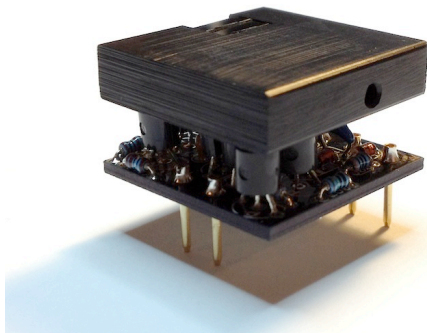


# BA512

Discrete Operational  
Amplifier

Eisen Audio  
Version 1.2  
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**BA512** is a discrete operational amplifier introduced by Rupert Neve™ & Company Ltd. in 1976, as a drop-in replacement for its BA440 serial feedback amplifier. We have re-engineered the BA512 for use in a variety of third-party applications, conforming to a more popular form factor and pinout. Specifications are as follows.

\* *Serial feedback amplifiers, also known as quasi-operational amplifiers, lack a true differential input, instead utilizing the emitter of a lone input device as an inverting input.*

**BA512 Electrical Characteristics** at  $V_{cc} = +/-15V$ ,  $T_{amb} = +20^{\circ}C$

Symbol	Parameter	Typical	Unit
Vio	Input offset voltage, $R_s = 600\Omega$	3	mV
Voo	Output offset voltage	30	mV
Iib	Input bias current	3	$\mu A$
En	Equivalent input noise, $f = 1kHz$ , $R_s = 25\Omega$	-147	dBu
CMRR	Common mode rejection ratio, $R_s = 600\Omega$	70	dB
Icc	Supply current, no load	+/- 16	mA
Icc	Supply current, 150 $\Omega$ load	+/- 36	mA
Vopp	Output voltage swing, $R_L = 150\Omega$	+/- 14	V
Zi	Input Impedance	460	k $\Omega$
Ro	Output resistance	3	$\Omega$
SR	Slew rate $V_i = +/- 1V$ , $R_L = 600\Omega$ , $C_L = 100pf$ , unity gain	10	V/ $\mu S$
AOL	Open-loop voltage gain $V_i = 100mV$ , $R_L = 150\Omega$ , $f = 10kHz$	72	dB
GBP	Gain bandwidth product $V_i = +/- 10mV$ , $R_L = 150\Omega$ , $C_L = 100pf$ , $f = 40kHz$	2	MHz

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## Architecture

The BA512 discrete operational amplifier is composed of the following three stages:

1. A differential Long-Tail Pair input stage, with Constant Current Source biased for  $\sim 2.2\text{mA}$  and emitter degeneration resistors, feeds [2.] from the loaded collector of its non-inverting input device.
2. A Voltage Amplification Stage, with its own Constant Current Source biased for  $\sim 4.3\text{mA}$ , provides level-shifting and feeds [3.] as follows. Single pole miller compensation is employed.
3. A voltage source of two times  $V_{be}$  comprises the VAS collector load, passing the same constant  $\sim 4.3\text{mA}$  branch current. From either side of this "base spreader" a complementary pair of medium power output transistors is connected, yielding class A/B push-pull operation.

## Power Supply

The BA512 is optimized for bi-polar DC power supplies of  $\pm 12$  to 20V, with the typical offering of  $\pm 16\text{VDC}$  being ideal. It will draw approximately  $\pm 16\text{mA}$  of DC current under idle conditions. [Note: The BA512 can easily drive AC coupled output loads presenting a nominal impedance of  $140\Omega$  or greater, but will draw more DC supply current, accordingly.]

When tested with  $\pm 24\text{V}$  power supplies, the BA512 shows an increase in idle current to  $\pm 22\text{mA}$ , and output offset voltage increases to  $100\text{mV}$ . With the exception of a greater  $V_{op}$ , audio performance shows no significant changes.

On-board  $0.01\mu\text{F}$  bypass capacitors make local power supply decoupling unnecessary. However, we recommend best practice for decoupling a discrete op amp, e.g. local reservoir capacitors of  $22\mu\text{F}$  or greater, in parallel with  $0.1\mu\text{F}$  film bypass capacitors.

## Feedback and Stabilization

Typical frequency response for non-inverting applications is flat from  $10\text{Hz}$  to  $100\text{kHz}$ . Low value capacitors (e.g.  $100\text{pF}$ ) at any junction (i.e. power bypass, output load, series feedback, input shunt) will not significantly alter this high-frequency response, and are not necessary for stability, so long as the BA512 is operated within application guidelines from  $0$  to  $50\text{dB}$  of voltage gain.

## Application Hints

The BA512 maintains a DC offset of  $\sim 3\text{mV}$  at its non-inverting input, depending on source resistance. While this amount is negligible in most circumstances, the following configuration considerations must be made:

1. Input transformers having a secondary winding DCR of less than  $200\Omega$ , and/or unusually thin and sensitive coil wire, should either not be DC coupled to the BA512, or have a resistor of  $\sim 1\text{k}\Omega$  inserted in series with the BA512 input.
2. When configured for variable gain, or any fixed gain greater than 1, an adequately sized (i.e. for  $1/(2\pi \cdot R \cdot C) = \text{better than } -3\text{dB @ } 10\text{Hz}$ ) electrolytic blocking capacitor should connect the shunt feedback resistor to ground. BA512 voltage gain thus occurs only in the AC domain, avoiding an increase in DC offset. This also protects a sensitive gain adjust potentiometer from DC damage.

Assuming an AC coupled source, the BA512 requires an input bias shunt resistor (ideally 47kΩ or less, when gain greater than 40dB) connected directly from its non-inverting input to ground. Depending on the value, this resistor may provide an excess of secondary termination for input transformer ratios greater than 1:8.

Although gains of 54dB or more are possible, the extremes of high and low frequency response will suffer from decreased bandwidth and increased distortion. Recommended gains should be limited to ~50dB, which is the case when using the preferred negative feedback resistor values of 15kΩ series and 43Ω shunt.

For inverting configurations (e.g. active combining amplifier), tie the BA512 non-inverting input to ground, source the inverting input from a resistance of 47kΩ or less, and adjust the feedback resistor for a gain of 1 or greater. There will be DC offset of approximately -30mV at the inverting input, so you may wish to place a blocking capacitor in this node.

Complete circuitry for popular microphone preamplifier configurations is demonstrated in the figures 1 and 2 below.

Fig. 1

BA512 as drop-in replacement for 2520  
in generic 512 mic preamp circuit.  
No component changes are necessary.

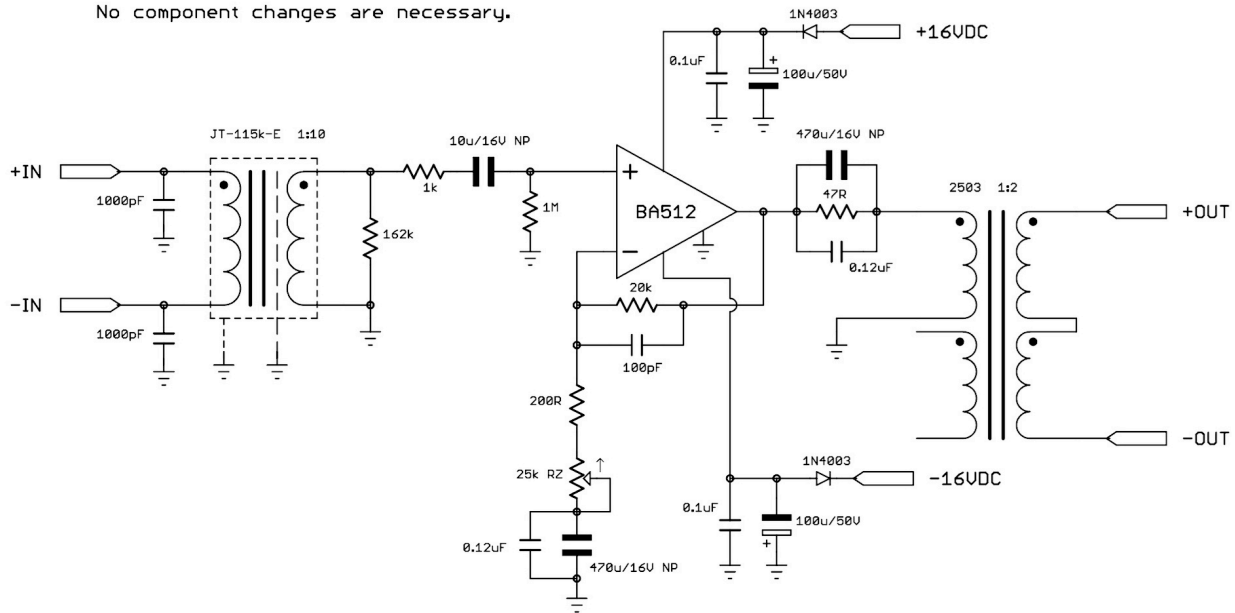


Fig. 2

BA512 as minimal "Neve-style" mic preamp circuit.

