WELBORNE
Laboratories

MINI - AMP

Class-A Discrete Operational Amplifier Design

Assembly Manual

INTRODUCTION

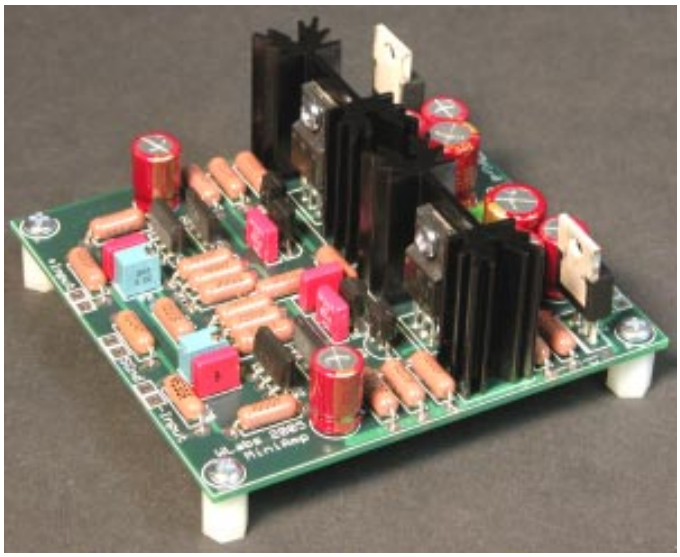
The MINI AMP, originally designed by Erno Borbely, is a very high quality discrete operational amplifier (op-amp). Why design a discrete op-amp? While state of the art op-amps are very good quality and many boast great specifications, they still possess both technical and sonic limitations due to their monolithic nature. A discrete op-amp allows the designer to hand pick each and every component for both performance and sonic enhancements. Transistors can be selected for low noise, low capacitance and quick response time. High quality film caps can be applied as well as super low noise resistors. Higher voltage rails can be incorporated allowing for greater voltage swings and beefier output devices can be selected to operate in full class-A mode providing both excellent linearity and high current drive.

The MINI AMP has very good open-loop linearity at high frequencies, is extremely stable and boasts some very impressive specs like; an input noise voltage below 1uV, a slew rate greater than 100V/usec and a THD figure that's so low most test equipment can't measure it! S/N ratio greater than 110dB and a frequency response of 5Hz to 110khz +/-0.5dB. But most importantly, this is the BEST op-amp you'll ever hear, with loads of low level detail, impressive bass, a nice neutral but warm midrange and rounded out with a very smooth and extended top end.

Did we say this is an op-amp? Yes, we did.... and therefore you can use the MINI AMP like you would any other audio op-amp. For example; it can be configured for inverted or non-inverted outputs; balanced or single-ended operation; balanced to singled-ended converter; it can be set up for unity gain, gain of 10, 20, etc. The MINI AMP can be used as a simple linestage stage, a buffer amp, an I/V converter in your DAC, a summing amplifier for a mixer, active crossover filters and more.

Our MINI AMP features a JFET input circuit incorporating matched devices and a bipolar output stage operating in full class-A mode. Its input impedance is approximately 1 Mohm and its output impedance is less than 100 ohms. It requires a power supply capable of providing + 24 and - 24 volts DC @ 0.5 amperes.

We have packaged the MINI AMP as a mono amplifier, i.e. two boards are required for stereo operation and four boards are required for balanced stereo operation. The MINI AMP is packaged on a silkscreened 4-layer printed circuit board measuring a very petit 3"(76mm) by 3"(76(mm). This 4-layer board features a dual ground-plane design providing a very low impedance return path and superior shielding for added immunity from noise. Each unit also includes on-board voltage regulation circuitry. These regulators can be bypassed if using a power supply with a more elaborate regulation scheme. The kit includes all components necessary for proper operation and all components are individually packaged in plastic bags and marked with their reference designators.



As usual, with all Welborne Labs kits, we offer several options including: with or without the on-board voltage regulators, kit or assembled, and upgrade options featuring the super low noise Caddock foil resistors, ELNA Cerafine capacitors and the low noise Linear Technology voltage regulators. We suggest you mate a couple of the MINI AMPs with our PS5 dual-mono power supply kit and you will end up with a killer linestage that'll enhance ANY system.... tube or solidstate!

WORDS OF CAUTION

Always keep in mind that you are the manufacturer of this amplifier. The final appearance of this unit and its sound quality will largerly depend upon the care taken during the assembly of this kit. We recommend that your work surface be padded, clean of debris and kept clean during assembly. Don't create antennas out of the hookup wire by making big loops and arches. Keep all wiring neat, lead lengths short and routed close to the chassis plate. Believe us when we say "neat wiring sounds mo better".

Always remember the nature of the equipment that you are working on. It contains high voltages and can cause serious personal injury. Always make sure that capacitors are completely discharged before handling or soldering the internal components. Never disconnect the power cord, or remove tubes while the unit is powered on.

TOOLS REQUIRED FOR ASSEMBLY

Soldering Iron
Solder
Solder Wick™ or Solder-Removing Device
Pliers
Wire Strippers
Screw Drivers
Volt/Ohm Meter that can precisely measure millivolts
Jumper Wires

ASSEMBLY

Begin by checking the parts you received against the parts list below. Notify us immediately if any parts are missing.

MINI - AMP Parts List (parts for one amplifier only)

R1, R3, R4, R7, R8,		
R9, R15, R16, R17	100 ohms	1/2 watt Dale metal film resistors
R2	1.0 Mohms	1/2 watt Dale metal film resistors(sets input impedance)
R5, R13	1.5 kohms	1/2 watt Dale metal film resistors
R6, R14	22.1 kohms	1/2 watt Dale metal film resistors
R10	0 ohms	use jumper wire
R11, R12	75 ohms	1/2 watt Dale metal film resistors
R18	10 kohms	1/2 watt Dale metal film resistors
R19	2 kohms	1/2 watt Dale metal film resistors
R20	953 ohms	1/2 watt Dale metal film resistors (for 10dB gain)
	1k or 2k	(for Converter/Balanced operation)
	not used	(for unity gain buffer)
R21	45 ohms	1/2 watt Dale metal film resistors
R22, R24	121 ohms	1/2 watt Dale metal film resistors
R23, R25	2.21 kohms	1/2 watt Dale metal film resistors
P1	50ohms	Multi-turn Cermet trim pot
P2	200ohms	Multi-turn Cermet trim pot
C1	47pf/630Vx 2	WIMA film capacitor
C2, C3, C4, C5	0.1uf/63V	WIMA film capacitor
C6, C7	150uf/35V	Nichicon low impedance electrolytic
C8	33pf/630V	WIMA film capacitor
C9	1500pf/63V	WIMA film capacitor
C10, C11, C12, C13	15uf/63V	Nichicon low impedance electrolytic
C14, C15		
Q1A,Q1B	2SK170	Matched Pair
Q2A,Q2B	2SJ74	Matched Pair
Q3A,Q3B	2SC2705	Matched Pair
Q5A,Q5B	2SA1145	Matched Pair
Q7	MPSA06	
Q8	2SA1837	
Q9	MPSA56	
Q10	2SC4793	
Q11	LM317T	Adj. positive regulator
Q12	LM337T	Adj. negative regulator
D1, D2	LM336Z-2.5	Voltage Reference
HS		Heatsink for Q8 and Q10 w/hardware
ST		Circuit board standoffs
PCB		Printed Circuit Board

ASSEMBLY

Assembly is relatively straightforward and consists of mounting the components on the circuit board and soldering the component leads on the bottom side of the board.

It is recommmended that you build and test the onboard voltage regulators first before proceeding with the remaining assembly steps. If you purchased the MINI AMP without the regulators you can skip this step but first solder jumper wires in the two locations indicated below. One end of the jumper wire is soldered to the pad next to Q11 (Q12) and the other end of the jumper is soldered to R22's (R24) pad. If your kit is supplied with the voltage regulators Q11 and Q12, do not install these jumpers.

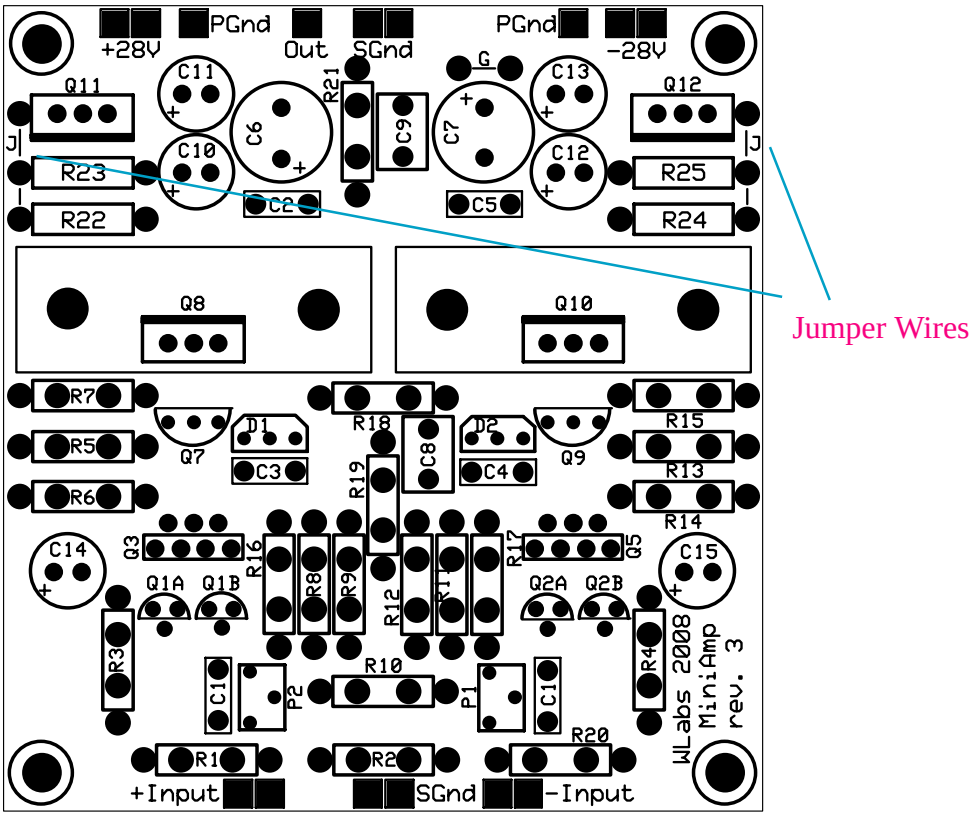
Begin by soldering the following components to the circuit board. Follow the placement guide shown below:

Resistors R22, R23, R24, R25.
Capacitors C2, C5
Capacitors C6, C7, C10, C11, C12, C13 (be sure to install these capacitors with the correct polarity. The band on the capacitor body is closest to the negative lead.)
Voltage regulators Q11 and Q12 (note proper orientation: the white band on the circuit board diagram represents the metal tab on the regulator)

Once these components are installed, you should test them for proper operation before proceeding. Connect the power supply you intend to use with this amp (or a bench power supply). Connect the positive voltage to the circuit board pad marked (+28V) and the power supply ground to the pad marked (PGnd). Apply power and using a volt meter measure the outside lead of resistor R22 with respect to to PGnd. You should measure approximately 24 volts.

Connect the negative voltage to the circuit board pad marked (-28V) and the power supply ground to the pad marked (PGnd). Apply power and using a volt meter measure the outside lead of resistor R24 with respect to to PGnd. You should measure approximately -24 volts.

If these measurements are good, install and solder the remaining components.



ASSEMBLY

We recommend you install all of the resistors first, followed by the capacitors (note the polarity on the electrolytics), trim pots and then the semiconductors saving Q8 and Q10 for last. Make sure all of the components are mounted flush against the surface of the circuit board.

Using the supplied 4-40 screws, secure the heatsinks to the circuit board by inserting the screws from the bottom side of the circuit board and tightening until the heatsinks are flush against the board and there is no wobble. Then the transistors Q8 and Q10 can be mounted to the heatsinks using the screws and nuts and finally soldered to the board.

There is one jumper wire to be installed and its pads are located next to capacitor C7. Just a short piece of wire soldered and connecting these two pads is all that is required.

Once these components are installed, you will need to test them for proper operation and make a few adjustments. However, before applying power, we highly recommend you inspect your solder joints under a bright light and using a magnifying glass. Make sure all of the pads a filled and make sure there are no solder bridges between adjacent pads.

Connect the power supply you intend to use with this amp (or a bench power supply). Connect the positive voltage to the circuit board pad marked (+28V) and the power supply ground to the pad marked (PGnd). Connect the negative voltage to the circuit board pad marked (-28V).

Using jumper clips, connect the pad marked (+Input) to the pad marked (SGnd) and connect the pad marked (-Input) also to (SGnd).

P1 and P2 are 12-turn trim pots. Using a small screwdriver, turn the setscrew counterclockwise approximately 12 turns and then back clockwise for 6 turns. Do this for both P1 and P2.

Apply power to the circuit board (+/-28 Volts) and using a volt meter measure “across” resistor R5. Adjust P2 until you measure approximately 3.5 to 3.8 volts. If this measurement is good proceed to the next step.

Connect your positive voltmeter probe the circuit board pad marked (Out) and the negative probe to (SGND). Adjust P1 until you measure zero (0) volts. We suggest you allow the amp to stay powered on for 15-20 minutes and periodically readjust the voltage to zero volts as it will initially have a tendency to drift. You most likely won’t be able to set it for exactly zero volts but as long as it is set for less than +/- 50 mV (0.050V) it will be fine.

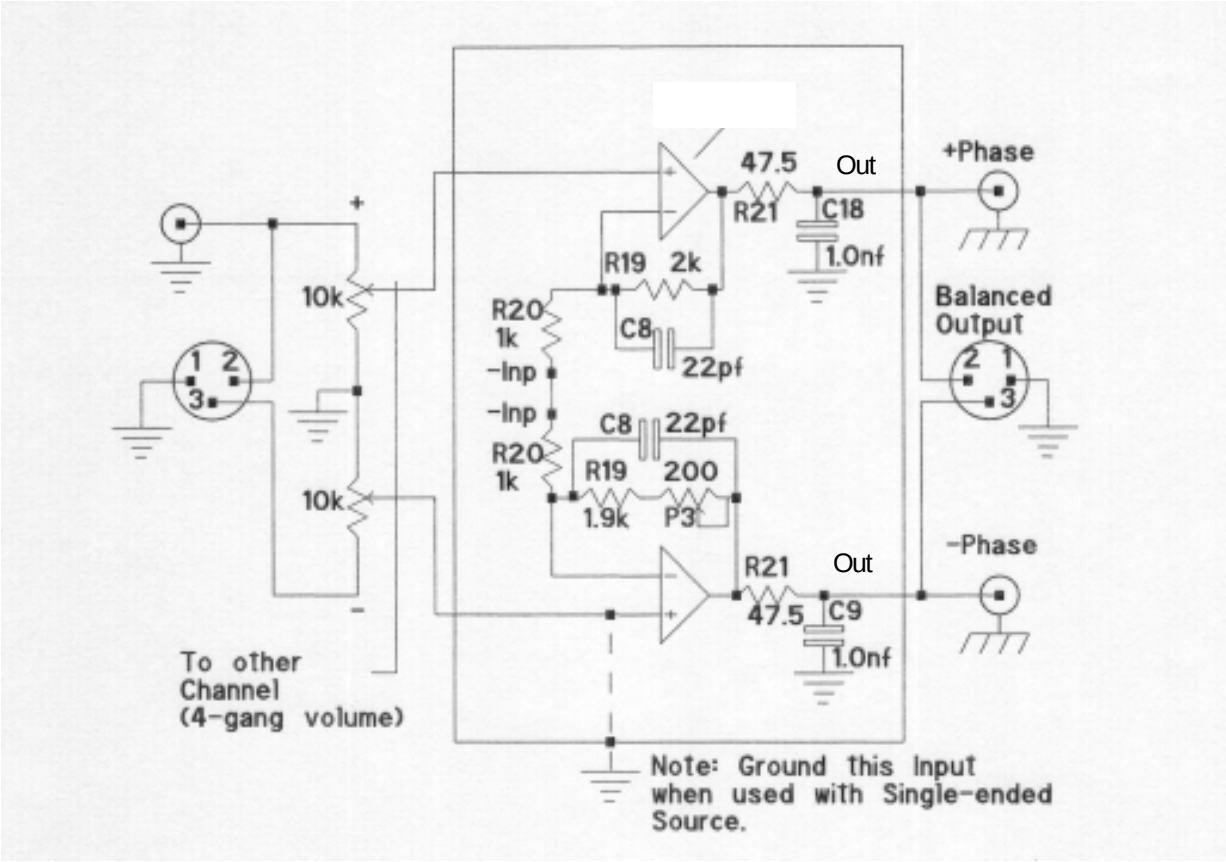
If these measurements are successful, you can now install the MINI AMP into your application.

Connections:

If the MINI AMP is used as a non-inverting lineamp, solder a jumper wire between the pads marked (-Input) and (SGnd). The (+Input) pad will be the amplifier input connections and (SGnd) will be the signal ground. The pad marked (Out), is the amplifier output connection.

Resistor values for various gain settings:
Gain of 6dB: R19 = 2kohm, R20 = 1.8kohm
Gain of 10dB: R19 = 2kohm, R20 = 953ohm
Gain of 20dB: R19 = 5.11kohm, R20 = 511ohm

If the MINI AMP is used as a unity gain (gain of 1) buffer, the pads marked (-input) are left floating, i.e. it is not connected to anything. The (+Input) pad will be the amplifier input connections and (SGnd) will be the signal ground. The pad marked (Out), is the amplifier output connection.


47.5
Out
+Phase
R21
C18
1.0nf
R19 2k
10k
R20
1k
-Inp
C8
22pf
Balanced
Output
1 2
3
2 1
3
-Inp
C8 22pf
R20
1k
R19 200
1.9k P3
10k
R21
Out
-Phase
47.5
C9
1.0nf
To other
Channel
(4-gang volume)
Note: Ground this Input
when used with Single-ended
Source.