

GLASS AUDIO

A Versatile Line Amp for Preamp, Headphone, and Power Use

Here's a do-it-yourselfer's dream in tube amp design: four operating modes, high quality, low cost, and low distortion.

By Joseph Norwood Still

This design offers two versions: a ten-tube \$160 line amplifier and an eleven-tube preamplifier/headphone amplifier/power amplifier. Either way, it is probably the most versatile stereo amplifying device ever offered to the DIY audiophile. It offers four operating modes with outstanding specifications: line amp, headphone amp, preamp, and power amp. The 10W, 0.9% distortion single-ended (SE) amp is the lowest distortion amplifier I have come across. It also has lower distortion than published tube manual push-pull amps.

The damping of the 10W amp is incredible: 2.8V across an 8Ω resistor increases to only 3.8V when the 8Ω load is removed. This is accomplished in a standard output circuit without the aid of negative feedback. It is obvious new design ideals for vacuum tubes are still with us. Behold! The magic of paralleling and low mu tubes.

Note: If operating in the 10W SE Stereo mode, you need to add two Hammond output transformers (P-T1640SE, \$93 each) from Antique Electronics to the cost.

THE CHOICE IS YOURS

The eleven-tube amplifier (**Photo 1**) uses very linear low mu, high perveance 12B4s, and a 12AT7 preamp. Five paral-

leled 12B4s are used in each channel of the stereo line amp (**Fig. 1**). In the line amplifier mode only the 12B4s are used. In the headphone/power amplifier/pre-amp mode, the 12AT7 drives the 12B4s.

The line amp and multi-mode amp do not employ negative feedback. The line amplifier frequency response is flat from 10Hz to 50kHz, distortion is less than 0.15% at 2V RMS output, and output impedance is 420Ω. The voltage gain of the 12AT7 and five paralleled 12B4s is 125.

Note: The gain of a single 12B4 is 2.4 and five paralleled 12B4s have a gain of 3.8 (cathode un-bypassed) and a gain of 5.6 (cathode bypassed). The plate current requirement of the five 12B4As is 50mA when using a plate load resistor of 3.1kΩ.

The selection of the low mu 12B4 enables this line amp to rival or surpass the performance of the most expensive commercial line amps because they use medium mu triodes. For truly superlative sonic performance a line amp requires a low mu, high linearity, high perveance tube, and the 12B4 meets this requirement. I

know of no other tube more suitable for this application. The amp is designed to outperform \$3k to \$10k commercial line amplifiers.

GENERAL INFORMATION

Great care is required when operating tubes in a parallel configuration to prevent oscillation or instability. To address this problem most resistors in the amp are carbon composition. The 3.1kΩ, 10W plate load metal-oxide resistors have 2Ω carbon composition resistors in series with the plate load resistors. The cathode resistors are 220Ω, 5W metal-oxide types.

The construction of the amp requires short leads as used in R-F circuits, and an aluminum chassis is mandatory to ensure good grounding. A ground lug between tubes 1-5 ensures short leads for the cathode resistors. The "plate stopper" 2Ω resistors are connected to a terminal strip located between tubes 2 and 3. Single 2Ω resistors are connected to the plates of tubes 2 and 3, and two series-connected 2Ω resistors are connected to plates of tubes 1 and 5, respectively. This

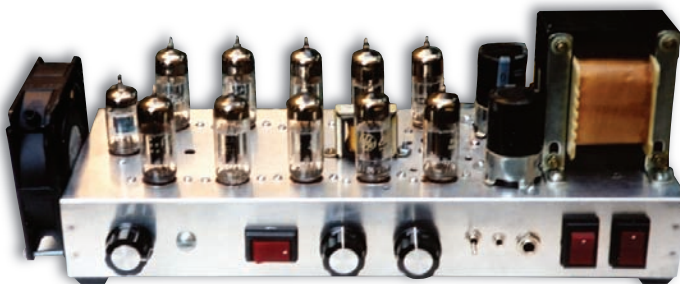


PHOTO 1:
Finished unit.

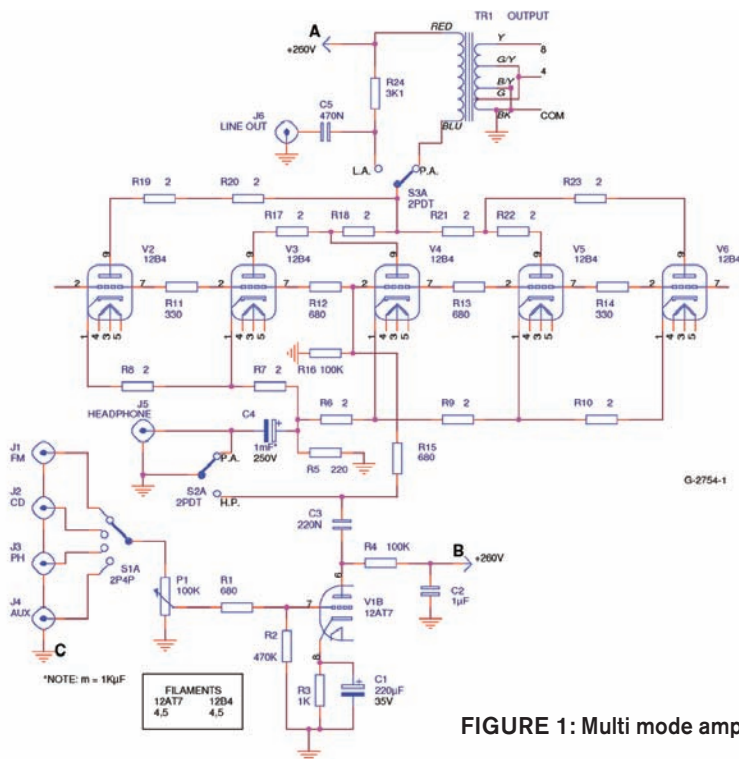


FIGURE 1: Multi mode amplifier.

ensures a carbon block exists on the long lead required to connect tubes 1 and 5 to the terminal strip and the metal-oxide plate resistors.

Figure 1 shows that much thought was given to ensure the stability of the paralleled 12B4s. The pin configuration of the 12B4 grid with pins 2 and 7 connected to the grid ensured a short path for the insertion of a “grid stopper” resistor between tube stages. Pins 1 and 9 of the tube sockets face toward the middle of the chassis ensuring short runs for the cathode, plate, and grid resistors. It is important that you do not substitute other types of resistors for the carbon composition resistors. These recommendations are required to ensure stability when using parallel tube circuits.

HEADPHONE

Application: The headphone amplifier circuit uses a 12AT7 to obtain sufficient

audio output signal to drive the five paralleled 12B4s line amp. A 0.25V RMS input signal to the 12AT7 provides an output of 9V RMS from the 12AT7-output circuit to drive the headphone 12B4s amp (maximum output). The output for the headphones is obtained from the cathodes of the five paralleled 12B4s. You operate the headphones by simply plugging the headphone jack into the chassis mounted $\frac{1}{4}$ " or 3.5mm jack. For best performance, a 55 Ω -75 Ω impedance headphone is required.

The amp has a distortion of 0.4% at 1kHz when using a 65 Ω Behringer headphone with a measured output signal of 0.8V RMS. At a normal output level of 0.6V RMS, distortion is 0.15%. The 0.6V and 0.8V RMS signals provide a very loud listening level. The frequency response is flat from 20Hz-50kHz. The distortion and frequency response measurements are made at the coil of

the headphone. I recommend the \$20 65 Ω headphones from Behringer, model HPX2000, or the \$50 Audio Technology units, model ATH-M30, from Parts Express (800-338-0531).

Switch Settings:

1. Set S2 to H.P. position.
2. Set S3 to L.A. position.

PREAMP

Application (Optional): You may choose the preamp mode if you prefer to build a power amp that uses only a single amplifying stage to drive a SE power output tube or a phase inverter stage to drive push-pull power output tubes. The preamp mode is the same as the headset mode except the output signal is obtained from the plates of the 12B4s via the 0.47 μ F capacitor. If you require direct DC coupling of the phase inverter, add a separate pair of RCA female jacks.

The +115V DC output from the 12B4s (3.1k Ω) plate load resistor is compatible with the DC grid voltage requirements of most direct-coupled phase inverters. The voltage gain of the 12AT7 and 12B4s is 125 with cathodes of the 12B4s un-bypassed and 185 with cathodes bypassed. The distortion at 10V RMS output is 0.4% at 32Hz, 0.34% at 1kHz, and 0.6% at 20kHz with 12B4s cathodes un-bypassed. The distortion at 30V RMS output is 1.2% at 32Hz, 0.65% at 1kHz, and 1.5% at 20kHz with cathodes bypassed. The frequency response is flat from 20Hz-25kHz.

Switch Settings:

1. Set S2 to H.P. position for a voltage gain of 125 or to P.A. position for a voltage gain of 185.
2. Set S3 to L.A. position.

POWER AMP

Application (Optional): To operate in the power amp mode, set the DPDT switch (S3) from the line amp mode to the power amp mode and the DPDT switch (S2) to place the negative end of the 1000 μ F capacitor at ground. The S3 switch setting connects the 3.1k Ω resistor from the plate circuit of the 12B4s to the 1200 Ω 25W Hammond output transformer of the SE-12B4s. The power output of the SE 12B4s is 10W, and the distortion at this level is 0.9% with no

SPECIFICATIONS OF LINE AMPLIFIER

1. The frequency response is flat from 10Hz to 50kHz.
2. The 100Hz, 1kHz, and 10kHz square waves are perfect.
3. The distortion at 2V RMS (cathode un-bypassed) is 0.15% -20Hz, 0.12% -1kHz, and 0.14% -20kHz.
4. The distortion at 5V RMS (cathode un-bypassed) is 0.25% -20Hz, 0.2% -1kHz, and 0.24% -20kHz.
5. The distortion at 2V RMS (cathode bypassed) is 0.25% -20Hz, 0.15% -1kHz, and 0.36% -20kHz.
6. The distortion at 5V RMS (cathode bypassed) is 0.38% -20Hz, 0.25% -1kHz, and 0.5% -20kHz.
7. Clipping occurs at 30V RMS.
8. Plate impedance is 420 Ω .
9. Voltage gain is 3.8 (cathode un-bypassed) and 5.6 (cathode bypassed).

Important: If you require only the line amplifier mode, omit switches (S2/S3), headphone jacks, and the 12AT7.

loop feedback. The frequency response is flat from 30Hz to 15kHz at 10W output level. A 0.7V RMS input voltage is required for 10W output from the power amp.

The plate current of the five 12B4s in each stereo channel is 148mA. The damping criterion of the amplifier is excellent. At 10W without feedback, the distortion at 32Hz is 2.0%, at 50Hz it is 1.2%, and is 0.9% at 1kHz, 1.6% at 5kHz, and 2.2% at 15kHz, respectively. At 5W the distortion is 0.8% at 32Hz, at 50Hz it is 0.7%, and 0.6% at 1kHz, 1.5% at 5kHz, and 1.8% at 15kHz, respectively. These specifications are outstanding for a single-ended amp, especially when op-

erating with a low plate voltage of 260V DC.

Switch Settings:

1. Set S2 to P.A. position.
2. Set S3 to P.A. position.

Note: A separate volume control is provided for R and L channels to prevent crosstalk. Switch S1 (**Fig. 2**) turns the heater supply on and off, and switch S2 turns the high voltage supply on and off. The H.V. switch S2 only operates if the heater switch is set to the on position.

Of Interest: The right and left channel amps are connected in a monaural

configuration by adding audio interstage transformer A.E.- P-T124B (10K to 90K C.T.) to the input of the amp and P-P, 120W, 1900 C.T. (A.E.-P-T1650T) to the output of the right and left channels. No changes are made to the 11-tube amp. The power output of the monaural amp is 24.5W, and the distortion at 1kHz measures 1.2%. A large percentage of the distortion is attributed to the input transformer.

The frequency response is relatively flat from 20Hz to 15kHz. Sensitivity is 0.56V RMS for 24.5W with 33k Ω resistors connected across the secondary windings of the interstage transformer. I do not recommend this amp for use as a monaural amplifier, but I thought the information here might be interesting. The 35W/60W amp presented in *aX* June 2004 is more cost effective and a more desirable choice.

AMPLIFIER PARTS LIST

Qty.	Value	Watts	Part No.	Type	Mfg.
<i>Note: Double Parts for Stereo</i>					
14	2 Ω	1/2W	30BJ500-2	Carbon Composition	M
1	220 Ω	5W	286-220	Metal Oxide	M
2	330 Ω	1/2W	30BJ500-330	Carbon Composition	M
4	680 Ω	1/2W	30BJ500-680	Carbon Composition	M
2	1.0k Ω	1W	282-1K	Metal Oxide	M
2	6.2k Ω	5W	286-6.2K	Metal Oxide	M
<i>6.2 K/5W resistors are paralleled to form 3.1 K/10W resistor.</i>					
2	100k Ω	2W	282-100K	Metal Oxide	M
1	470k Ω	1/2W	30BJ500-470K	Carbon Composition	M
1	100K, single	1/2W	31VJ501	audio taper	M
1	0.22 μ F, 400V orange drop		715P22454MD3	polypropylene	M
1	0.47 μ F, 400V orange drop		715P47454MD3	polypropylene	M
1	1.0 μ F, 250V, metalized		1430-2105	polyester	M
1	220 μ F, 35V			electrolytic	ALEL
1	1000 μ F, 400V		EC-1000	electrolytic	ALEL
<i>Note: Do not double the parts listed below:</i>					
1	6-position, dual deck, 2 pole		275-1386		RS
1	knobs, 4-per pack		275-415		RS
4	5-lug tie point, terminal strips		274-688		RS
10	RCA, female, phono jacks		161-002		M
1	5-conductor, shielded cable, 10'		P.N. 5C-S22		ALEL
1	single conductor, shielded cable, 3'		P.N.42-2371		RS
11	T-61/2 tube socket, 9-pins		P-ST9-137R	micalex	AE
10	12B4A (NOS)-Order 12				AE
<i>Note: Parts shown below are not required for line amp mode operation.</i>					
1	DPDT rocker switch		112-R13-130B	3/4" hole	M
1	DPDT toggle switch		10TF115	miniature	M
1	12AT7 (Note: I recommended you order 3)				AE
1	1,200 Ω primary-4,8,16 Ω secondary, 25W (P-T1640SE)				AE
<i>Note: Transformer is only required for SE 10W power amp.</i>					

POWER SUPPLY PARTS LIST

Qty.	Value/Designator	Part No.	Type	Mfg.
1	100k Ω (R-1) 2W	282-100K	metal oxide	M
1	4700 μ F, 25V (C1)		electrolytic	ALEL
3	470 μ F, 400V (C2-4) 1.4" dia. $\times$ 1.63"	EC-4740	electrolytic	ALEL
2	SPST switch (S1-2) 3/4" panel hole, 125V	112-R13-130A	Rocker Sw.	M
1	Bridge rectifier (BR-1) 25A, 200V	FWB-252	1 1/8in ²	ALEL
1	Bridge rectifier (BR-2) 4A, 600V	FWB-46		ALEL
1	1.0H, 300mA choke (L1)	P-T158T		AE
1	2.0H, 100mA choke (L2)	P-T154M		AE
1	115V-12.6V ct, 6A (T1)	546-166Q12 (Hammond)		M
1	115V-230V, 0.860A(T2) 100VA	553-N77U (Triad)		M
1	3AG fuse block	FHBL-3		ALEL
1	1 pack, 1A, 3AG, 5-fuses	FS-1		ALEL
1	3 connector, AC power cord	S-W206		AE
1	Chassis box, aluminum 16" $\times$ 8" $\times$ 3"	548-1444-28		M
1	1 pack Rubber feet-Self stick, rubber	64-2342		RS
1	115V AC Fan, 32 cfm, 80 $\times$ 80 $\times$ 38mm	433-3E-115B		M

CONSTRUCTION

The amplifier I originally built as a line amp on a 13.5 $\times$ 5 $\times$ 2" chassis is shown in **Photo 1**. The chassis was very crowded (wiring) and required mounting the heater transformer on the rear of the chassis. To avoid the crowding and to mount the heater transformer on the underside of the chassis and the two 25W output

12AT7& 12B4 OPERATING VOLTAGES

	Headphone	Preamp	Line amp	10W Power Amp
	12AT7	12B4	12AT7	12B4
Ebb	260V	260V	260V	260V
Eb	110V	115V	105V	220V
Ek	1.5V	12V	1.6V	33V
Ib	1.5mA	50mA	1.6mA	148mA

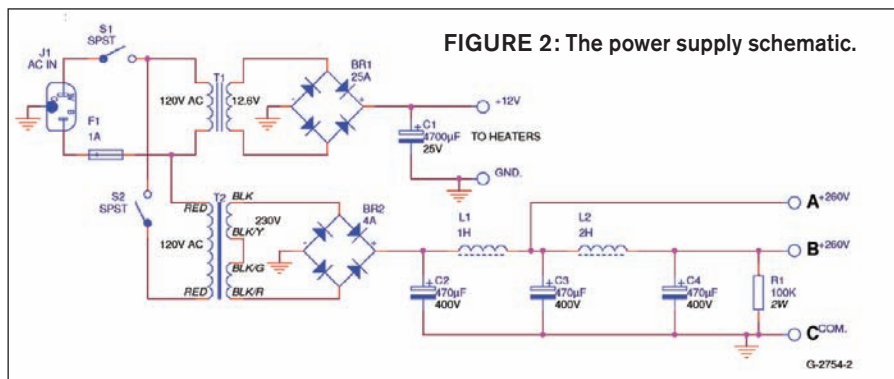
Plate Dissipation (no signal) per 12B4 tube 6.5W

Plate Dissipation (max signal) per 12B4 tube 4.5W

Efficiency of 10W Power amp 24%

with the power transformer, and position the five right-channel 12B4s and five left-channel 12B4s on either side of the 25W output transformer. Connect the four electrolytic capacitors in the power supply to

terminal strips on the underside of the chassis. Mount the fan facing the power transformer and notch out the bottom of the chassis to enable the fan to cool the electrical components on the underside of the chassis.



CONCLUSION

I believe this amplifying device is the most versatile and outstanding in technical specifications for each of its four operating modes of any device currently offered to the audiophile. The headphone and 10W SE amp modes are especially ideal for apartment dwellers. If you elect to build this amp, you will enjoy many hours of listening entertainment. *ax*

WARNING: Dangerous voltages are present, exercise extreme caution when working on the line amp and never leave the line amp upside down when children are present.

If you encounter any problems or have any questions, contact me at 302E. Joppa Rd., Apt. 1911, Towson, MD 21286.

Distributors:

RS - Radio Shack	
AEL - All Electronics	800-826-5432
AE - Antique Electronics	480-820-5411
M - Mouser Electronics	800-346-6873



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