SYNTHESIZED BASS For Your Recordings

March 2010
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Danish Pro Audio
Mike **Reviewed**

portable tube mike preamp suitable for live concerts

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By Gregory L. Charvat

Portable Tube Preamp

This battery-powered vacuum tube microphone preamplifier is ideal for recording, in addition to a range of other applications

During my undergraduate years, I would listen to a blues radio program every Wednesday night. My friend, who was the host DJ at the time, wanted to record a blues show in Chicago and later play it over the air. I volunteered to help.

As a tube audio designer, I chose not to record this concert using a boring solid-state microphone preamplifier and digital recorder. Instead, we decided to use vacuum tubes because we wanted soft clipping and a nostalgic warm tube sound to go along with the electric bluesy tones.

Unfortunately, tube devices do not lend themselves well to portable applications. In this instance, the equipment would be stuffed into a backpack and randomly located in a crowd.

COMPONENT SELECTION

The problem with portable tube electronics is the high power consumption of the filaments and generation of high voltage required for the plates. Most "portable" tube radios of the 30s-50s utilized special high-voltage batteries to supply the plate voltages and large-capacity low-voltage batteries for the filaments. I could not find these batteries at my local hardware store, so I decided to use a modest number of AA batteries to supply both the filament and the plate voltages.

I developed a high-voltage power supply to up-convert the lower voltage supplied by the AAs to a usable plate voltage. I utilized tubes that required a modest amount of filament power. The high-voltage power supply and tube circuitry would need to operate for many hours on one set of batteries in order to record a live concert without interruption.

To implement the preamplifier, I found a pair of West German 12AX7 "computer tubes" that I scavenged out of an early op amp module. These tubes require only 150mA each of filament current at 12V. Using the 12AX7s, I built a two-channel, two-stage stereo preamplifier. Each channel has adjustable attenuators in between the stages. This flexible design allows the preamp to be utilized in a broad range of applications including microphones, electric guitars, CD players, MP3 players, portable car audio, and so on. I used a pair of military surplus connector housings for the chassis, providing a rugged 1950s radio look (**Photo 1**).

OPERATION

The schematic is shown in **Fig. 1** and the parts list itemized in **Table 1**. With a battery pack consisting of eight AA batteries, 12V is supplied to the input power connector J5. 12V is fed through the main power switch SW1 then out to a power-on LED, to the filaments for V1 and V2, then on to the driver circuit for the high-voltage power supply.

The driver circuit consists of U1 and U2. **Photo 2** shows the driver circuit. U1 is a 555 timer IC that is set up to generate a 40kHz square wave. I chose this frequency so that any hum caused by the high-voltage power supply would be inaudible.

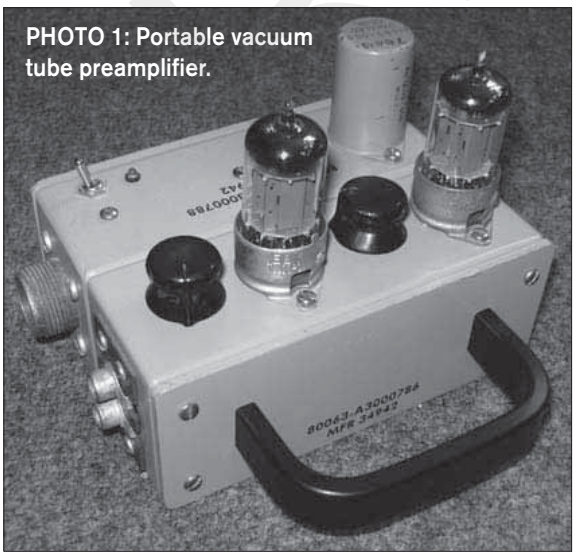

PHOTO 1: Portable vacuum tube preamplifier.

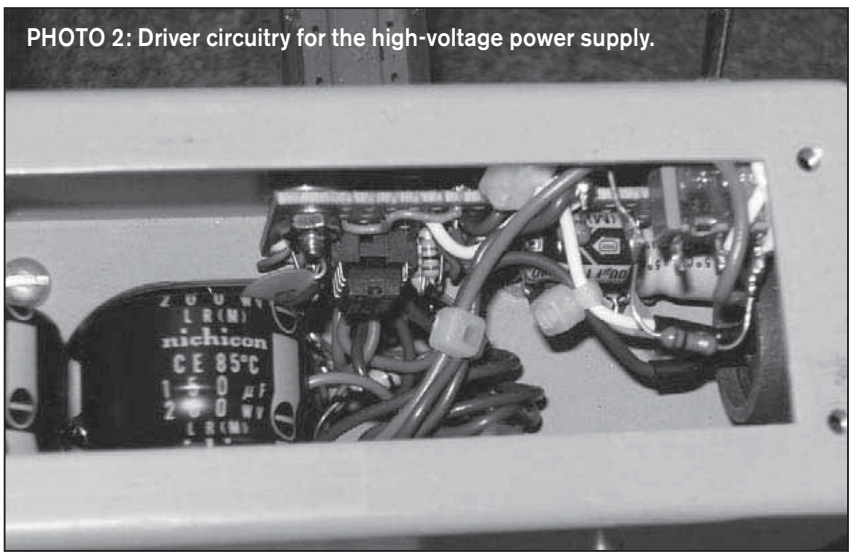

PHOTO 2: Driver circuitry for the high-voltage power supply.

Resistors R17 and R18 attenuate the output of U1 to the appropriate level to drive the input of U2, which is a TDA2822M two-channel consumer audio power amplifier IC (the second channel is not used in this circuit). U2 amplifies the square wave output of U1 driving the secondary coil of an old audio output transformer T1. T1 is a military-surplus audio output transformer, most likely from a radio receiver, whose audio output would have been single-ended.

Any similar audio output transformer scavenged out of an old radio will work in place of T1. In this case I use T1 as a step-up transformer that is fed backwards. The audio power amplifier U2 drives the secondary 8Ω side of T1. The primary side of T1 is 2500Ω.

When driven by U2, over 90V AC at 40kHz is present on the primary of T1. This is fed into the full-wave rectifier D1. The output of D1 is filtered with C10, where R20 is the bleeder resistor. The high-voltage output on the + terminal of C10 is fed into the zener diode regulator circuit consisting of R21, D2, D3, and C11. D2 and D3 drop the voltage across R21 down to approximately 64V (D1 and D2 as listed in **Table 1** will provide approximately 66V of plate voltage).

It is difficult to predict what the output of an unknown recycled audio output transformer will be when driven backwards from secondary to primary. For this reason, make sure that the voltage at the + terminal of C10 is less than 95V when the circuit warms up (if the voltage at C10 is greater than 95V, then the power dissipated across R21 will exceed 1W, burning up the resistor). You can achieve this by adjusting the value of R18; lowering the resistance provides less output voltage. It might be beneficial to replace R18 with a 500Ω trimmer potentiometer to make it easier to dial in the appropriate voltage across C10.

C11 filters the output of the zener regulator circuit, further attenuating any residual noise. This zener regulator circuit completely eliminates hum from the plate voltage feeding the plates on V1 and V2. C10 and C11 have very large values for this application, but I chose them because they were available at the time I fabricated this circuit. Any capacitors in the 10-100mF range 200V or more should work for C10 and C11 if the output of U1 is upwards of 40kHz in frequency. **Photo 3** shows the high-voltage rectifier and regulator circuit.

Low-level audio signals from microphones (or any source with a 50kΩ or undefined impedance) are fed into the ¼″ jacks J1 and J2—the inputs for the first and second channels, respectively. The input signals from J1 and J2 are fed

PHOTO 3: High-voltage power supply.

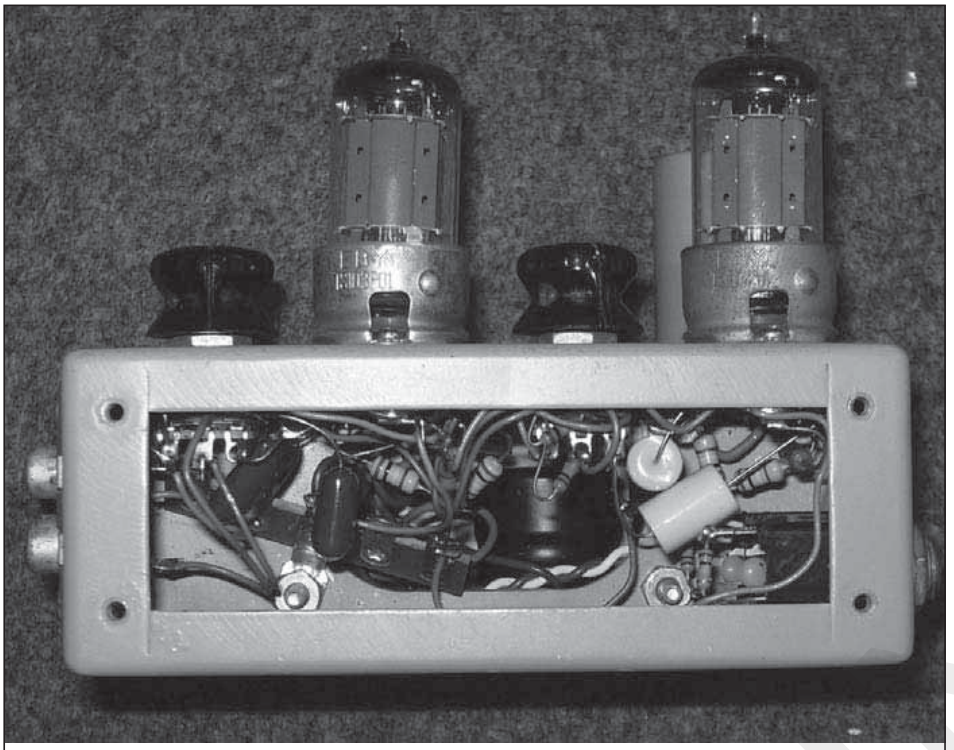

PHOTO 4: Vacuum tube preamplifier circuitry.

directly into the grids of V1. This DC coupling into the first stage reduces the overall low-frequency attenuation of the preamplifier circuit, providing excellent bass response. The inputs J1 and J2 are terminated by 100kΩ resistors R1 and R4, which set the input impedance of the preamplifier and can be changed to whatever input impedance suits your application.

V1 amplifies both channels by approximately 20 times. The output of V1 is coupled through C1 and C2 and into the 100K attenuators RV1 and RV2, which are ganged together resulting in one knob for both channels. You can think of these as the pre-gain controls, where RV3 and RV4 make up the post-gain controls. This pre- and post-gain attenuation allows you to set the clipping level of this preamplifier. **Photo 4** shows the tube circuitry.

The wipers of RV2 and RV1 are directly fed into the grids of V2, which

FIGURE 1: Schematic (all resistors ½W unless otherwise marked, all capacitors are 200V and the units are in µF).

amplifies the signals an additional 20 times (approximately). The outputs of V2 are coupled through C3 and C4 and into the post-gain control attenuators RV3 and RV4. These are ganged together resulting in one knob on the front panel. The wipers of RV3 and RV4 are fed out of the preamp through two RCA jacks J4 and J3.

START RECORDING

This preamplifier has proven itself to work exceptionally well with microphones and recording devices and electric guitars driving power amplifiers. You can also use it as the preamplifier in your stereo component system, with a radio receiver, CD player, or MP3 player as the source. In addition, the 12V power supply allows you to use this unit as the preamplifier in your car audio system, facilitating the development of vacuum tube car audio equipment.

One improvement in this design would be to develop a smaller and more efficient high-voltage power supply using a switching power supply design rather than a step-up transformer. I believe it would also be possible to further shrink the size of this preamplifier by using peanut tubes, which, unfortunately, are not easy to find. DC coupling J1 and J2 into the grids of V1 is somewhat risky if you live near a broadcast radio tower. If you encounter RFI due to grid demodulation of strong nearby radio signals, then it might be useful to place DC blocking capacitors in series with J1 and J2 and the grids of V1. If that does not work, try adding small 10s of pF range caps across the grids of V1, and, if necessary, try RF chokes in series with J1 and J2 and the grids of V1.

In summary, this preamplifier has an outstanding bass response. The clipping is soft and adjustable. The dynamic range is large due to the 64V DC plate voltage. I measured the gain with both attenuators set to 0 (no attenuation) to be 50.5dB. The preamplifier draws 500mA at 12V; therefore, with eight AA Alkaline batteries providing 1.7-3 Ah capacity (depending on the quality of battery), this preamplifier should run for 3.4-6 hours, providing enough time to record a live concert. *aX*

Table 1: Parts List

Part	Description	Supplier/Part #
C1-4	0.22µF, 250V	Mouser 146-MEF2E224K
C5	0.01µF, 50V	Mouser 140-50P5-103K-RC
C6, C8	100µF, 25V	Mouser 140-XRL25V100-RC
C7	10µF, 25V	Mouser 140-XRL25V10-RC
C9	0.1µF, 50V	Mouser 140-50Q9-104Z-RC
C10, C11	100µF, 250V	Mouser 140-XRL250V100-RC
D1	400V full-wave bridge rectifier	Mouser 512-DF04M
D2, D3	33V zener	Mouser 512-1N5257B
J1, J2	1/4 jack	Antique Electronics Supply W-SC-11
J3, J4	RCA phono jack	Antique Electronics Supply W-SC-3501FR
J5	2 pin mil connector	Mouser 97-3102-12S-3P
LED1	green LED, panel mount	Jameco 1766876
R1, R4	100kΩ, ¼W	Mouser 291-100K-RC
R2, R3, R9, R10	470Ω, ½W	Mouser 293-470-RC
R5, R6, R11, R12	100kΩ, ½W	Mouser 293-100K-RC
R7, R8	1MΩ, ¼W	Mouser 291-1M-RC
R13	1kΩ, ¼W	Mouser 291-1K-RC
R14	100Ω, ¼W	Mouser 291-100-RC
R15	2.3kΩ, ¼W	Mouser 271-2.32K-RC
R16	10kΩ, ¼W	Mouser 291-10K-RC
R17	22kΩ, ¼W	Mouser 291-22K-RC
R18	200Ω, ¼W	Mouser 291-200-RC
R19	4.7Ω, ¼W	Mouser 291-4.7-RC
R20	680kΩ, ½W	Mouser 293-680K-RC
R21	1kΩ, 1W	Mouser 294-1K-RC
RV1/RV2, RV3/RV4	100K dual potentiometer	AES R-VD100KL-PM
SW1	¼" toggle switch	Mouser 611-7108-001
T1	universal single-ended transformer	AES P-T125ASE
U1	NE555 Timer IC	Mouser 595-NE555PE4
U2	TDA2822M audio amplifier IC	Mouser 511-TDA2822M
V1, V2	12AX7	AES T-12AX7LPS-SOVT
socket for V1 & V2	9 pin tube socket	AES P-ST9-700
circuit board	proto board, cut this to size	Jameco 263207
enclosure	4.49" × 3.68" × 1.18" D, black	AES P-H1590BBBK
interconnections	terminal strips	AES P-0501H

Antique Electronics Supply (www.tubesandmore.com) Jameco (www.jameco.com) Mouser (www.mouser.com)

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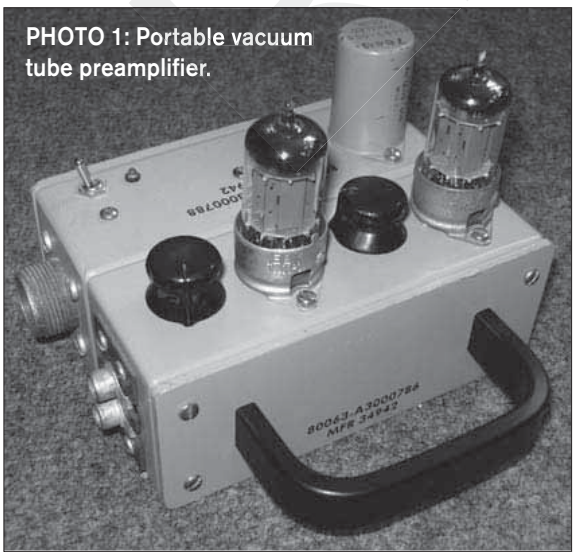
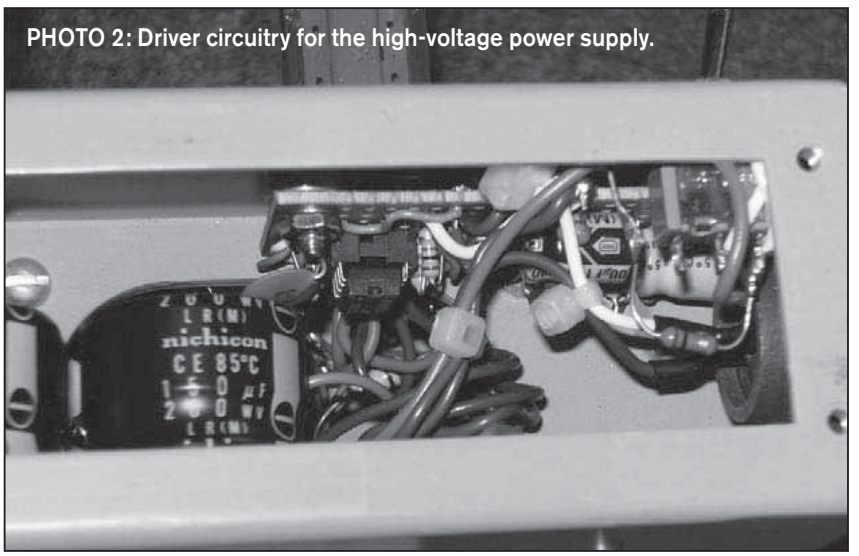


PHOTO 1: Portable vacuum tube preamplifier.



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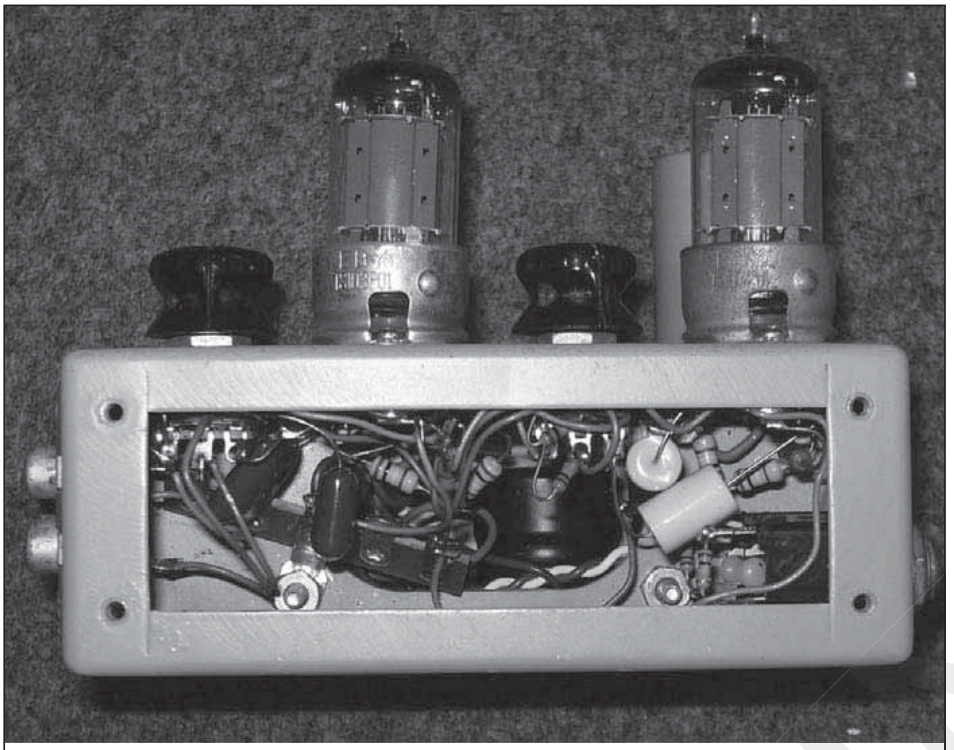

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C9	0.1µF, 50V	Mouser 140-50Q9-104Z-RC
C10, C11	100µF, 250V	Mouser 140-XRL250V100-RC
D1	400V full-wave bridge rectifier	Mouser 512-DF04M
D2, D3	33V zener	Mouser 512-1N5257B
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