BREADBOARDING

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Bring Historical Circuits to Life On Your Workbench!

AWA Universal Battery Eliminator

By Joe Stoltz and Dean Faklis

Breadboarding seeks to explore historical circuits in a manner that is accessible to new builders and veterans alike. All of our construction efforts start on wooden boards but we're not shy about using modern modeling tools and printed circuit boards if it helps more people get into the game. In this installment, we review the power supply requirements for battery-operated sets and arrive at some circuitry to help these radios entertain listeners well into the future. This work is a natural extension of our previous work on the AWA Low Power AM Transmitter,[1] which offers the user the opportunity to broadcast personalized programming over a useful range.

We arrived at a set of basic requirements for a battery eliminator that should cover nearly all vintage "A-B-C" battery-powered radios. For the "A" or filament supply, we decided on the range 1.25 to 6.0 volts DC at a continuous load up to 4.0 amperes. For "B," we chose DC voltages of 22, 45, 67, 90, 135 and 180 volts. For "C," we decided on -4.5, -9, -16.5 and -22.5 volts. Another requirement was for the battery eliminator to operate using 120 or 240 volts AC. Perhaps most importantly, we wanted to give the builder every opportunity to use junkbox parts or brand new and readily-available parts from the big distributors. In addition, we wanted to offer an integration path that did not require a bulky enclosure. Finally, a printed circuit board (PCB) approach allows rapid construction of the circuit without the need for making decisions about parts placement, wiring components together, etc. Here's a case where using a PCB can make a lot more sense than point-to-point wiring.

A thoughtful breadboarding phase gave rise to the AWA Universal Battery Eliminator (UBE) power supply circuit, which is highly configurable and can power vintage battery-operated tube radio sets of the 1920s-30s era, including TRF and "Farm" radios.

As shown in Figures 1 and 2, the UBE's printed circuit board (PCB) measures 6¼ by 6¾ inches with a maximum assembled height of 2¾ inches. Three PCB-mounted transformers along with rectifier and regulator circuitry develop the "A," "B" and "C" supply voltages. The transformers can be configured for either 120 or 240 VAC operation by installing the appropriate onboard jumpers. As an option, the builder can use off-board chassis mounted transformers if desired. Appropriate AC mains wiring, fusing and switching choices are left to the builder.

The "A," "B" and "C" supplies are isolated electrically from each other as well as from chassis ground, to allow maximum flexibility in connecting to a wide array of vintage radio sets. Each supply is also pro-

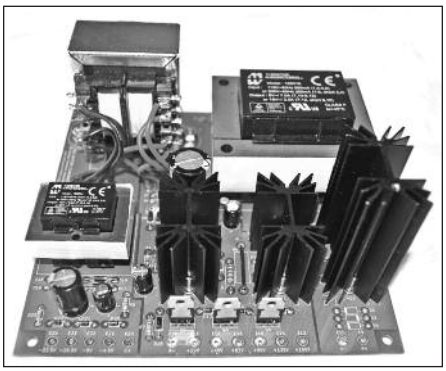

Fig. 1: Assembled AWA Universal Battery Eliminator power supply—side view.

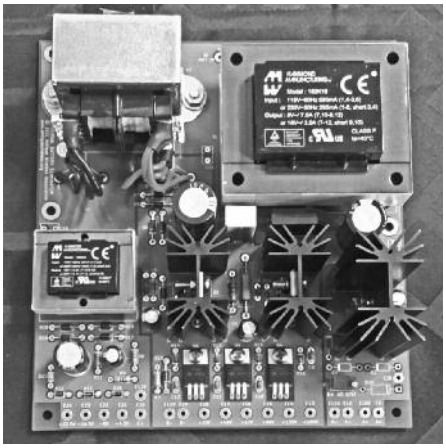

Fig. 2: Assembled AWA Universal Battery Eliminator power supply—top view.

tected against momentary short circuits to its negative rail. However, care must be taken to prevent voltage-to-voltage shorts.

Another important feature of the AWA UBE is the ability to customize the power supply to fit individual needs. As designed, the UBE has a number of "B" and "C" output voltages in multiples of +22.5 and -4.5 volts. However, some early radios required only +90 volts plate and 1.25 V filament supplies. For such applications the "C" supply components can be left off, and the "A" and "B" transformers downsized to reduce cost and weight. A simple resistor change in the "B" regulator can be made to lower the +180 V to +90 volts. The rest of the "B" output components associated with the +135 V and lower output voltages can be left off of the board.

The PCB can be mounted inside a project enclosure with terminal strip connections or within the radio cabinet itself, with wires connected directly to the appropriate PCB pads. A line cord, fuse and on-off switch will be needed to complete the installation.

Circuit Descriptions

"A" Supply

The "A" supply can provide 1.25 to 6.0 volts DC at a continuous load up to 4.0 amperes for the set's filament supply. The voltage can be adjusted to any value between 1.25 and 6.0 by means of a precision multi-turn potentiometer.

The maximum continuous current stated above is limited by the temperature of the LM1084 regulator using the on-board heat sink. Maximum current value should be derated if the supply is mounted inside a radio cabinet or non-ventilated enclosure. The table in Figure 3 shows the maximum recommended filament current versus temperature for the most popular filament voltages.

The continuous current value could be increased by using an off-board series pass transistor. Connection to the off-board transistor can be made via terminals E7, E8 and E28, with a trace cut between E8 and E28 necessary to complete the change. The builder should be advised that T1, C1 and the circuit wiring itself will impose further current limitations.

Filament	Max Current @ Temp	
Volts	25° C	40° C
1.25	1.25 A	1 A
1.5	1.25 A	1 A
4.5	2.25 A	2.0 A
6	4.0 A	3.25 A

Fig 3: Maximum recommended filament current versus temperature.

A transzorb diode can be connected across the "A" supply output to protect 6-volt tube filaments against a regulator failure. For situations where only 1 V filament tubes are used, three 1N4007 diodes can be installed for protection. Short circuit limiting is built into the regulator integrated circuit (IC).

"B" Supply

The "B" supply provides voltages of 22, 45, 67, 90, 135 and 180 volts DC. Triad's workhorse VPS230-110 transformer powers the bridge rectifier for this circuit and is connected to the PCB using hookup wire. The +180 volt source is developed using a LR8N regulator with series pass transistor, while the lower voltages are derived from a

string of Zener diodes.

To minimize power consumption, TIP50 emitter followers on the Zener regulator string provide a very low impedance source of current only when a load is connected. With this configuration the total Zener dissipation is about 0.7 watts as contrasted with other designs, where dissipation ranges from 6 to 8 watts.

With the exception of the 180 V supply, each individual B+ supply can provide up to 50 mA in a standalone configuration. Where multiple voltages are needed, the total combined current drawn from the 22/45/67/90/135 supplies must be limited to 50 mA maximum. If the 180 V supply is used, it can handle up to 80 mA by itself but the total current draw from all B+ supplies cannot exceed 80 mA. This is the heat sinking limit of the pass transistors, particularly Q1.

"C" Supply

The "C" supply is derived directly from a Zener diode regulator string and provides voltages of -4.5, -9, -16.5 and -22.5 volts, all referred to terminal C+. Total current draw of 10 to 20 mA can be handled without significantly changing the output voltage.

Construction

The AWA UBE power supply circuit is about the best we've seen in this category in terms of versatility and overall capability. The parts cost for a complete battery eliminator power supply is currently about $80, half of which is the cost of the transformers, if all of the parts are purchased brand new. A reduced feature supply, such as the 90V/1.25V example mentioned above, will have a parts cost of about $50, again with half of the cost in the new "iron." A well-stocked junkbox will lower the cost appreciably. Please note that the cost of the PCB is additional and is currently $30, plus $5 shipping to USA addresses for AWA members ($33, plus $5 for non-members). Your purchase of AWA PCBs helps to support the organization and its important mission.

As mentioned previously, the builder must provide a line cord, fuse, and on/off switch. A filtered power-entry module will help minimize interference from noise appearing on the AC mains. Choice of mounting in a separate enclosure or radio cabinet is also left to the builder.

Here are some examples where the AWA UBE PCB is currently being used:

- Atwater Kent Model 20 "big box" five tube TRF, used with A-K horn speaker. Utilized 6V "A;" 22V and 90V "B."
- Atwater Kent Model 20C 5-tube TRF, a compact version of the Model 20, same circuit with added provision for "C" battery, plus split B+ feeds. Used with A-K horn speaker. Utilized 6V "A;" 22V, 45V and 90V "B;" -4.5V "C."
- Crosley Model 51 2-tube regenerative. Used with Brandes headphones. Utilized 6V "A;" 22V and 45V "B."

A professional quality, silk-screened circuit board with a representative parts list may be purchased from the AWA Museum Store (antiquewireless.org) using a credit card or PayPal, or by mail order to:

Antique Wireless Association
Attn: Bob Hobday
P.O. Box 421
Bloomfield, New York 14469

Please make checks payable to AWA, and direct any questions to: dean@antiquewireless.org.

The AWA UBE PCB can fit into some very tight spaces within radios or become the focal point of a bench-type supply contained in a fancy enclosure of the builder's choice. This new battery eliminator circuit should help keep our antique radios playing well into the future in listening rooms all over the world. Special thanks to David Kaiser for his much-appreciated critical review and testing of the AWA UBE prototype.

Breadboarding is always interested in your ideas, thoughts and comments! All emails to dean@antiquewireless.org will be answered promptly.

REFERENCES:

1 Joe Stoltz, Richard Achter and Dean Faklis, "AM Transmitter for Enjoying Vintage Radios," *The AWA Journal*, Vol. 61, No. 1, p. 49, Winter 2020.