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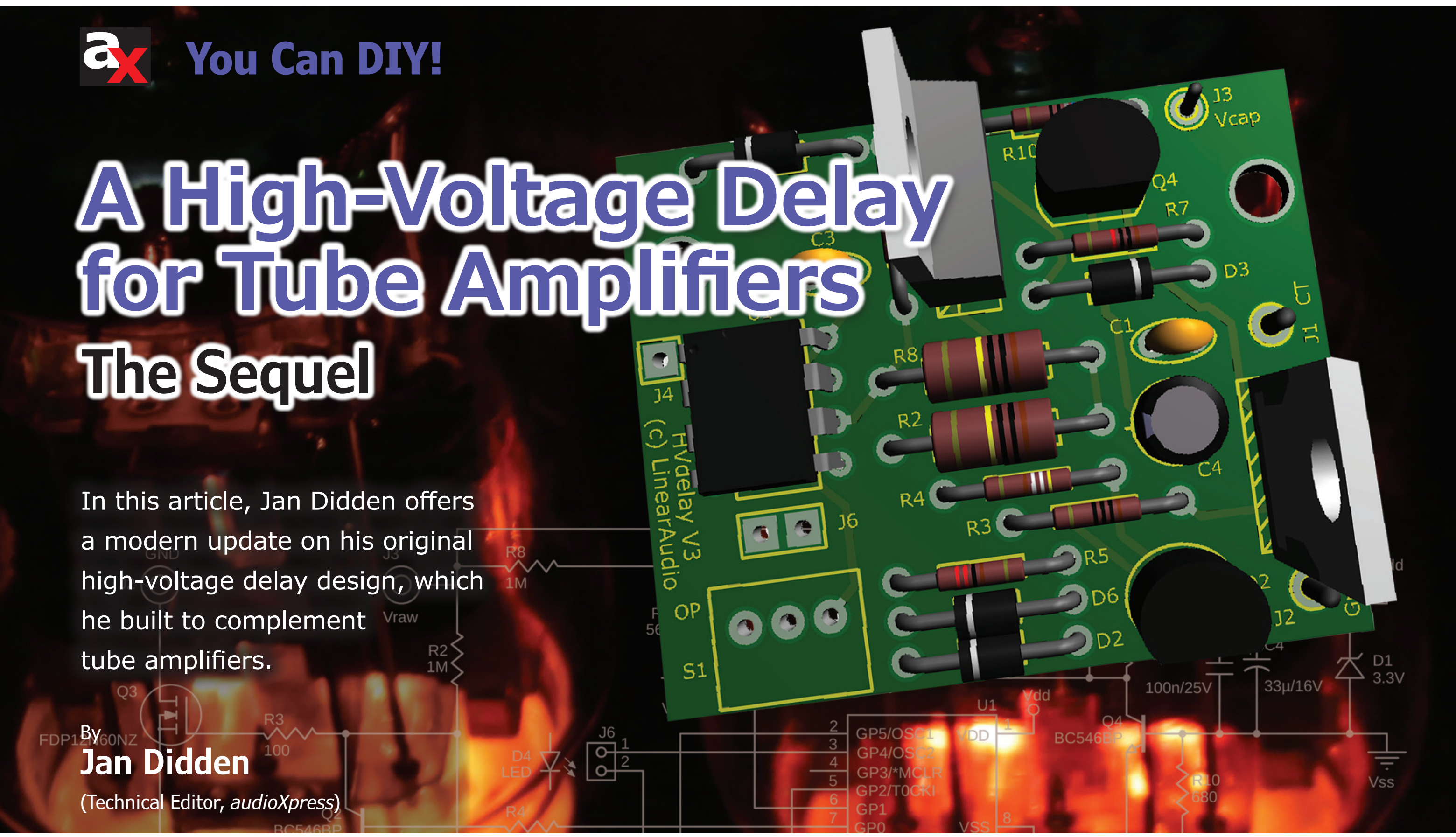
A High-Voltage Delay for Tube Amplifiers

The Sequel



In this article, Jan Didden offers a modern update on his original high-voltage delay design, which he built to complement tube amplifiers.

By
Jan Didden
(Technical Editor, *audioXpress*)

In 2014, *audioXpress* published my design for a delayed on-switch for a tube amplifier's high voltage. Tube heaters need some time to heat up, before a tube starts conducting. Depending on the tube type, this can range from a dozen seconds to a minute. In itself, this is no problem—you just wait a little bit before your music starts playing.

But normally the high-voltage supply for that tube comes on at the same time as the heater voltage comes on—often supplied from the same transformer. That means that the tube sits there for up to a minute with high voltage applied and no conduction. This may shorten tube life—it depends on the tube type and the actual high voltage. The jury is still out on how significant it is, but the effect is known.

Another issue is that the high voltage initially, when the tubes do not yet draw current, can be quite a bit higher than the voltage under load, putting additional stress on the tubes and possibly the high-voltage capacitors. So we should not take chances with limiting the life of our precious tubes, and switch on the high voltage only after the cathodes have been properly heated up.

Why the Sequel?

The original unit worked fine, but it had two disadvantages: It needed a separate 6.3 V heater winding for power, and was limited to a selection of just two delay periods. The heater winding had to be separate from the other heater windings used in the amp because they float on the high voltage. That often meant getting an additional transformer for it, which meant extra cost and extra space required in the chassis. The dual delay selection sometimes meant that one was possibly too short and the other too long.

So I set about to redo this unit by making it self-sufficient—there's no additional outside power required, and you can set the delay between 20 seconds and 254 seconds, which should cover all requirements.

The Circuit

The circuit is solid-state switch-based for noiseless and long-life operation and low power dissipation. It is also easy to integrate even in existing tube amps, and switches on the high voltage from the zero mains crossing to avoid loud thumps in the speaker. (There can still be an "on" thump but that is then from something else in the amp, like asymmetrical circuitry.) And, of course, no impact on amplifier audio performance!

The topology is shown in **Figure 1**. By inserting the switch in the return line to the power transformer I leave everything after the last reservoir cap unchanged. So there is no impact on the power supply quality and no messing up any carefully laid out ground circuitry. It can be used either with a bridge-type rectifier or a center-tapped secondary with a double-phase rectifier as shown.

The actual switch is connected between Gnd and CT. The unit is powered by a very small current stolen from the high voltage. The complete circuit is shown in **Figure 2**.

The control circuit is simple in its working but getting it to work through a wide range of voltages and under its own power makes it a bit non-intuitive. Let's start with the switch Q3 on the far left, an N-channel high-voltage MOSFET. The drain is connected to the transformer return line as shown in Figure 1. The source is connected to ground, and if this field-effect transistor (FET) switch is closed, the loop from secondary and rectifiers to the cap is closed. The cap will then charge and high voltage is provided to the amp.

On the center-right is the microcontroller U1. It's a small, 8-pin DIL chip that I programmed to turn the FET on after the set delay. Through its pin 7, the controller keeps the FET gate shorted through Q2, keeping the switch open during the delay. (Capacitor C2 keeps the switch open during the short time the controller needs to get its act together). Through R8 and R9, a sample of the secondary AC is provided to U1, so it can see when the AC goes through a zero crossing. After the delay, and at the zero crossing point, the controller releases Q2 by pulling down its GP0 pin 7, R2 drives the gate voltage up, the FET switches on and the power supply capacitor charges up. Music flows from the speakers!

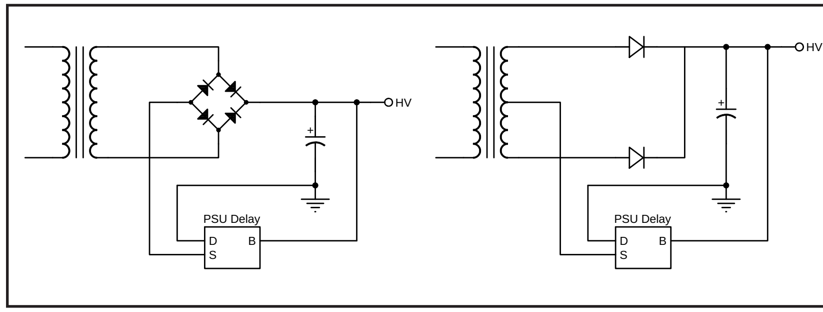


Figure 1: Connecting the high-voltage delay to an amplifier

The controller also drives a LED to show delay or active state: It blinks in a 2 second rhythm during the delay period, then comes on steady (or goes out, see later text) after the high voltage is on.

Q1, driven by Q4, provides a small current from the secondary voltage to power the controller and the LED. I specified a very low current LED, total supply current is just 1.8 mA maximum, and the dissipation in Q1 is generally less than 1 W. Nevertheless, with very high voltages Q1 can become hot to the touch. If you want to play it safe, mount Q1 below the PCB to your amplifier chassis (see Construction).

The Controller

You may wonder what business a digital (there—I said it!) controller has in audio. Well, none of course, that's why it isn't in the audio. And if you are afraid

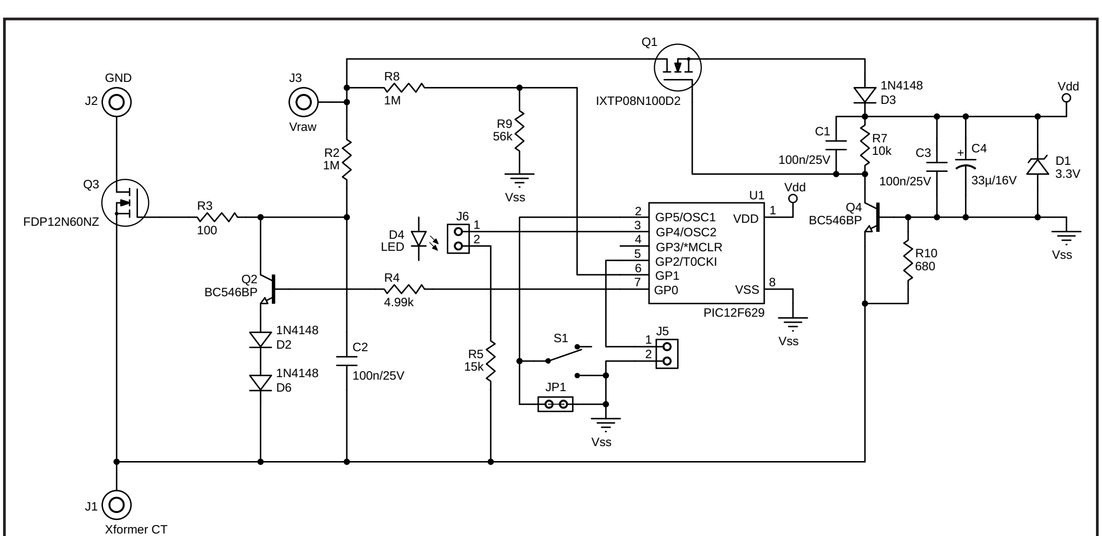


Figure 2: The schematic shows the complete circuit for the high-voltage delay unit. J3/Vraw is the top of the first rectifier capacitor.

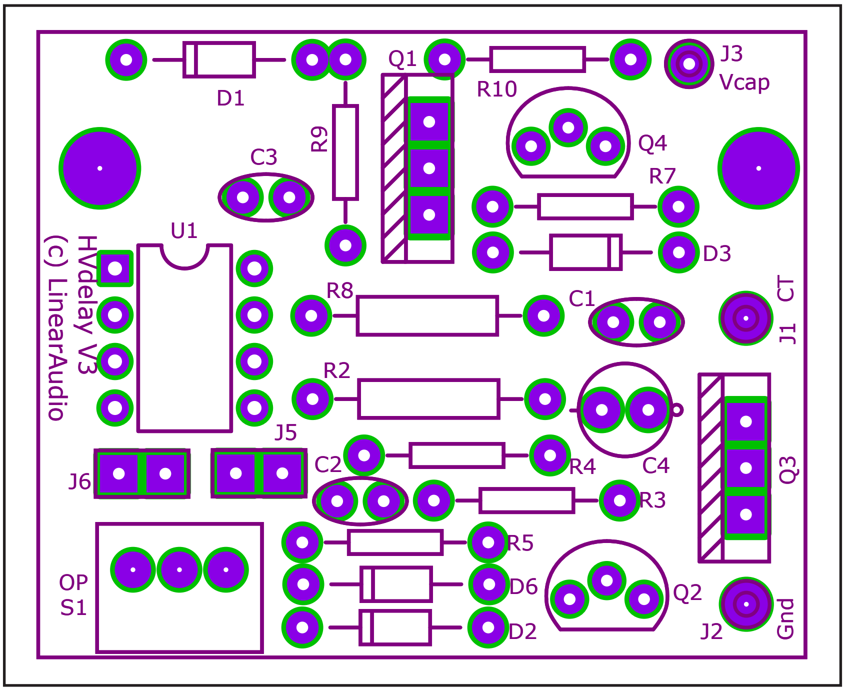


Figure 3: PCB parts location and stuffing guide

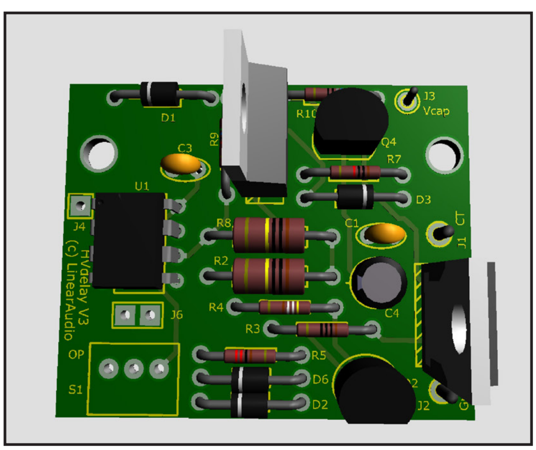


Photo 1: Top of the board in 3D view

About the Author

Jan Didden has written for *audioXpress* since the 1970s. He is retired following a career with the Netherlands Air Force and NATO. He worked in logistics, air defense, and information technology. Retirement has provided him with the time to finish all the audio projects that have piled up for decades. He writes about them on his website linearaudio.nl. Jan is also the publisher and managing editor of the twice-yearly bookzine *Linear Audio*.

Resources

J. Didden, "Extending Tube Life with a High-Voltage Delay," *Linear Audio*, May 2019, https://linearaudio.nl/extending-tube-life-hv-delay.

J. Didden, "Tube Amplifier High-Voltage Delay," *audioXpress*, February 2014, https://www.audioxpress.com/article/how-to-extend-the-useful-life-of-those-precious-tubes-use-a-tube-amplifier-high-voltage-delay

of "digital hash" or whatever, be assured: After the initial delay and switch-on of the high voltage, the controller goes to sleep and switches itself off until the next time you cycle the mains voltage.

If you are new to controllers, or are unfamiliar with it, it may seem like a bit of magic, but it is simple engineering. The controller program is just a bunch of instructions that are executed by the chip after it wakes up at power-on, something like (in order of execution):

- Immediately set pin 7 high to keep the FET switched off.
- Read the voltage at pin 5 to determine whether the manual delay jumper at JP1 is placed. If not, get the saved delay time from memory and start it. If yes, start the delay and keep on checking the jumper. If it is removed, terminate the delay and save the delay for next time. Flash the LED during the delay.
- After the delay, wait until the secondary voltage at pin 6 goes through zero.
- Set pin 7 low to allow the FET to switch on.
- If the jumper at J5 is set, turn off the LED. If not set, turn the LED on to indicate 'active' state.
- Turn yourself off and go to sleep.
  (Poor controller—so much power, so few challenges ...).

Customization

The way I have set up the program is that the delay is 30 seconds out of the box. You can set it to your need as follows. Place jumper JP1 (or switch S1, see later text) before switching on the amp. Determine the delay you want to set, and divide that number by two. Switch on the amp and the LED will start flashing in a 2 second rhythm, so you count off the number you have previously determined. When you get to zero, pull off the jumper (or flip the switch).

Important note: Be careful when handling a jumper with the amp on, since high voltage is present on the board. You are responsible for your safety—not me, not the publisher. If you anticipate experimenting, you could replace the jumper with one of those small PCB toggle switches, they should fit the 0.1" pitch, but use a switch with a plastic or isolated lever. Jumpers are available with a little extra "handling strip" so you can remove them without touching the jumper itself. Better yet, use pliers with insulated handles.

You can also change the way the LED works. If you already have some on/off indicators on your amp, you may want to solder the LED directly to the board and use it only for checking/setting the delay. In that case, place a jumper at J5—the LED will then blink during the delay only and after that go to sleep, along with the controller.

The Specs

There's only a few specifications. The absolute maximum voltage (that is the maximum at your supply cap, when switching on the amp, before it is warmed up!) is 600 V. This is where the professional manufacturers would say: "exceeding this maximum spec may permanently damage the device."

Maximum high voltage supply current that can be switched has no practical limit. If you have an amp that takes more than a couple of amps, you probably operate a transmitter and even then, no sweat! The delay time default is 30 seconds and can be changed to any value, in 2 second steps, between 20 and 254 seconds.

Construction

I have laid out a small PCB for this. **Figure 3** shows the stuffing guide. **Photo 1** and **Photo 2** give a 3D view of the completed small board; maybe I should call it a boardlet. Be sure to use a standard DIP08 socket for the controller in case you need to trouble shoot or replace it!

The dissipation in FET switch Q3 is so small that you can just solder it in an upright position to the top of the board as shown in Photo 1. Q1 may get warm to the touch at very high voltages, and if you want you can mount Q1 below the PCB to your amplifier chassis with a standoff as shown in Photo 2. Since the tab of Q3 is at Gnd, isolation is not strictly required, but mounting it on the chassis could impact the ground curents in your amp and is a reason to use isolation hardware. Then connect the board as shown in Figure 1, GND and CT to J2 and J1, and a wire from Vraw to the top of the (first) power supply capacitor, and you're good to go.

The Bill of Materials (BOM) for this project is shown in **Table 1**. The LED that comes with the diyaudio.com kit is a very low current, high brightness, red clear lens one. Feel free to replace with your favorite color, but do not replace the LED series resistor (R5) because increasing the LED current will significantly increase the dissipation in Q1. If the brightness is too high for your liking, you can place a resistor in series with one of the LED leads to dim it.

Availability

Our friends at diyaudio.com agreed to make a kit available for this project, consisting of the PCB, the programmed controller chip, the two power MOSFETs and the low current LED. You can order it at https://diyaudiostore.com/collections/kits. All other parts are available and/or in your parts bin.

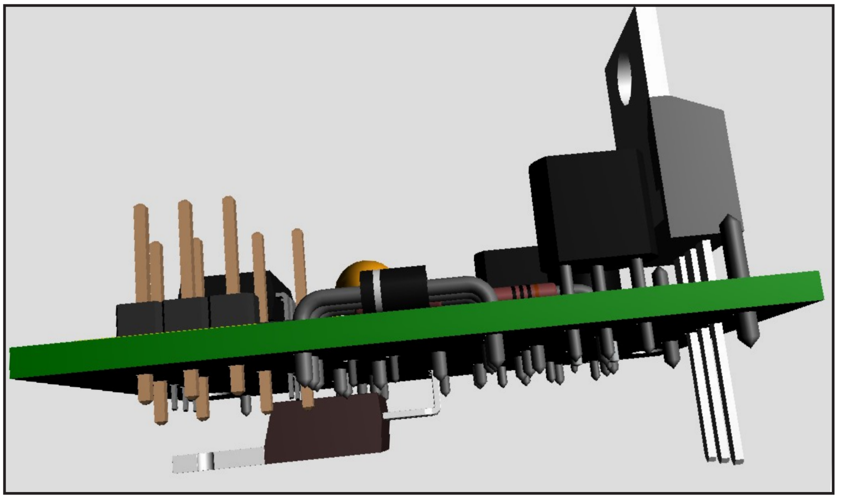


Photo 2: Mounting Q1 on the chassis in 3D view

Quantity	References	Value	Comment
3	C1-C3	100 n/25 V	0.1″ pitch ceramic
1	C4	33 µ /16 V	0.1″ pitch
2	R2,R8	1 M	1 W
1	R3	100	1/4 W
1	R4	4.99 kΩ	1/4 W
1	R5	15 kΩ	1/4 W
1	R7	10 kΩ	1/4 W
1	R9	56 kΩ	1/4 W
1	R10	680	1/4 W
1	U1	PIC12F629	programmed controller (part of kit) Use DIP socket!
1	Q1	IXTP08N100D2	part of kit
2	Q2,Q4	BC546BP	or equivalent small signal TO-92
1	Q3	FDP12N60NZ	part of kit (see text)
1	D1	Zener, 3.3 V	400 mW
3	D2-D3,D6	1N4148	or equivalent small signal
1	D4	LED	low current, Mouser 604-WP710A10SEC/J3 (part of kit)
1	J1	Xformer CT	off-board connection
1	J2	GND	off-board connection
1	J3	Vraw	off-board connection
2	J5-J6	2-pin hdr 0.1″	LED header
1	JP1	JUMPER	3-pin header (see text)
1	S1	SPDT	optional (see text)

Table 1: Here is the Bill of Materials (BOM) for the High-Voltage Delay project.