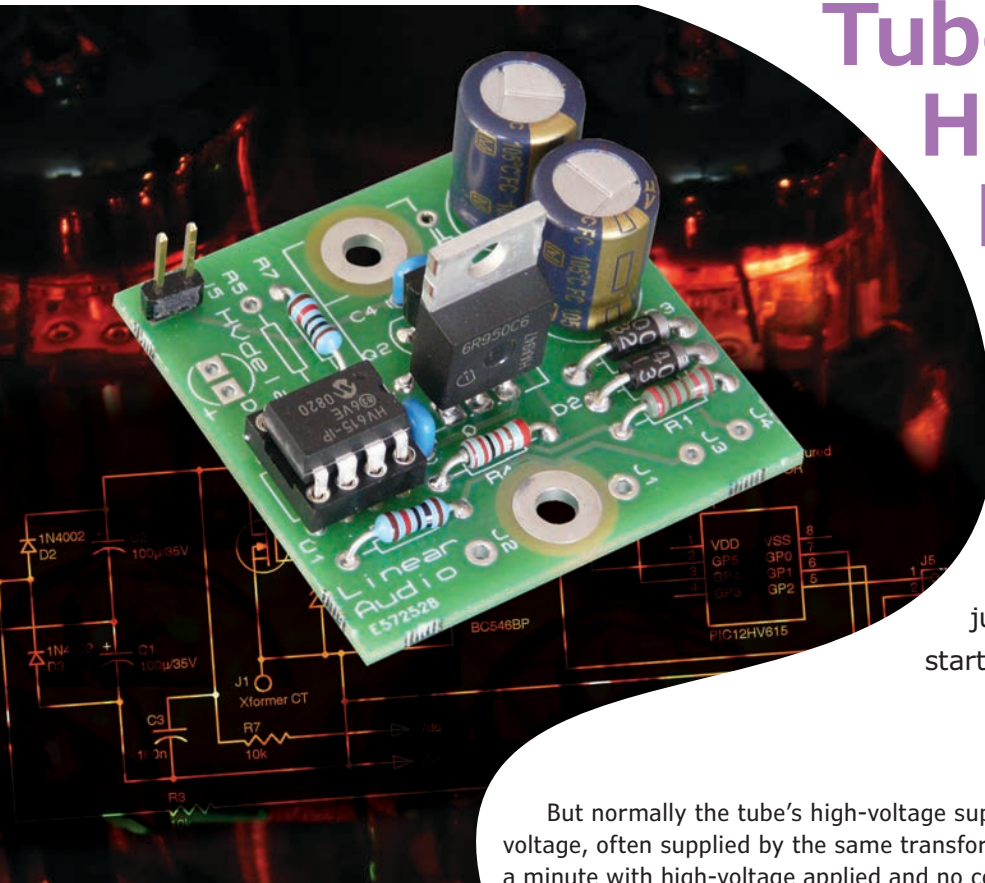


Tube Amplifier High-Voltage Delay



Tube amplifiers need some time for the heaters to warm before a tube starts conducting. Depending on the tube type, this can range from a dozen seconds to a minute. This delay is not typically a problem—you just wait a little bit before your music starts playing.

By
Jan Didden
(The Netherlands)

But normally the tube's high-voltage supply comes on at the same time as the heater voltage, often supplied by the same transformer. That means the tube sits there for up to a minute with high-voltage applied and no conduction. This can appreciably decrease tube life. Again, it depends on the tube type and the actual high voltage, but the effect is there.

It is compounded by the fact that the high voltage in the initial, unloaded situation can have a much higher value than when the amplifier is operating and the high-voltage supply is loaded down. To preserve the tube life, a device should delay the high voltage until after the tube heaters have warmed.

There are many ways this can be done. The simplest method is probably to use a delayed relay that switches on the high voltage after a preset time delay. This can be achieved with a discrete or integrated timer circuit to activate the relay. You can also buy a timer unit that includes a relay and an integrated delay you can set with a dial. But I don't like relatively bulky and mechanical systems with their power dissipation and mechanical failure modes. So, I thought there must be a more elegant and more reliable way to do this.

To solve my dilemma, I built a power supply unit (PSU) delay. However, I had a few additional requirements for the device including a solid-state switch used for noiseless and long-life operation, low power dissipation, a programmable delay time, easy integration even in existing tube amplifiers, and no impact on amplifier audio performance.

Figure 1 shows the topology I selected for the last two requirements. By inserting the switch in the return line to the power transformer, I left everything after the first reservoir cap unchanged so there is no impact on the power supply quality and no changes in any carefully laid out ground circuitry. It can be used either with a bridge-type rectifier or a double-phase rectifier as shown.

The actual switch is a MOSFET connected between D and S. The unit also contains a time-delay circuit. The switch and the delay circuits are powered by a spare heater winding on the power transformer. **Figure 2** shows the complete circuit.

The spare heater voltage on J3 and J4 is followed by a voltage doubler to sufficiently raise the voltage for the control circuit and MOSFET gate drive. The control circuit is simple but you need to examine it a bit closer to see *how* it works.

Let's start with the switch Q1, which is an N-channel high-voltage MOSFET. The drain is connected to the transformer return line at J1 (see **Figure 1**). The source at J2 is connected to ground. If the switch is closed, the transformer's secondary return is connected to ground and the high voltage is applied to the amplifier.

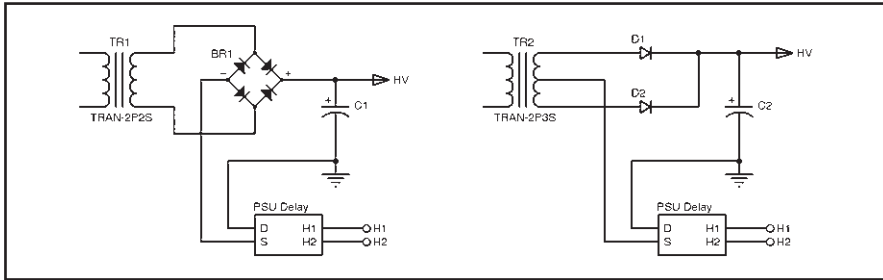


Figure 1: The high-voltage switching topology shows the switch inserted in the return line to the power transformer.

On the right you see microcontroller U1, which controls the switching. U1 is a small eight-pin dual in-line (DIL) chip that is programmed to turn the MOSFET on after a set delay. I will discuss that later. R3 provides a sample of the AC mains voltage to the controller. This enables the controller to detect the mains zero crossing and switch the supply on at the right moment. The result makes for a smoother increase in the high voltage and avoids any high in-rush currents.

Initially, the controller holds the MOSFET in the Off position by shorting the gate to the drain via the activated transistor Q2. R2 and C4 provide that function for the first few milliseconds until the controller is operational. Following the delay, the controller releases Q2 by pulling down its GP10 Pin 7. R2 increases the gate voltage. The MOSFET switches on at the next mains zero crossing and the high-voltage supply circuit is enabled. The controller also drives a bi-color LED to show a delay or an active state.

The controller has an internal shunt regulator, which is supplied via R7. V_{SS} is the controller ground pin, and V_{DD} is its supply pin (not shown on the chip drawing).

Since I had one pin left at the controller chip, I connected that to J5. Depending on whether J5 is jumpered to ground, the controller selects one of two delay times: low or high.

Controller

You may wonder what business a digital (there, I said it!) controller has in audio. The answer is none, of course. That's why it isn't in the audio. And if you are afraid of "digital hash" or whatever, rest assured: After the initial delay and the switching on of the high voltage, the controller goes to sleep and switches itself off until the next time you switch on the amplifier's mains voltage.

If you are new to controllers or are unfamiliar with them, it may seem like a bit of magic, but it is not rocket science. The controller program is simply several instructions executed by the chip after it is powered on. For example (in order of execution):

- Set Pin 7 to V_{DD} to keep the MOSFET switched off
- Read the voltage at Pin 5 to determine whether the jumper is placed and choose either the Low or the High delay value from memory

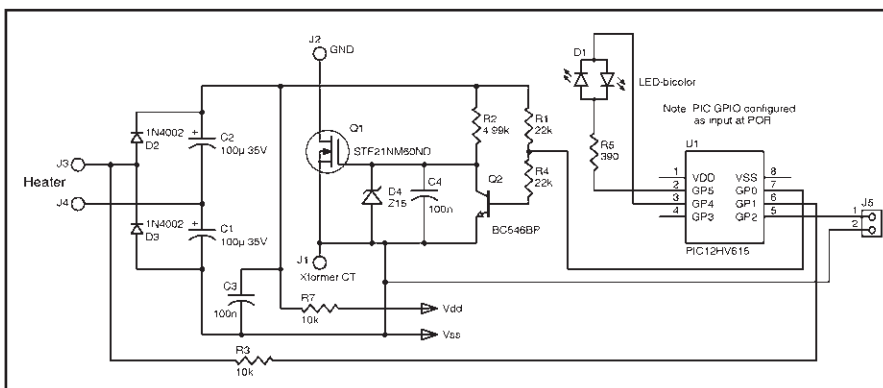


Figure 2: The complete circuit for the high-voltage delay unit contains a time delay.

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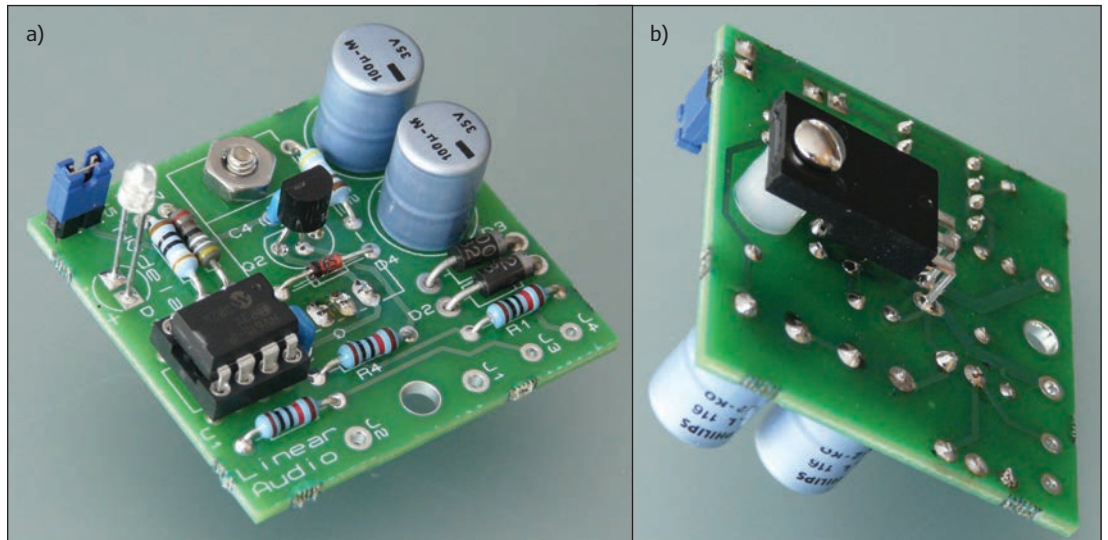
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Photo 1: The top (a) and bottom (b) of the Psudelay PCB are shown.



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*.

- Switch on the LED for the Delay state
- Wait the required time until the delay has passed
- Wait until the voltage at Pin 6 goes through zero (mains zero crossing)
- Set Pin 7 to 0 V to switch on the MOSFET
- Switch on the LED for the Active state

The way I set up the program, the delay is 40 s without the jumper at J5; with the jumper, the delay is 60 s.

For small microcontrollers such as the PIC12HV615, there are many open-source development programs you can use to translate the previous program into instruction codes and read it into the PIC through an inexpensive USB programmer. But

to make life easier, you can download the compiled program from my website (www.linearaudio.nl) and program the chip yourself or you can order the chip and the small PCB from *Circuit Cellar's* CC-Webshop.

Construction

I have laid out a small PCB for this device (see **Photo 1**). If you want to roll your own, the PCB Gerbers are available through my website under My Projects. The website also contains a stuffing guide.

The designated MOSFET has an insulated tab so you can simply attach it to the amplifier chassis. Personally, I prefer a more secure approach, so I use a small TO-220 isolator. Actually, the dissipation in the MOSFET is so small you can also just solder it in an upright position to the top of the board. Connect the GND and CT to J2 and J1, and connect a heater winding for the supply at J3 and J4.

One word of caution: The heater used for this supply floats with the full transformer high-voltage output voltage. So, it should have adequate isolation from the other parts of the transformer and the chassis. If in doubt, use a separate small heater transformer (or anything that delivers a secondary 6 to 10 VAC at a few milliamps). Note that you cannot use this heater winding to power other tube heaters in the amplifier. You would need a separate winding (or transformer).

I have used this little circuit for more than a year. I found it to be very reliable and it does what it's told to do. Have fun!

Category	Quantity	Reference	Value	Comment
Resistors	2	R1,R4	22 kΩ	0.25 W MF
	1	R2	4.99 kΩ	0.25 W MF
	2	R3,R7	10 kΩ	0.25 W MF
	1	R5	390	0.25 W MF
	Capacitors	2	C1,C2	100 uF/35 V
2		C3,C4	100 nF	
ICs	1	U1	PIC12HV609	eight-pin DIL
Transistors	1	Q1	STF21NM60ND	
	1	Q2	BC546BP	or equal Small-signal
Diodes	1	D1	LED-BICOLOR	
	2	D2,D3	1N4002	
	1	D4	Z15	Zener 400 mW
Miscellaneous	1	J5	CONN-H2	sil-2 header

Table 1: Bill of Materials

Source

PIC12HV615 microcontroller

Microchip Technology, Inc. | www.microchip.com