DIY HiFi Supply Ltd Ultra Low noise VCS filament supply

- 2V - 12V with slow turn-on, 2V - 24V without slow turn-on or 12V - 30V without slow turn-on DC output with up to 2.5A load. Adjustable with on-board trimmer and jumper
- Device needs between zero and 2V more AC input than DC output (see table in application section)
- Output ripple typically < 2mv unweighted into 300B. Output ripple varies with load
- High output impedance to limit intermodulation distortion
- Input and output short-term (ie. momentary) short-circuit proof
- Overheat protected
- LED function indicator
- PCB cutouts for airflow around diodes and regulator.
- Schottky diodes
- Adjust on-board trimmer

The Skinny View:
Noise on the filament gets sucked into the audio chain and amplified. Friendly noise as from AC heaters obscures detail and adds warmth – like looking into a pool of un-still tepid water.

Unfriendly noise as from a bridge rectifier + cap sprays high frequency noise everywhere. Sure, quiet but the sound?

Something akin to digital gone wild – like looking into a pool of still water but not being able to see past the surface glare.

And joltingly cold.

So kill the noise. Add a big choke. Peace at last.

But...said choke must be BIG and where can you stow that thing? Not in my chassis. Enter The Regulator. But electrons are lazy critters, especially the green ones (hifi electrons). We've got light green ones that carry the audio signal. We want them to go tube>>transformer and nowhere else. And we've got dark green ones that we just want to go regulator>>cathode and nowhere else. If we don't put up a brick wall between cathode and regulator, the lazy light green audio electrons get lost and/or start acting crazy as they mix with the dark green ones.

How do we get a one-way brick wall? - Voltage current source regulator (VCS).

Audio electrons, all of them, stay in the signal path. And the filament supply electrons don't bother anyone. Noise is ultra low. All music, all the time.
**Directly Heated Triode Filament Supply Issues**

Directly Heated Triode – the cathode is the filament so both heating current and signal voltages are present

Common perceptions: AC=good but noisy, DC=quiet but cold sounding and has glare

**What is needed:**

1. low noise heating current (ie low ripple and no high frequency hash)
2. no intermodulation between signal and heating current
3. no audio signal loss through heating current device

**1. Low noise heating methods compared**

- **Straight-in AC.** Needs hum pot to reduce hum but will still always be audible on efficient speakers. Impractical for >2.5v filaments even with hum pot. Hum pot always in the signal path and acts as shunt for signal. Filament voltage unstable as varies with line voltage and load. Fast startup stresses power tube.

- **AC > bridge rectifier > big cap.** Most basic DC supply, ripple still in 250-300mv range and needs hum pot. High frequency artefacts from solid state rectification give nasty glare to the sound. Voltage unstable as with straight-in AC. Fast startup stresses power tube.

- **AC > bridge rectifier > big cap > big choke > big cap.** Low ripple < 10mV, suppresses high frequency hash. Voltage unstable as above, switch-on a little slower than above. Sound is good. Big choke needed and not space friendly.

- **AC > bridge rectifier > big cap > regulator.** Can be voltage stable, low noise – several mV. Sound depends on implementation, needs AC voltage headroom to regulate (ie DCV out = ACV in +1 to 2v)

**2. Intermodulation issues**

Any voltage fluctuations across the cathode are part of the output circuit (cathode-anode-output transformer). Audio signal produces music at the outputs. Any fluctuation (high/low frequency) in the heating current circuit produces noise at signal output. Such noise can modulate audio signal and create harmonics that colour (distort) the audio signal causing subjective glare, warmth, exaggerated or diminished detail etc.

**3. Audio Signal loss**

Current will always take the path of least resistance. 100% of audio signal should stay within the tube/transformer output circuit. Caps across the filament will short a percentage of audio signal. Any path with resistance lower than the net output circuit loop will reduce audio signal through that loop. Subjectively audio output quality suffers in every way.

**Regulated Supply**

Can be implemented as ‘current source’ or ‘voltage source’ or ‘voltage controlled current source’ (ie current source at audio frequency and voltage source at DC):

- **Voltage Source:** voltage source is like a battery: low output impedance and tends to maintain voltage regardless of load, irrespective of current. Good for stabilizing voltage, bad for intermodulation with audio signal as impedance of the device is low.

- **Current Source:** current source has high output impedance and tends to maintain current regardless of load and irrespective of voltage. Good for preventing intermodulation and loss with audio signal as output impedance is very high. Bad for voltage stability.

- **Voltage controlled Current Source:** Acts as a current source at audio frequencies but as a voltage source at DC. Benefits include voltage stability, High impedance at audio signal frequency (audio signal sees a 'brick wall' and doesn't go there). No shunting/shorting paths for audio signal, all signal stays within the audio output circuit. No humbucker or caps across cathode used in this implementation.
Application notes:

Thanks for purchasing the DIYHFS ultra low noise filament supply. The package includes:

- 8 x 5mm standoffs and nuts
- 4 x 0.47ohm 10watt resistors to trim supply voltage as needed (one or two may be used before each supply)
- 2 x Filament Supply Circuit Boards (complete, tested)

Place and mount the supplies for best cooling, ensuring good airflow over the heatsink. Generally the heatsink should be placed so that air flows along the channels in the heatsink.

Here an example showing the installation in an Amplifier chassis (note, this shows an older version filament supply):

Observe how the Filament supply is aligned so that air from below the amplifier will flow upwards past the heatsink and the placement of the optional “white coffin” AC reduction resistors. It is best to place the heatsink near chassis opening for improved airflow.

Mount the supply (85mm x 50mm x 45mm tall with 40mm x 75mm mounting centres) using 5mm standoffs (supplied).

Beware, the heatsink is not isolated and must not be allowed to make contact with the chassis or any other metal part! Note that the heatsink will have the same voltage as the cathode of the tube supplied!

AC supply: Connect the suitably rated AC supply (see table below) using suitably current rated wires to the ‘AC in’ connectors and screw down snugly but don’t overtighten. If the connector starts to twists, you have overtightened. These AC supply must be floating (i.e. no centre tap connected to ground.). Twist the AC wires together about 3 twists per inch to reduce induced hum). Below the minimum AC input voltages and expected AC currents for a number of popular Tubes:

<table>
<thead>
<tr>
<th>Tube</th>
<th>DC Voltage</th>
<th>DC Current</th>
<th>AC Voltage</th>
<th>AC Current</th>
</tr>
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<tbody>
<tr>
<td>Type</td>
<td>V&lt;sup&gt;r&lt;/sup&gt;</td>
<td>A&lt;sup&gt;r&lt;/sup&gt;</td>
<td>V&lt;sup&gt;-&lt;/sup&gt;</td>
<td>A&lt;sup&gt;-&lt;/sup&gt;</td>
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<td>2.5</td>
<td>1.5</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>2A3</td>
<td>2.5</td>
<td>2.5</td>
<td>4.5</td>
<td>4.6</td>
</tr>
<tr>
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<td>1.2</td>
<td>5.4</td>
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<tr>
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<td>2.4</td>
<td>6.1</td>
<td>4.6</td>
</tr>
<tr>
<td>6A3 / 6B4G</td>
<td>6.3</td>
<td>1.0</td>
<td>6.2</td>
<td>2.4</td>
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<td>7.5</td>
<td>1.5</td>
<td>7.3</td>
<td>3.4</td>
</tr>
</tbody>
</table>

If the available AC supply is appreciably higher in voltage than the recommended value it is recommended to add resistors into the AC lines to reduce the AC voltage. You can roughly calculate the needed resistor by dividing the excess AC voltage by the AC current, the power dissipated is excess voltage multiplied by current.

For example if we have a 5.5V/5A AC winding and want to use a 2A3 tube we divide the excess 1V by 4.5A current and hence need one 0.22 Ohm Resistor. The power DISSIPATED by the resistor will be 4.6 Watt so at an absolute minimum a 9 Watt resistor (rated at twice the actual power dissipated) must be used. More expediently the two pieces of 0.47 Ohm 10 Watt supplied with the Module may be placed in parallel and may be used thus instead of a single 0.22 Ohm resistor, giving 0.235 Ohm / 20W.

DC output: Connect to ‘DC out’ and then to the tube socket pins. Note the polarity is labelled. Connect ‘DC’ out to connect to the tube socket pins (1 and 4 in the case of 300B/2A3/45/PX25 etc).

The DC output is rated at 2.5A as this is a value where all parts operate at a reasonable stress. However if care is taken to ensure heat is minimised this may be exceeded considerably without ill effects. The current must be limited absolutely to 3.3A DC and otherwise is limited by the heat produced. Please note however that operation under such conditions exceeding 2.5A load current is neither guaranteed nor covered under warranty.
Follow the drawing below to make the connections from and to the filament supply.

The device comes preset at 5V output. If lower voltage is required adjust lower using the blue trimpot provided before inserting power tubes. Always check the final voltage at the actual tube pin and if necessary re-adjust.

Adjust the blue trimmer to the desired DC voltage using a 10 Ohm / 5 Watt “dummy load”. Then re-adjust precisely with the actual tube in place, measure at the actual tube pins.

It is generally desirable to set the heater voltage slightly low, by around 5% from the nominal value. This will improve valve life.

You should also measure AC noise across the heater with the Amplifier input shorted. In our own test amplifier with 300B we have measured as low as 1.8mv. If all else is well with the circuit output noise from the amp can be vanishingly low and reveal much hidden musical detail.

**Note:** there must be no cap or humpot across tube socket. This will defeat the sound as music signal will be shorted or shunted away from the output circuit. In the case of cathode bias it should be connected as shown.

**Jumper Setting:** To use the Filament Supply for traditional directly heated audio tubes use the default jumper setting, as shipped (shown below – ignore the notes printed on the PCB). This gives an adjustment range from around 2V DC to 12V DC, allowing most small and medium power directly heated tubes and offers soft start for the tubes.

If you have requirements for different applications with higher voltages (for example field coils for externally excited magnet loudspeakers) you may change the jumper.

With the jumper removed you can adjust the voltage from 2V to 24V and softstart is disabled. If you for some reason require voltages above 24V fit the jumper in the position opposite from the default, you can now adjust the voltage above 24V.

Note that the diodes are rated at 60V and the capacitors at 35V, so realistically the DC output should not exceed 30V DC with minimal excess input voltage.