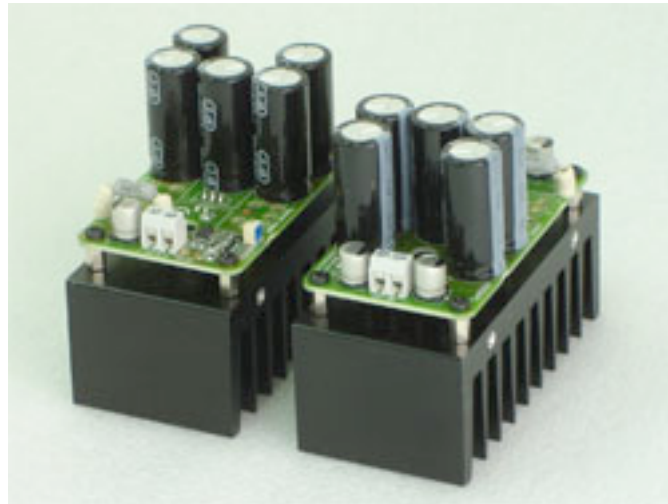


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Tentlabs Application Note AN.02 – Filament supplies



This Note applies to Tentlabs filament supply version V1.6 and later, delivered from February 2007 onwards.

This note describes the use of Tentlabs filament supplies. It shows how:

- they work in general
- to connect them in tube amplifiers

Finally an FAQ is added to help trouble shooting, and the specifications are listed for reference.

Filament supplies - general

Traditional supplies are always based on voltage regulation, either AC or DC. One of the properties of these regulators is their low output impedance. Tentlabs has investigated the effects on [the impedance feeding the filaments](#)

Purpose

TentLabs filament supply is designed to heat DHT's the cleanest way possible, without affecting the music currents generated inside the tubes' heater. The supplies generate a very low noise output, while maintaining its' high output impedance. Result areas are:

- Bigger soundstage
- Better focus
- Cleaner tone
- Better resolution

Existing current supplies lack true high output impedance and need adjustment during use. This new module is truly different in many areas - read on!

Versions

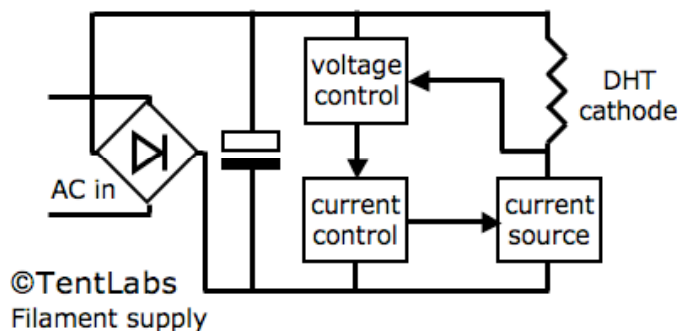
Currently 3 hardware versions are available:

- Low noise version, output currents up to 1A.
These typically serve small size triodes to be used as line stages. Output noise is 26dB lower compared to the standard version. Often used in conjunction with type 26 tube, integrated heatsink.
- Standard version, output currents up to 2.5A.
These typically serve small and medium size triodes up to output tubes like 300b and 2A3, and have an integrated heatsink.
- Standard version, output currents up to 5A. These will suit the beefy types like 211, 813, 845 and SV572 and have a bigger heatsink.

Disclaimer

Technology

An overview of the architecture of the filament supply is shown below:



The rectifier consists of a low noise Schottky-barrier diode-bridge and electrolytic capacitors (a total of about 20.000uF for the 2.5A version and 35.000uF for the 5A version) with a well-chosen amount of ESR, to dampen and reduce the current peaks. All these measures contribute to low noise output.

The current source maintains its' high output impedance (typically > 10 kΩ from 5 Hz onwards), whereas the DC voltage control takes away any need to trim the output voltage after installation, or during use. An accurate voltage reference guarantees long-term stability, and contributes to a clean output current. The module exactly supplies that amount of heater current, until the required DC voltage is achieved, e.g. 5V for a 300b.

The low noise version made available for line and driver tubes consists of a cleaner reference, low noise operational amplifiers and low noise resistors.

Application

- Warning!

Prior to all installations, measurements and adjustments, make sure the amplifier is switched off and no high voltage is present in the amplifier.

- General

Each tube needs its own filament supply module. Each module shall be fed by a separate winding from the power transformer. The whole supply is then floating, and only has one connection to ground or cathode resistor.

The maximum output current is limited, depending on the version (see the specifications), so slow start-up is the result. Especially when the tube is cold, this is a nice feature. Cold tubes, when heated with traditional supplies, draw currents up to ten times their nominal current. Using Tentlabs filament supplies will gently switch on your tubes.

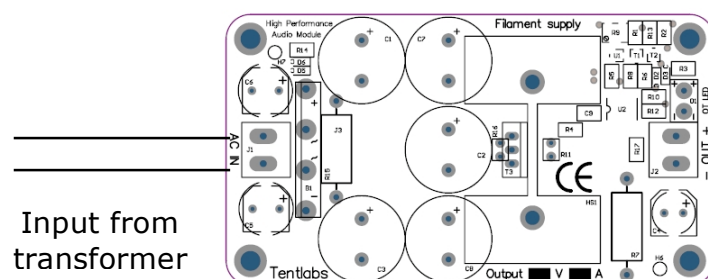
The modules are tested and factory adjusted to customer requirements. After installation, the supply may need minor DC adjustment, to compensate for small voltage losses across the wiring (some 100 mV are easily lost). During use, no adjustments are needed, not even after changing tubes!

- Input wiring

The input wiring is not limited to length, but be aware some voltage is lost across this wiring, especially when using tubes consuming higher currents (like 2A3, 211 or 5Y572). The wiring should have diameters according the following table:

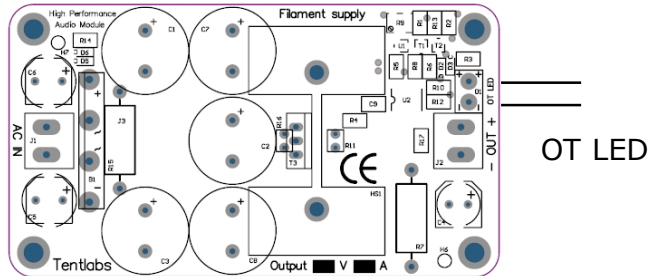
Version	Wire diameter [mm]	Wire size [AWG]
1A low noise	> 0.50	26 or lower
2,5A	> 0.75	20 or lower
5A	> 1.00	18 or lower

Twist this wiring to reduce stray fields and make sure the input wiring is connected from transformer to module only.



- Over Temperature (OT) LED wiring

The modules have an integrated temperature shut down, when the heatsink achieves a temperature of 90C. Once the module shuts down, the output voltage reduces and a LED lights up. This LED can be connected to the OT terminals, as shown below:



The LED and wiring are supplied with the module. The longest pin of the LED is the + connection, this should coincide with the OT "+".

Input voltage requirements

- Input AC voltage

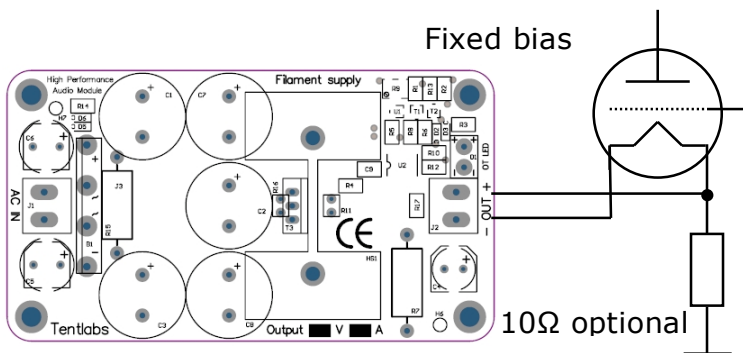
To minimize heat development, it is best to optimize the input voltage of the modules. A separate file can be downloaded from www.tentlabs.com. In this file, graphs show the advised input voltage (V_{ac}) and current (I_{ac}) as function of:

- Output voltage (V_{dc})
- Output load (I_{dc})

In V_{ac} advise, 8% margin is incorporated to cope with mains voltage variations. When the exact voltage is not available, it may be convenient to increase or reduce the number of turns of the transformer winding. This is easily done when toroidal transformers are used, but mostly it is also applicable with traditional EI cores. A value of 0,2 to 0,5V/winding is a good rule of thumb. The phase of the extra winding defines whether the voltage increases or decreases (reverse when required).

- Output wiring – fixed bias

When using **fixed bias**, the circuit looks like:

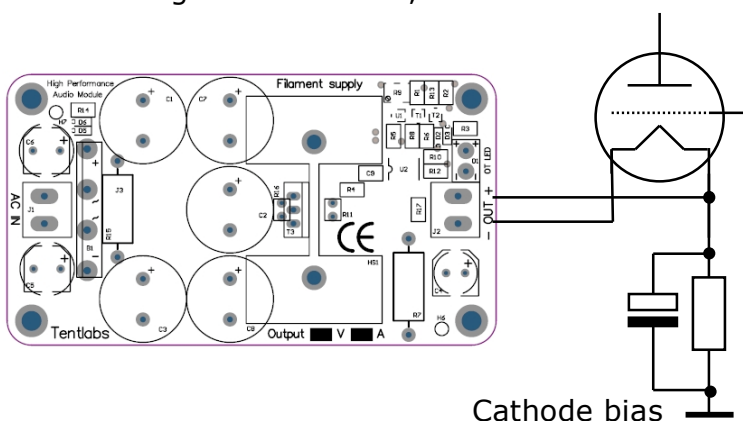


Notes:

- the + side of the filament shall go to ground (or 10 ohm resistor)
- sometimes a small (say 10 ohm) resistor is inserted between filament + and ground, to facilitate anode current measurements.

- Output wiring – cathode bias

When using **cathode bias**, the circuit looks like:



Notes:

- The + side of the filament goes to the cathode resistor / capacitor
- To measure the anode current, the voltage drop across the cathode resistor can be measured.
- Regardless of the bias method, readjustment of the bias current may be needed. Always check the bias current after installation of the modules.

Note on bias methods

Soundwise, we prefer fixed bias (regardless of the filament supply type). To make fixed bias safe, always insert a fuse in the anode. This will protect the tube and the output transformer in case the bias voltage drops.

- Other components

No external capacitors or resistors should be used across the filament. The same holds for the good old humbucker potentiometer.

So, make sure: no connections across the filament !

- Location of the modules

The location of the supplies is sub-critical, but take care of:

- Wiring:

The wiring between the module and the tube should not exceed 50cm and should have diameters according the following table:

Version	Wire diameter [mm]	Wire size [AWG]
1A low noise	> 0.30	29 or lower
2,5A	> 0.50	24 or lower
5A	> 0.75	20 or lower

- Heat and temperature:

The low noise and 2,5A modules have an integrated heatsink. The fins should be vertical and normal airflow should be allowed. If this isn't possible, bolt them to a heat conducting chassis, using the 2 holes on top of the heatsink (pitched 25.4mm). Assure the chassis is flat and use a small amount of conducting compound.

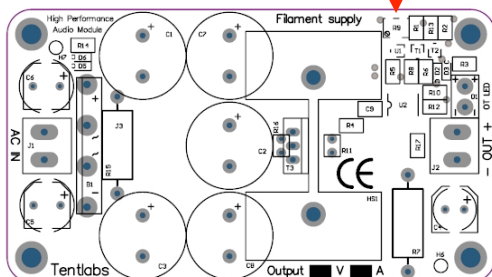
The 5A versions have bigger heatsinks, and wherever possible, the fins should stick outside the chassis, to allow airflow. Assure the fins remain vertically.

- Output voltage adjustment

The modules come adjusted according the order. However, in case other voltages are needed, or when some voltage loss across the wiring is detected, the output voltage can be trimmed.

Note: Use a small, suitable screwdriver (flathead, 1 mm) to avoid damage to the trimmer.

Adjustment potentiometer ↓



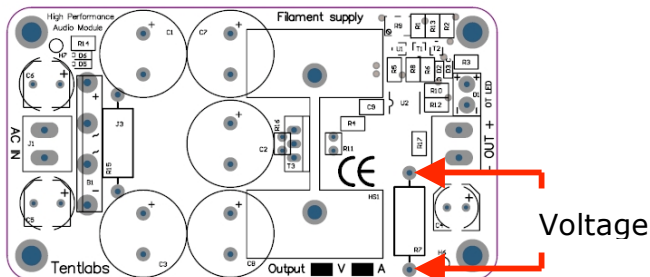
Procedure

- Switch amplifier off and assure no high voltages are present in the amp.
 - Connect a multimeter across the tube filament, at the tube socket.
- Choose a suitable range like 10 or 20V DC.
- Switch amplifier on
 - Let the voltage stabilize, and re-adjust the volume if required.

Switch the amplifier off, and repeat for other channel

- Filament current check

As a final check, after installation and adjustment, the filament current can be checked, by measuring the voltage across the big resistor. Note that this is a check only, and not obligatory.



Switch the multimeter to DC volts, range 100 or 200mV full scale. Switch the amplifier on, and measure the voltage across the resistor (unit: mV). Write that down (repeat for other channel). Since we measure a voltage, and we need info on current, we need to convert, using the resistor value (51 mΩ). The calculation goes like:

- Filament current = measured voltage (in mV) / 51

- Example:

We measure 64mV using a 300b. The actual current is: $64 / 51 = 1,25A$.

Output loading

A minimum output current of 200mA is required to assure correct function of all models

None of the filament supplies is short circuit proof

FAQ

- No or too low output voltage

Q: I checked the output voltage and it is below specification

A1: Check the AC input voltage and verify with the chart

A2: The current consumption of the circuit exceeds the specification

- Ripple in output voltage (hum out of speaker)

Q: I checked the output using an oscilloscope, and saw a ripple

A: It is very likely that the input voltage is too low, or the output load exceeds the specification. Check output current and eventually adapt the input voltage.

Specifications Electrical

All versions voltage adjustable between 1.5V and 12.6V, specify when ordering.

- Output current: automatically adapts to required level to reach voltage specified
- Input voltage should not exceed 1 V above specification
- Output noise normal versions < 20 uVrms (1 Hz - 20 kHz)
- Output low noise versions < 0,7 uVrms (1 Hz - 20 kHz)
- Output hum < 200 uVpeak at 100Hz / 120Hz
- Output impedance @ 0Hz: 10 mOhm at 0Hz.
- Output impedance > 5 Hz 10kOhm
- The heatsink is electrically isolated from the circuit and can be attached to a chassis
- Over-temperature shutdown with LED indication

Mechanical

1A and 2.5A unit:

- Total size 50*90*40mm (W*L*H, heatsink included, standoffs excluded)
- Weight each 90 gram (each, excluding packaging)
- Hole pitch 41* 81mm.
- Needs 10mm stand-offs to mount on chassis, supplied with modules.

5A model

- Total size 50*100*90mm (W*L*H, heatsink included).
- Weight 375 gram (each, excluding packaging).
- Needs M4 bolts to mount on chassis, not supplied with modules.

All specs and parameters subject to change without prior notice