AMP INRUSH
MLA-2500B

A good candidate to perform inrush current measurements is the Dentron MLA-2500B Linear Amplifier due to its high transformer inrush current, which often will trip the mains circuit breaker. We will also take a look at the tubes high filament inrush current, and the filter capacitors charging.

The MLA-2500B does not have any form of soft start, so using a soft start will limit or avoid the inrush current effects and thereby increase the lifetime expectancy of the amp, i.e. tubes and other components. For technical explanation of inrush current, see "Tech" at my Soft Start Site.
This amplifier is a 2000Watts PEP, amateur radio 1.8 - 30 MHz RF amplifier, using two Eimac 8875 ceramic / metal triodes which have an indirectly heated oxide coated cathode. This tube has the same characteristics as the 3CX400A7 / 8874, except for the cooling and plate dissipation.
The filament voltage, 6.3V ± 0.3 V, 3 Amps RMS per tube, is fed from the 6.3VAC secondary winding on the high voltage transformer.
Also interesting to know is that the amplifier tested, draws a current of 1 Amp RMS in the Stand By mode (after the inrush).

Test conditions:

Line Voltage	Amplifier mode	Ambient temp
230VAC, 50Hz	Stand By - CW / Tune	21 degrees C.

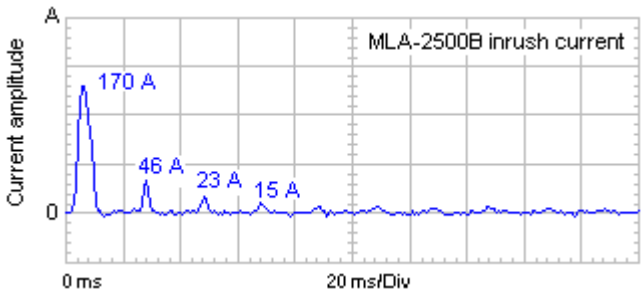
In the table below, you see the worst case measured transformer initial peak inrush current in two different test locations. Test location A has a higher mains impedance. Location B has a very low mains impedance (stiff) and therefore produce a greater amount of transformer inrush current. For comparison, the Drake L-4B Linear Amplifier transformer inrush current was also measured. For practical reasons, test location A was used for the further measurements in this project. Unless otherwise stated, the ampere figures are peak amperes.
The Delay Relay RL3 was removed during filament inrush current measurements.

Test location	Dentron MLA-2500B	DRAKE L-4B
A	170 A (120 A RMS)	140 A (99 A RMS)
B	230 A (163 A RMS)	200 A (141 A RMS)

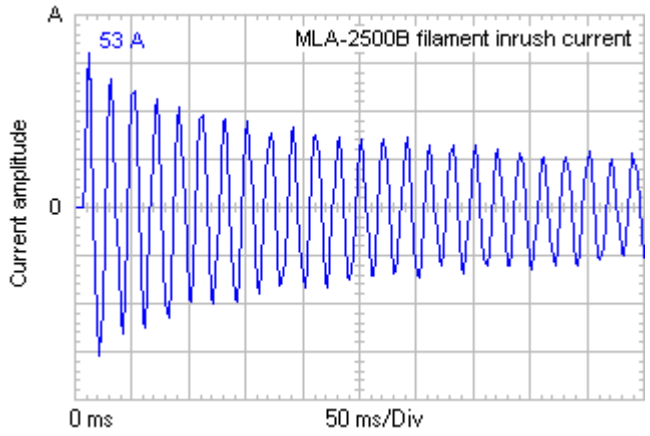
The rated nominal current for these amplifiers are about 10 Amps RMS.

MLA-2500B: The transformer inrush current is 12 times the rated nominal current in location A. In location B, the figure is 16 times.

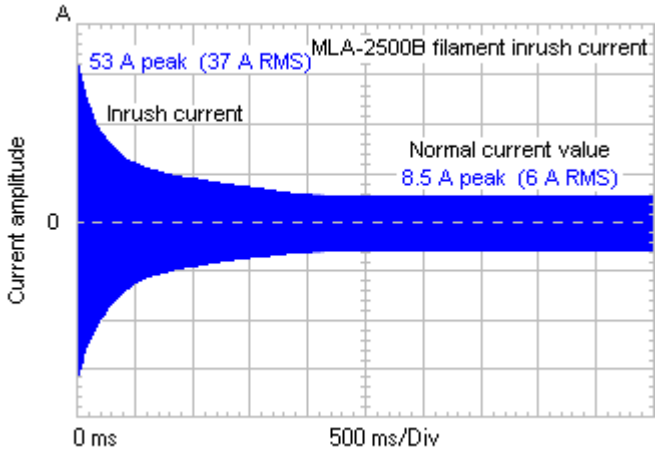
L-4B: The transformer inrush current is 10 times the rated nominal current in location A. In location B, the figure is 14 times.



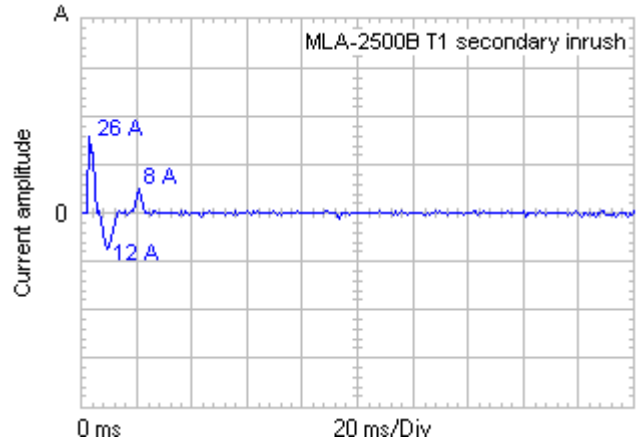
MLA-2500B transformer inrush current.
The waveform of the MLA-2500B inrush current measured at the transformer primary.
The duration of the inrush is about 70 ms, and in a decaying amplitude. There are no change in inrush current if the transformer HV secondary is disconnected from the rectifier diodes.



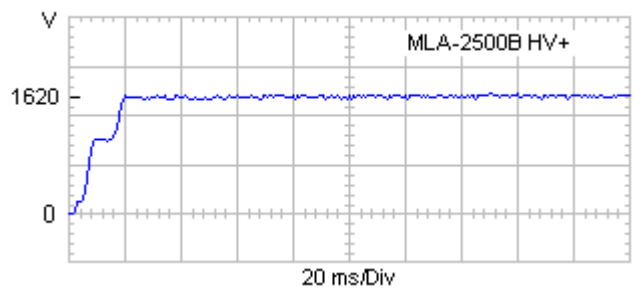
Filament inrush current.
At turn on with cold (ambient temp) filaments, the initial inrush peak current is 53 Amps (37 A RMS). That is about 6 times the normal value.
The filament winding is on the big HV transformer, using very heavy wire size. Better here would be to use a small filament transformer rated just enough to supply the tubes filament current. This would reduce the filament inrush current. Or you can use a step-start circuit of the transformer.
The filament inrush current should be limited to maximum two times the normal filament current to limit the stress of the filaments.



Filament inrush current envelope.
This is a graphical representation of the filament inrush current. The duration of the inrush current is about 2 seconds, until it reach the normal current value.
The reason is that the filament of a cold tube has about one-tenth the resistance of a hot filament. Therefore, at power-on, inrush current can be up to 10 times the normal amount, until filament temperature rises to the proper value.



Inrush current through the rectifiers.
At turn on, the discharged filter capacitors look like a short circuit and therefore causing an inrush current through the rectifier diodes. In the first half period, the peak inrush current is 26 A. However, the diodes used can withstand a peak forward inrush current of 400 A in a single half sine wave. The wires from T1 to the diodes and to the filter capacitors are long, small sized wires which limit this inrush.
But the filter capacitors are stressed.



High Voltage Supply.
This is the measured voltage at the electrolytic filter capacitors. With a soft start, the filter capacitors will have a longer charging time which mean less stress. (The first step in the charging curve is the charge of three filter capacitors during the positive half period of the transformer secondary voltage, and the second step is the charge of the three other filter capacitors during the negative half period of the transformer secondary voltage at initial turn on when capacitors are discharged).

Without a soft start, as seen from the measurements above, the inrush currents can cause the following problems:

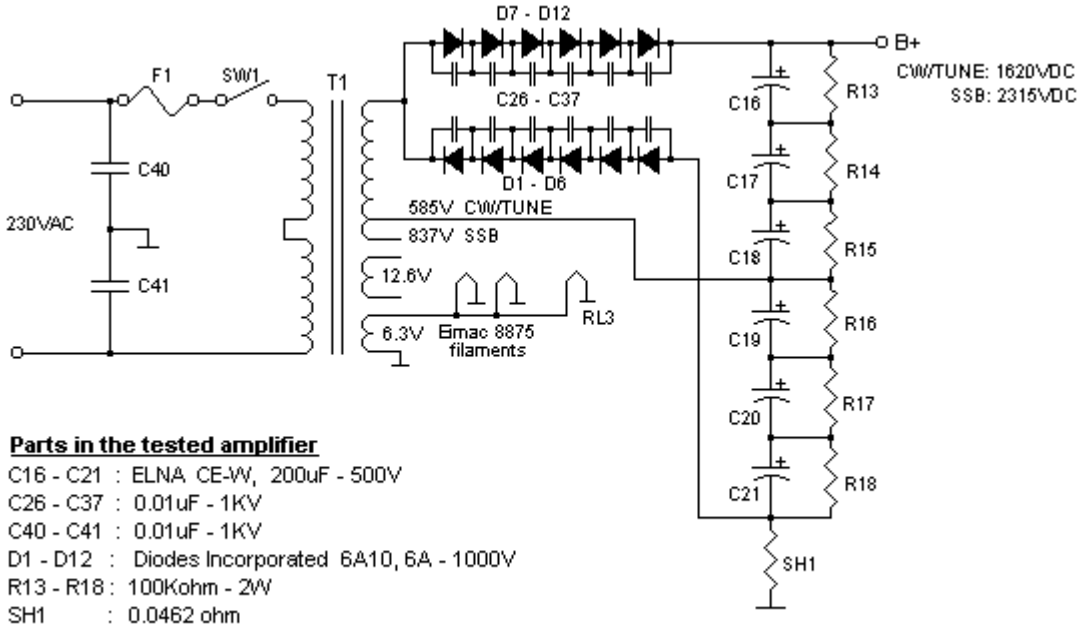
- Nuisance mains circuit breaker tripping.
- Flickering lights in your house.
- Destructive to On / Off switch. Its contacts are not designed for this stress, i.e. can cause pitted contacts due to the arcing of the contacts.
- Stress of filter capacitors and other power supply components. It is a known fact that the majority of failures occur at power on.
- Overloading of the filaments and therefore may shorten the life time of the tubes, (Filament inrush).

All these problems can be eliminated by use of a properly designed soft start. You will have a longer lasting amplifier.

There are several soft start solutions which can be used, like:

- A variac in the transformer primary to manually adjust the voltage slowly up to normal.
- A Step-Start. A current limiting resistor in series with the transformer primary. After power on, the resistor is shorted out after a set time by a time-delay relay.

Below is a simplified schematic of the MLA-2500B power supply. The high voltage supply is a full-wave voltage doubler. Note that the diodes and the filter-capacitors are other type than the original. The filter capacitors installed in this amp, manufactured by ELNA, is not produced anymore. They were used in the Kenwood TL-922 Linear Amplifier.



Parts in the tested amplifier

C16 - C21 : ELNA CE-W, 200uF - 500V
C26 - C37 : 0.01uF - 1KV
C40 - C41 : 0.01uF - 1KV
D1 - D12 : Diodes Incorporated 6A10, 6A - 1000V
R13 - R18 : 100Kohm - 2W
SH1 : 0.0462 ohm
F1 : 15A - 250V SB
RL3 : Amperite 6NO75T, Delay Relay

DenTron MLA-2500B Power Supply simplified schematic

Some of the measurements shown, should be taken with some caution, as this amp has other type of filter capacitors in the high voltage supply than delivered from the factory. The stiffness of the mains used should also be taken into account.

Acknowledgement.
My thanks to Hans Kise, LA1TCA for his help in this project.