Transformer Measurements and Calculations

Planeteer RF9000DCY, 6/14/02

In this analysis I measured the transformer in various line and load conditions to assess the suitability of the transformer in the Slow Blow tube mic preamp project.

Assumptions:
Sine Wave input power
Low line = 100V RMS (most consider 90V to be low line, but we'll assume we have "good" power)
High line =125V RMS (again, this is optimistic as high line is usually considered to be 130V)
Nominal line = 115V RMS
Diode voltage drop 0.7V (x2 for a bridge rectifier)
Ignore effects of ripple current in filtering caps (can be a significant factor in high current situations)
Pass-element style regulators require minimum of 2V "head" voltage to stay in regulation
Ignore "head" voltage in heat calculations
Power supplies must stay in regulation during low line and full load.
Assume regulators put out nominal voltage (ignore regulation accuracy)
Max number of channels are being powered with this transformer, so 3A for heaters, 100mA for Phantom and 200mA for B+ voltage (this is what was specified for the transformer)'
Assume B+ voltage is 230V DC – I don't know how high Slowie wants us to run this.
All heat sink recommendations depend on how much current the circuit you're building requires. If you have one channel it's half as much as 2 channels, etc. We need an estimate of how much current this thing is going to draw for each supply…

Worst case design and margin include making sure there is adequate voltage for regulation at low line, full load and that the high line full load voltage drop across the regulator times the current at full load does not result in more heat than can be reasonably dissipated.

Also high line, no load condition shows how much voltage differential you'll have across regulators (there is a threshold regardless of heat dissipated). And the regulation will show how much the voltage will vary from 10 to 100% load (pre-regulator).

12V (heater) winding

	Low Line	Nominal Line	High Line
No load	11.54	13.16	14.28
10% Load	11.46	13.13	14.3
100% Load	10.7	12.44	13.35
Regulation (%)	6.63	5.25	6.64

Low line, full load calculation:
10.7 * 1.414 – 1.4 –2 = 11.7 (should be 12V or greater) just shy of holding regulation in this condition.
May not be an issue since this is the heater power…
High line, full load heat calculation:
(13.35 * 1.414 – 1.4 – 12) * 3 A = 5.5W
Will need a decent heat sink if we have 3 A of heater current (multiple channels)
High line, no load: 14.28 * 1.414 –1.4 = 18.8V Gives us 6.8V max across regulator. No problem.

Phantom Winding

	Low Line	Nominal Line	High Line
No load	48.47	55.21	59.91
10% Load	47.97	55.16	59.78
100% Load	43.8	50.4	54.6
Regulation (%)	8.7	8.6	7.0

Low line, full load calculation:
43.8 * 1.414 - 1.4 - 2 = 58.5 Definitely adequate at low line, full load.
High line, full load heat calculation:
(54.6 * 1.414 –1.4- 48) * 0.1 A = 2.8 W
We will definitely want a heat sink for this one, but the phantom power doesn't usually source much current.
High line, no load: 59.91 * 1.414 –1.4 = 83.3V Gives 35.3 V max across regulator. This is not a problem if we use the TL783C part Slowie specified. It can withstand 125 V (absolute max!!!) across the input to output pins. Good part for this application, though it will need a heat sink and a 15 mA pre-load to operate correctly. No problem, we'll just put a ~900Ω resistor across it.

B+ winding

	Low Line	Nominal Line	High Line
No load	221.3	252.3	273.2
10% Load	213.0	247.8	266.0
100% Load	199.4	229.2	248.6
Regulation (%)	6.4	7.5	6.5

Low line, full load calculation:
199.4 * 1.414 – 1.4 – 2 = 278.6 Way more voltage than we need (assuming B+ voltage of 230V DC)! And it only gets worse with no load and increasing line voltage.
If we use a regulator, the input to output differential would be very high and the heat dissipated as a result of this differential times the max current gives us this calculation:
High line, full load heat calculation:
(248.6*1.414 – 1.4 – 230) * 0.2 A = 24.0 W – SERIOUS heat sinking required.

PLEASE, PLEASE, PLEASE BE CAREFUL WITH THIS WINDING. The peak-to-peak voltage can get to nearly 800 Volts!!!

I did let the transformer run at high line, full load for 10 minutes and there was no appreciable heating or change in the voltage.

Conclusions:

This transformer appears to be of adequate construction for reliable service in this type of audio application. The heater and phantom power sections are adequate for the specified current output with nominal line input voltage.
Concerns:
Inadequate voltage available for low line conditions for the 7812 type regulator.
Large B+ voltage with no regulator.
Lack of regulation for the B+ voltage will result in large variations in the voltage due to line conditions (other equipment affecting the high voltage supply on the tubes.

We could cascade regulators to share the heat and voltage differential, or insert a pre-load or some series resistance (or even a light bulb) to soak up some of this extra power. Or, ask the transformer manufacturer to adjust the winding ratio on this secondary to give us a more friendly resulting B+.
We need to ask Slowie where he wants us to run B+ so we can figure out what to do from here.