Measuring

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CRT heater voltages

Since a tube's heater voltage plays a vital part in determining its life, a means of determining this accurately is important. Most meters are unsuitable because of the nature of the heater current waveform. Denis Mott presents a design that converts the current to light which it then measures.

One of the most important voltages in a TV set or monitor is the CRT heater voltage. It's also one of the hardest to measure accurately. Since the CRT's heater voltage determines the life of the CRT, which is the most expensive single item in a TV set, it also in effect determines the life of the set. It's seldom worthwhile nowadays fitting a replacement tube. Thus correct running of the CRT's heater is vital.

The tube's heater voltage is usually provided by a winding on the line output transformer. It should be checked whenever a component in the line output stage has to be replaced. The most critical components here are the tuning capacitors, the S-corrector/coupling capacitor, any linearity or loss coils and, obviously, the transformer itself. If the value of a tuning capacitor changes by l00pF, or the HT voltage is not set correctly, the EHT and the CRT's heater voltage can vary by 5-10%.

Another cause of incorrect heater voltage is tube replacement. Maybe the original type wasn't available, so a substitute was fitted. In this case the heater specification should be checked. The last group of figures in a CRT type number, e.g. "0X01", indicate the characteristics of the deflection yoke, whose resistance and inductance play an enormous part in the tuning of the Line scan circuit and, ultimately, the heater voltage.

As you probably know, the CRT heater voltage is usually specified as 6.3V RMS. If the voltage is 6.5V or more the life of the tube's cathode will be shortened. Conversely, if the heater voltage is 0.2V or more on the low side the cathode will become poisoned, with the same effect.

Because of the nature of the heater current waveform supplied by a LOPT, it's pointless to measure the heater voltage with a conventional meter. A true RMS meter is also not accurate, because of the unsuitable pulse length or mark/space ratio. The only solution is to convert the pulse into a calorific value and measure that. One method is to convert it to heat and measure the temperature, another is to convert it to light and measure the intensity. The instrument described in this article does the latter. My original unit has been in use for over fifteen years, with only occasional calibration and no adjustments.

Circuit description

Fig. 1 shows the circuit diagram of the meter. In order to measure a voltage in a low-impedance circuit it's important that the source is not loaded with additional parallel resistance. A high input-impedance operational amplifier, IC1, is therefore used at the input. It's configured as a full wave rectifier and is a high power type to drive a lamp, LP1.

A BPW21 photodiode, PD1, measures the light output from LP1. It's connected as part of another operational amplifier circuit with IC2, that drives a moving coil meter, M!.

Stable positive and negative supplies are required to power the meter, so battery operation is not recommended.

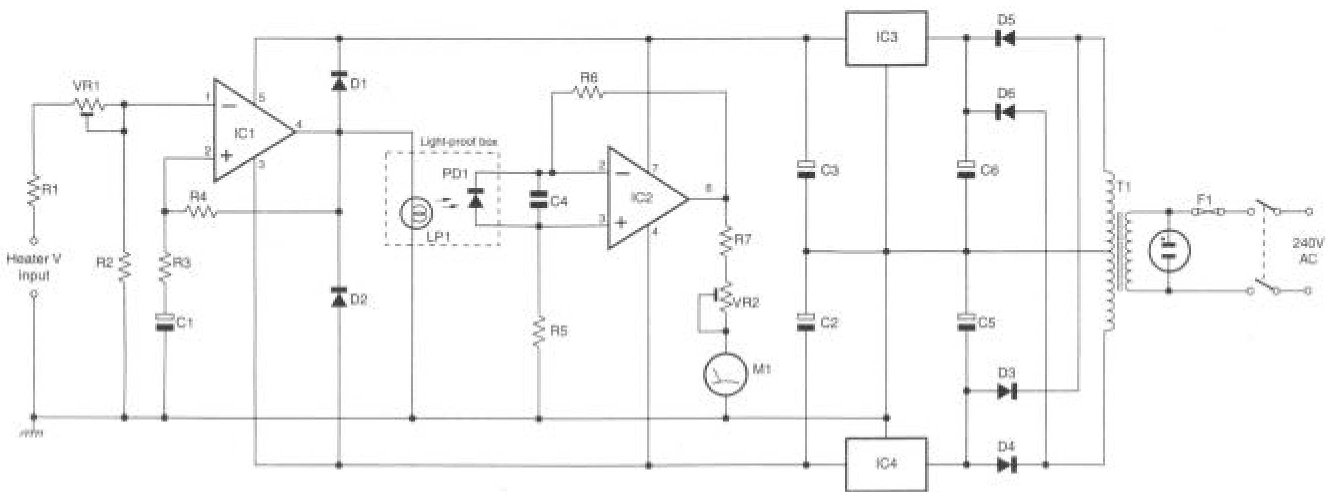

Fig 1: Circuit Diagram of the CRT heater voltage meter.

Construction

I've not included dimensions for a case since mine was home-made, but a suitable case from Farnells is listed in the components list. It all depends on the meter you chose to use and what's available in the 'junk' box. Obviously for more accurate readings, a meter with a large scale is preferable. The meter I use has a 3in. scale, with sensitivity to provide a 0-10V FSD reading. Any movement sensitivity within reason can be used: the value of R7 is selected to give an FSD of 10V, with VR2 included to provide a small amount of adjustment.

The only other important requirement is the optocoupling arrangement. I use a 12V, 0.18A MES-type lamp, which is mounted on the PCB with its glass nearly touching the photodiode - to prevent thermal coupling, a gap of about 2mm, is required. A lightproof cover must be provided for the optocoupler to prevent incident light affecting the reading. My cover was made of 1mm plastic sheeting painted black inside and out.

The dimensions of my case were copied from those old 'school-lab' type meter cases that have a sloping face.

Calibration

As the scale is non-linear, meter calibration must be done carefully. Fig. 2 shows the set-up for calibration. For optimum accuracy a true-reading RMS meter should be used. These are a little more accurate - and expensive - than a normal AC meter.

Before calibration, remove the meter scale and either cover it with paper or use some other masking to cover the original scale, leaving the curved line as cursor. Fit the meter back in circuit without its cover.

Set the variac and 10kOhm 10-turn potentiometer, VR3, for a true-RMS meter reading of 6.3V RMS. Adjust the value of the calibration resistor R7 so that the heater meter reading is at centre scale. Mark the scale 6.3V at this point, using a drafting pen and black ink. Then, increase the AC voltage above 6.3V and mark as required, also decrease it below 6.3V and mark. I marked the scale at 0.1V intervals between 5.8V and 6.8V. Refit the cover after marking the scale.

The scale is not linear. Recalibration will be necessary only if the lamp has to be changed. The circuit parameters were chosen to keep the lamp glowing moderately, so it should last a very long time.

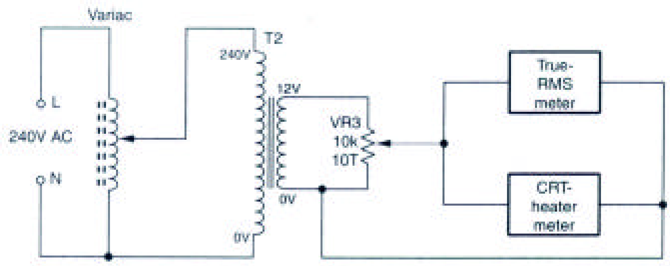

Fig 2: Calibration Setup.

Use & Operation

This may seem to be obvious, but care must be taken to get correct readings. The meter has an input and ground connection. These must be connected the right way round: I've experienced incorrect readings when the wires are crossed over.

Measure the voltage with a steady beam current - a LOPT-derived heater voltage will vary as the beam current changes. I use a mono grey-scale or a test pattern to ensure a 60 per cent average beam current.

Always find the heater pin and ground and connect the meter before applying power. If the meter is connected incorrectly its input may be damaged.

Ideally, the meter reading you obtain should be 6.3V, but as we don't live in an ideal world, +/- 0.1V is acceptable.

If the EHT voltage and width are OK but the heater voltage is high or low, adjustment of the value of the resistor in series with the heater supply may be advisable. Check that the EHT and other voltages are OK first.

In Conclusion

This meter will not be in use every day, but for the cost of the components, it's an invaluable instrument in any busy workshop.

Components List

Item	*Specification*	*Part No**
C 1	22uF, 25V Radial	VH26D
C 2/3	100uF, 25V Radial	VH37C
C 4/5	1,000uF, 25V Radial	VH51F
C 6	100nF, 50V Ceramic Radial	BX03D
R 1	390K, 0.6W 1% Metal Film	M390K
R 2	22K, 0.6W 1% Metal Film	M22K
R 3	680R, 0.6W 1% Metal Film	M680R
R 4	22K, 0.6W, 1% Metal Film	M22K
R 5/6	4.7M, 0.6W 1% Metal Film	M4M7
R 7	Adjust on test	
VR 1/2	22K Horizontal Carbon Presets	UH04E
IC 1	TDA2006	WQ66W
IC 2	LM741	QL22Y
IC 3	LM7812	CR16S
IC 4	LM7912	AV20W
D 1-6	1N4001	QL73Q
LP 1	12V, 0.18A MES Bulb	BT83E
PD 1	BPW21 Photodiode	Farnell 327-440
M 1	0-10V Moving Coil Meter	YJ96E
T 1	12-0-12V, 250mA	YN16S
F 1	315mA delay, 20mm	GL54
S 1	DP Mains Switch With Neon Indicator	KU99 or YX65
	20mm Fuse Holder	KU33L or RX96
	Case	Farnell 722-418
	Light Proof Box 35x15x12mm (Outer Dims)	

*Maplin unless otherwise stated.