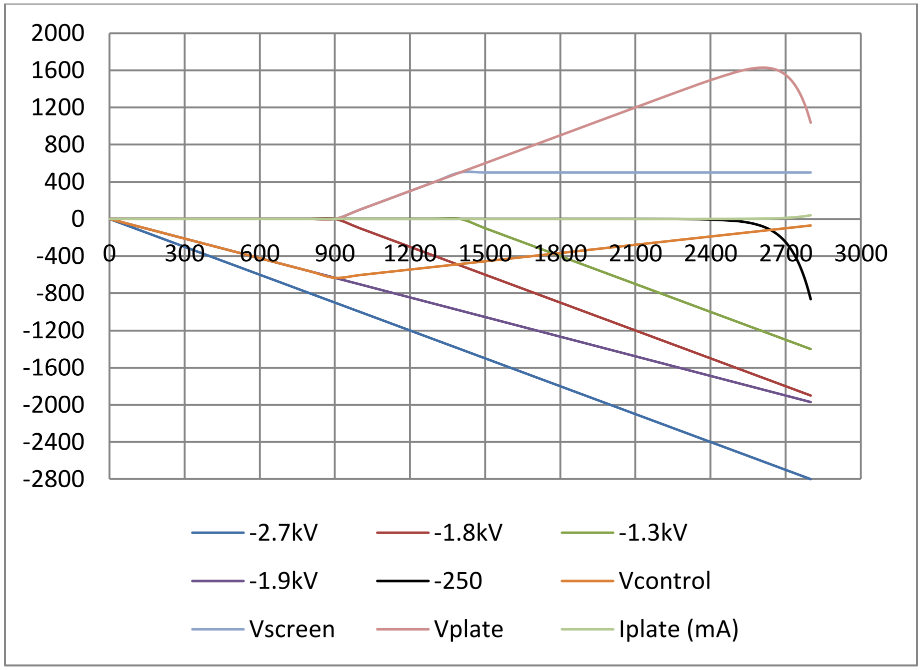
Modulator F1123 Bias Supply as seen by Trevor Butler on 5/12/2011

The modulator bias supply uses a series of capacitors, zener diodes, rectifier diodes, and simple resistors to create a power supply that is well regulated to line voltage fluctuations. I have attempted to understand the inner workings of the power supply. The transformer T4 puts out 3020 Vrms, which is 4271 Vpeak. This is applied through the 10 ohm and 1kohm resistors to charge the capacitor C1. The peak charging current is V/R = 4271/1010 = 4.2 Amps peak or 1.5 Amps average per phase, which is about 4.5 Amps assuming all three phases. This is why the current meter pegs when turning on the breaker. If the capacitor C1 was not connected to anything, such as the series regulator tube or the rest of the bias circuitry, it would float. In the actual system, the negative terminal of C1 is connected via many rows of resistors to ground. Since, up to the moment of turn on, these resistors are not carrying any current, this node is at ground potential.

After throwing the breaker, the capacitor charges up to approximately 4.1 kV (somewhat less than the 4271 Vpeak to resistive losses and other small differences in transformer ratios, etc.), this voltage is applied to the series regulator. Since there is initially no current in the resistors R18-R20, the grid of the series regulator is 0 volts. This turns on the series regulator tube to conduct current, which in turn pulls the voltage on the anode from ~4.1kV to eventually 1.4 kV. Since the capacitor still stays charged to 4.1 kV, the bias supply output then moves from 0 to -2.7 kV to compensate for the series regulator turning on. As the voltage rises on the bias supply, the suppressor (grid #3) and filament of the pentode are pulled negative with respect to the anode of the tube, which is initially at 0 Volts. From looking at the 4E27(A) tube curves, at 1550 Volts on the anode, 500 Volts on the screen, and -100 Volts on the grid (all these numbers are in relation to the tube filament/suppressor) that the tube conducts around 11 mA. It is this current which negatively increases the voltage on the pentode anode & series regulator grid from 0 to -250 Volts through R18-20 resistors, which “valves” down the current drawn by the anode of the series regulator. This can be seen in the plot. This creates a feedback loop to regulate the voltage.

For example, if the bias supply voltage rises above the nominal -2.7kV to say -2.8 kV, the curves plotted below show that V control rises from -100 Volts to -70 volts. This will in turn drive the pentode harder, creating more plate current. More plate current will increase the current through the R18-R20 resistors, which increase the voltage on the series regulator grid from -250 to <-250Volts. This increase in voltage will cause the series regulator anode to draw less current. If the series regulator draws less current, then the voltage rises from the nominal 1.4 kV. As this voltage rises, the bias voltage output of the supply drops down. This is the feedback mechanism that regulates the voltage of the bias supply. Also at 1.4kV on the plate and -250 Volts on the grid, the tube curves for the Eimac 3CX3000F1 show a current draw of 100 mA, which is the bias current seen on the bias PS meter in the modulator.

To turn on the modulator, the 6.5kV plate supply is modulated by the 6544 to change the voltage on the F1123 up from -2.7 kV to conduction. While the switch tubes are conducting, the is a lot of voltage across R28, which adds to the bias supply current meter reading since this power supply has to overcome this loading. To make a worst case calculation, assuming the F1123 switch are switched to the maximum 6.5kV, the resistors connecting the bias supply to the inner deck have up to (6500+2700=9200Volts) for up to 500 us, which gives about 131 Amps of peak power, or about 1 Amp average power. However, since the voltage on grid of the F1123 switch tubes is much less the 6.5 kV and since my calibration for average current assumes a 500 us square pulse instead of the <400 us ramped pulse we use today, the current average is less than 1 Amp, and typically in the 200-400 mA range. This is in addition to the 100 mA needed to bias the series regulator. This is why the bias current slowly rises as the modulator is turned on.



Also, after looking at the specifications of the 4E27, it appears to also work with our power supply. I have listed the specs below. I would purchase at least one of the 4E27 and run them and buy any 4E27A’s that we can find on the surplus market

	4E27A	4E27	Modulator
Max Plate Voltage	4000	2000	1550
Max Screen Voltage	750	750	500
Max Control Grid Voltage	-500	-200	-100
Max Plate Dissipation	20 Watts	75 Watts	18 Watts