XMM Optical Monitor

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Blue Detector HV Unit Electronics Design

DOCUMENT: XMM-OM/MSSL/SP/0047.01 18-May-94

Xmm-Om High Voltage Power Supply

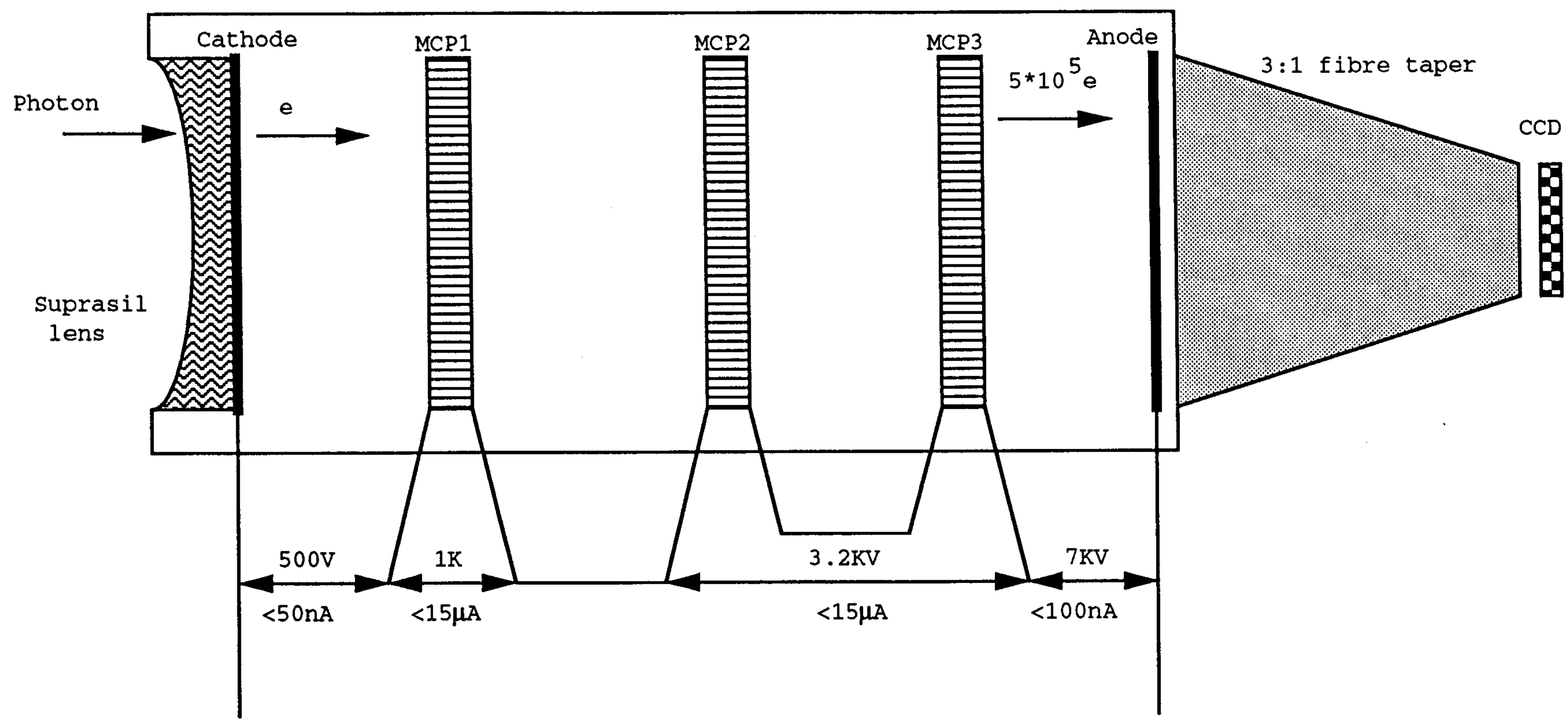
Summary

Four high voltage (up to 11.7KV) converters have to be designed and constructed for the XmmOm project. The space volume for the converters is extremely small and would, I think, introduce a challenge to most designers.

Much of the available space will be taken up by the voltage multiplier and step-up transformer, for this reason the switching frequency should be made as high as possible. The higher the frequency the smaller the physical size of capacitors, inductors and transformers. Peak pulse current would also reduce so reducing radiated E.M.I.

For this type of supply the high voltage transformer limits the converters switching frequency. Winding capacitance and the large inductance value of the secondary turns produce a low self resonance frequency, for high efficiency converter frequency must be kept much lower than this. Methods of increasing the self resonant frequency of the transformer are now being investigated.

Figure 1- XmmOm Image Intensifier.



Design Concept

A high voltage power supply is required to power an electron multiplier tube.

Figure 1 shows a basic diagram of the tube with maximum operational voltages and currents.

The converter is to run from a 25V line so large voltage multiplication is required. Two methods of conversion were considered, resonant and pulse width modulation (PWM).

Both serial and parallel resonant topologies were investigated. Resonant converters have not caught-on in the switch mode power supply industry even though at first they seem to offer some advantages. Here is a list of some disadvantages that may put designer off using them:-

1/ Generation of circulating currents 3 or 4 times those of PWM supplies.
2/ They are more susceptible to variations to component tolerances, temperature drift parasitic capacitor, inductance and general wiring layout.
3/ Technical difficulties in controlling the output over a wide dynamic range.

Similarly for the above reasons the PWM supply was chosen over the resonant converter for this particular project.

Pulse width controlled supplies are well documented and provide a standard proven method of power conversion which is relatively insensitive to parasitic components, temperature drift etc.

Power control is achieved by varying the on time, ton, of the electronic switch while converter running frequency is kept constant, see figure 5. The output power is proportional to ton^2 so a large controllable power range is possible.

Four power supplies should be sufficient to run the tube. There are several methods of connection, three are outlined below.

Method 1. the output from the 4 supplies are connected in series to produce the correct bias voltages (see figure 2). This system requires the lowest output voltage from each supply compared with the following methods of connection and would reduce the size of the voltage multiplier. However high voltages would be connected directly to the transformer secondary winding

Figure 2- Method 1 of HV connection

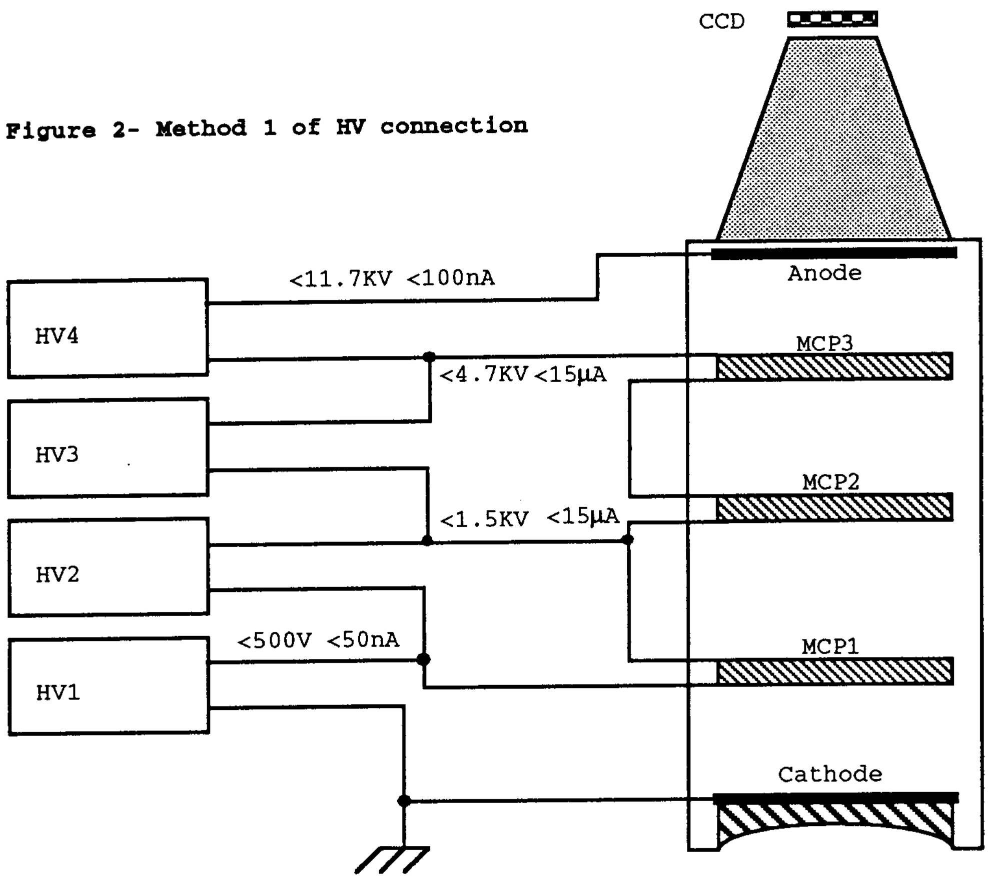


Figure 3- Method 2 of HV connection.

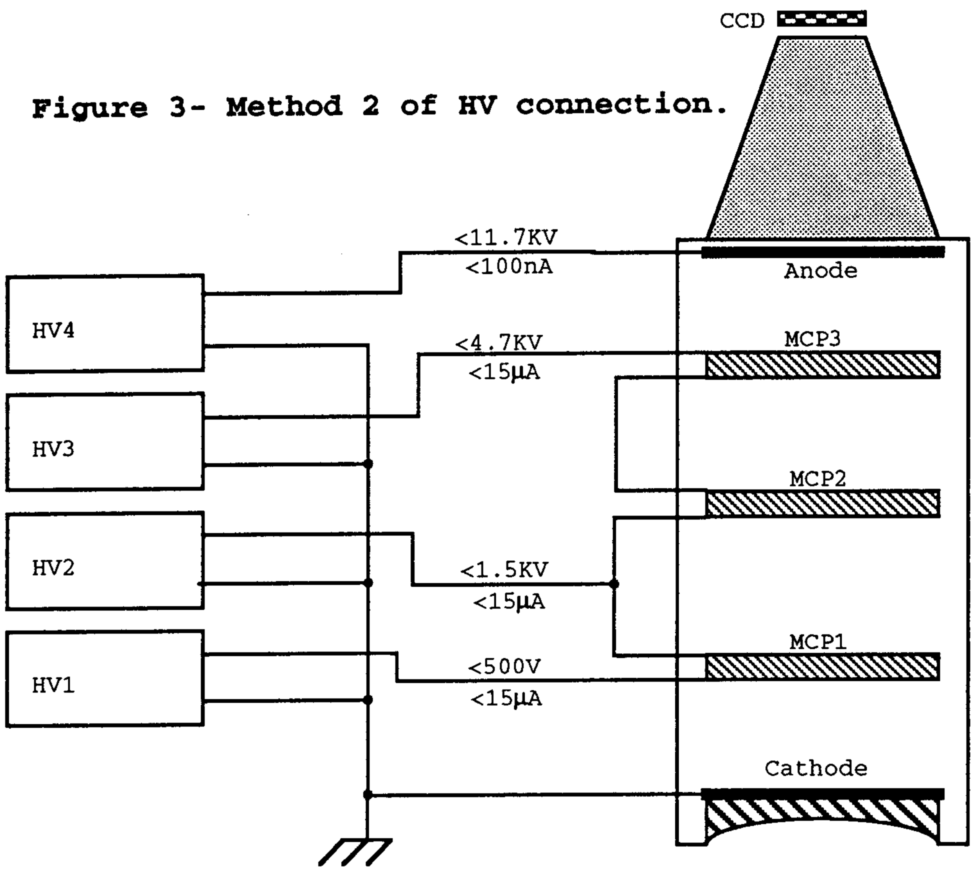
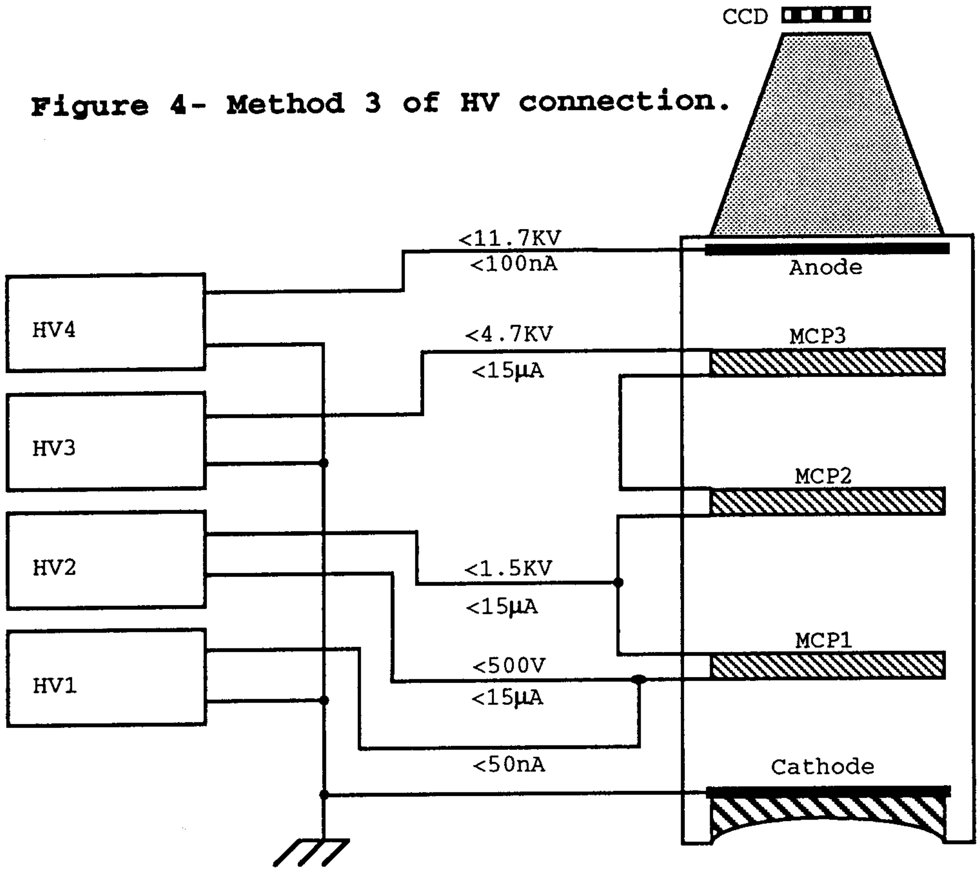


Figure 4- Method 3 of HV connection.



which may cause serious corona and breakdown problems within the transformer. To prevent this the transformer windings have to be separated a distance leading to an unacceptable large physical size.

The second method of parallel connection requires a higher voltage being developed by the voltage multipliers, this is simply achieved by the addition of more stages (figure 3). The transformer outputs are now isolated from the high voltage output by the multiplier.

The 3rd method of connection involves a combination of serial and parallel connection (figure 4). The 1st and 2nd outputs are connected in series while the 3rd and 4th are connected in parallel, this arrangement reduces the amount of current required from HV1 and consequently the response time is also reduced so speeding the on/off switching of the tube.

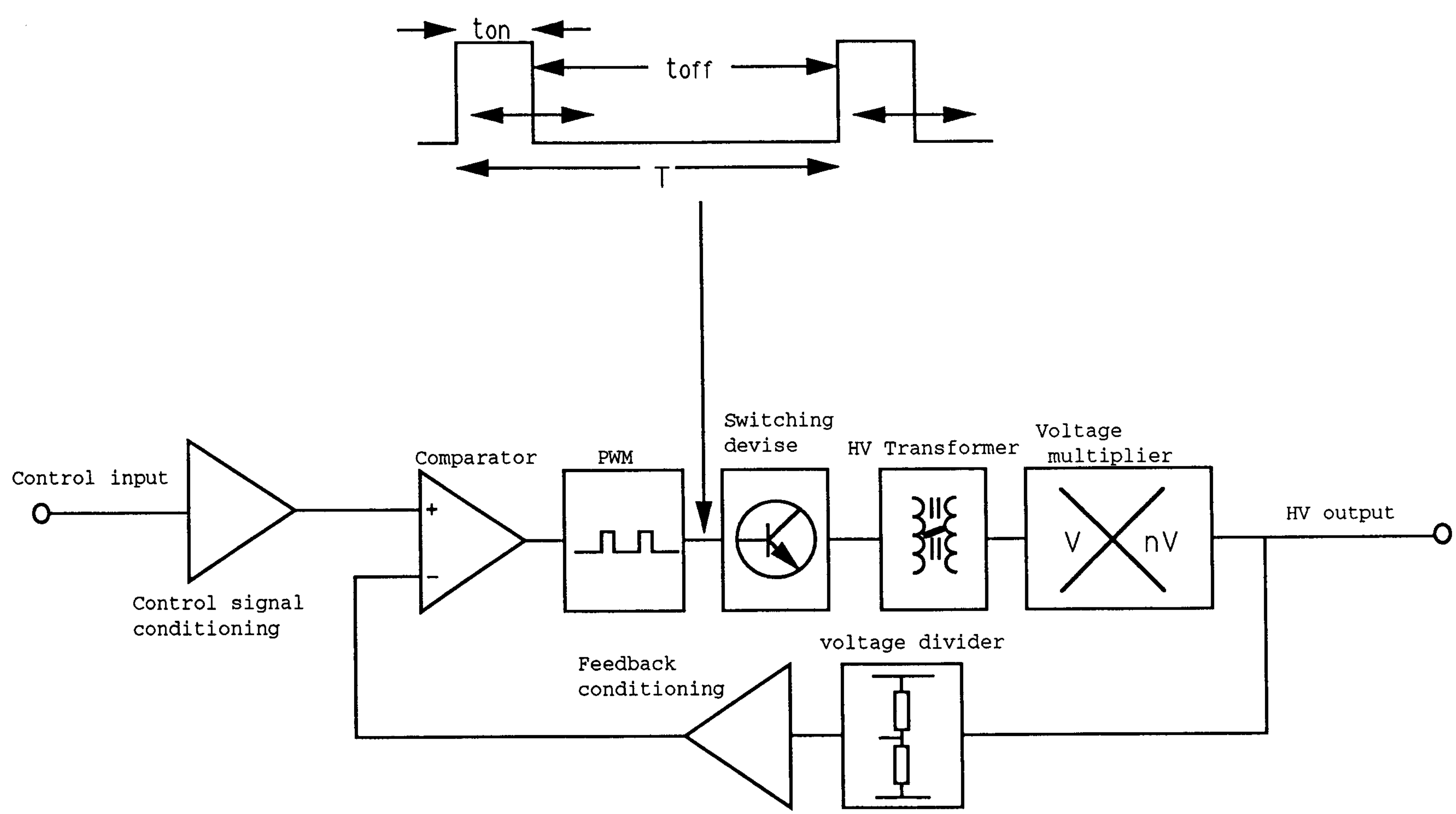
Figure 5 shows a block diagram showing the basic converter elements.

The heart of the converter is the 1524 pulse width modulator chip which has been used for a number of space qualified converters. The chip contains most of the necessary hardware for PWM control allowing the designer to use few external components.

An NPN bipolar transistor driven by a transformerised baker clamp will be used as the switching element. The baker clamp provides the transistor with base currents and voltages for producing fast switching transients and high voltage protection. The transistor is loaded by the step-up transformer used to increase the switching voltage of 25V to over 500V and to store energy in during the ton period. Energy stored is then released during toff into Cp (see figure 6) of the secondary circuit, during the next ton period this stored charge is pumped into C1. This charge then reduced by the load current passes on to the next capacitor along the chain, C2. The process continues until the diminished charge reaches the final capacitor Cx at the output where the remaining charge is finally reduced to zero. The output voltage is then attenuated by a resistor divider and fed back to the conparator for voltage control and regulation.

Ideally the switching frequency should be made as high as possible since the high frequency allows the use of smaller capacitors, transformers, inductors and also reduces electromagnetic radiation. Component size reduction is of prime

Figure 5- Block diagram of Converter.



Circuit Diagram 16/5/94

FIG 6

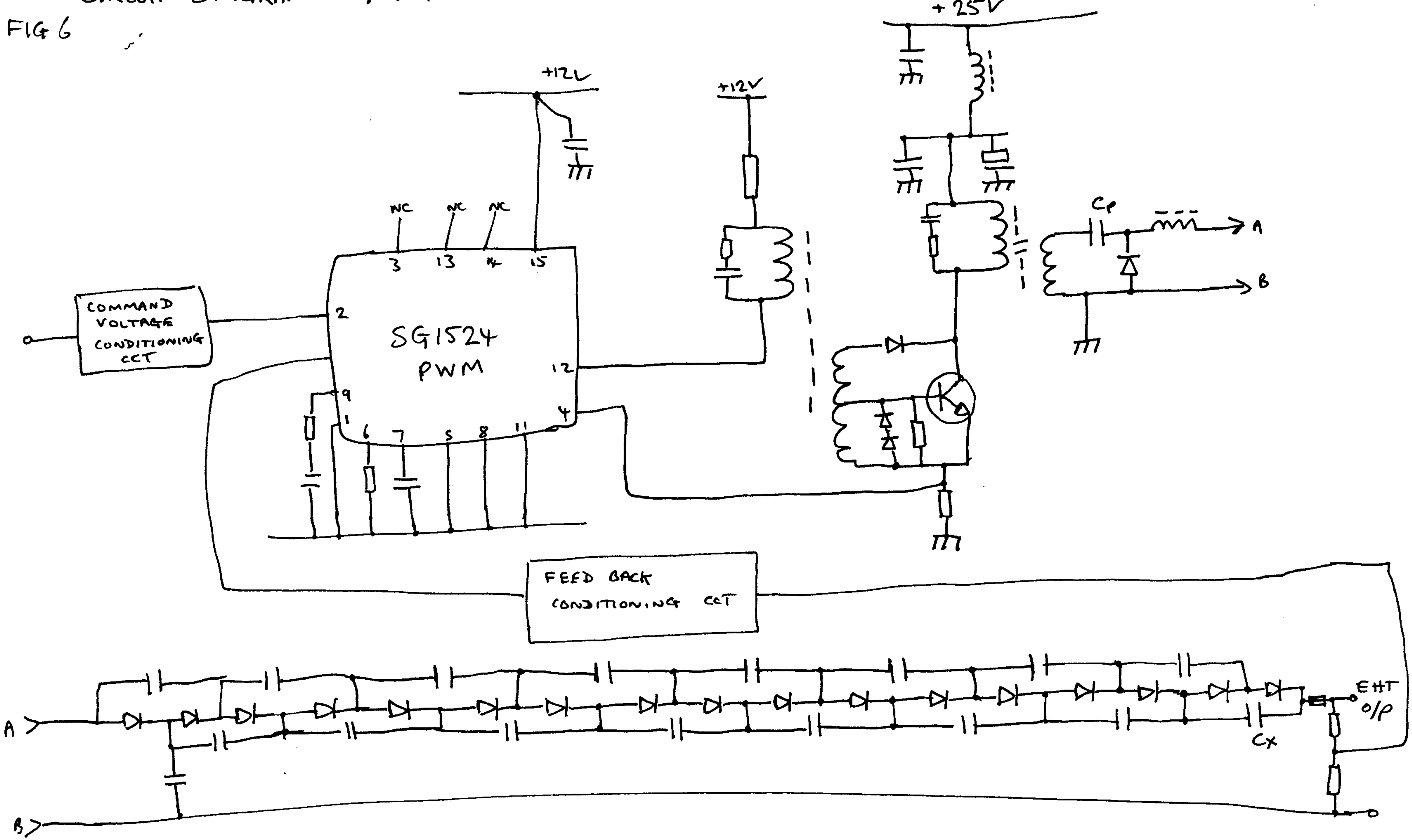


Figure 7- High voltage transformer windings.