

Luxeon PWM method applied to a CRT display.

Preamble.

In Vol. 31 No. 4 of the newsletter Jeremy Jago outlined a novel display method for NBTv on a scope screen. I was going to use this in conjunction with a CRT display which had no internal graticules to obscure the picture, but as I was planning to build this from the 'ground up' I decided to use the same PWM method as Steve Ostler has used in his Luxeon display, except the display device here is a CRT.

An outline of the differences between this system and the more conventional mechanical display is in order, this is interim; and will be developed in time to cater for more lines and a higher frame rate:-

- 1). Scanning is left-to-right for the lines and top-to-bottom for the frame, the same as 525/625 TV.
- 2). The aspect ratio is 4:3, slightly landscape, again the same as conventional TV.
- 3). There are 48 lines each consisting of 64 pixels, the line rate is 600Hz and frame rate is 12.5Hz.
- 4). This is a sync-less system with (currently) the exception of a frame reference.
- 5). There is black-level clamping ensuring true luminance values.

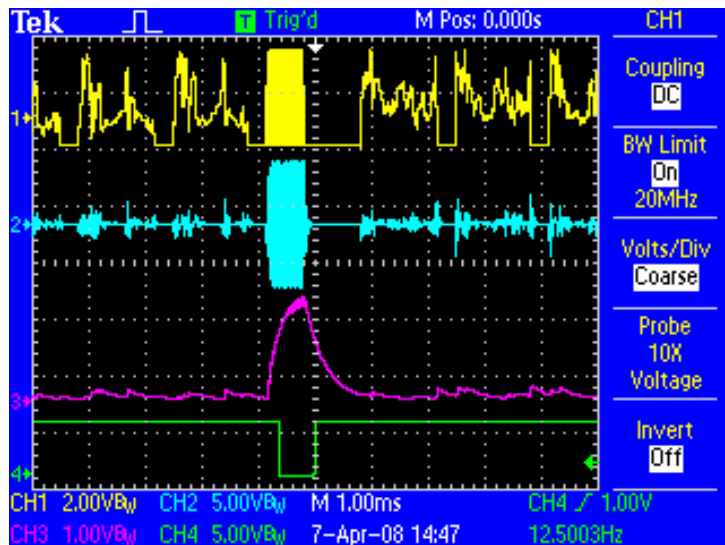
Caution.

This unit uses both high AC and DC voltages and the author of this in no way accepts any responsibility for any incident, injury or fatality of those attempting to replicate it. If you're not used to working with high voltages, get some experienced supervision. Although this is considered a low-voltage CRT, there is nigh on 1000V of potential difference in parts of the device. Do not work on this alone.

Basic Signal Characteristics.

The source material is from a .wav file played back on a PC; this is sampled at 48kHz with eight-bit video resolution. At a line rate of 600Hz this yields 80 pixels per line of which only 64 contain active video, the other 16 at the end of each line are set to black level. This was originally for black-level clamping but it proved unnecessary, more on this later.

There are no sync pulses used with the exception of a 'frame reference' consisting of 16 cycles of full amplitude 24kHz at the start of line 48. This is followed by a black reference for the remainder of the line where the black-level clamping is done once per frame. Sadly we lose one line in 48, but I plan to recover line 48.



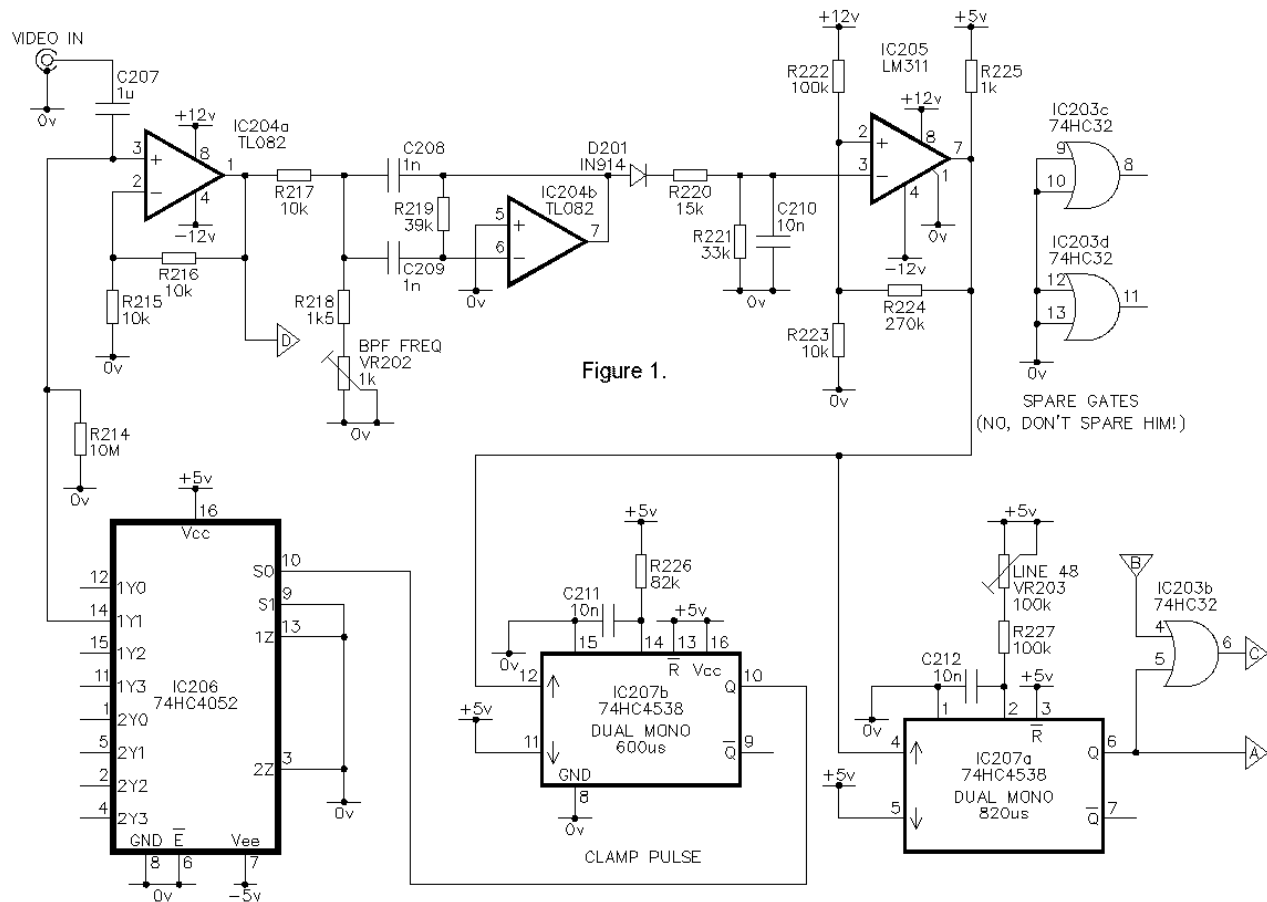
The snapshot to the left shows the input waveform from the PC (yellow) with the video utilizing the entire 8-bit resolution and the 24kHz burst for line 48 identification followed by the black reference.

The cyan trace is the 24kHz bandpass filter output (IC204b pin 7, Fig. 1 below). The magenta trace is the envelope detector output (C210) and the green trace is the comparator output (IC205 pin 7).

This results in a slow drift in line-rates, around one line in 90 seconds. But with a refresh every frame results in an error of around one tenth of a pixel per frame. I did consider adding a 24kHz reference signal to the right audio channel which would have made things very easy, but I felt this would be cheating.

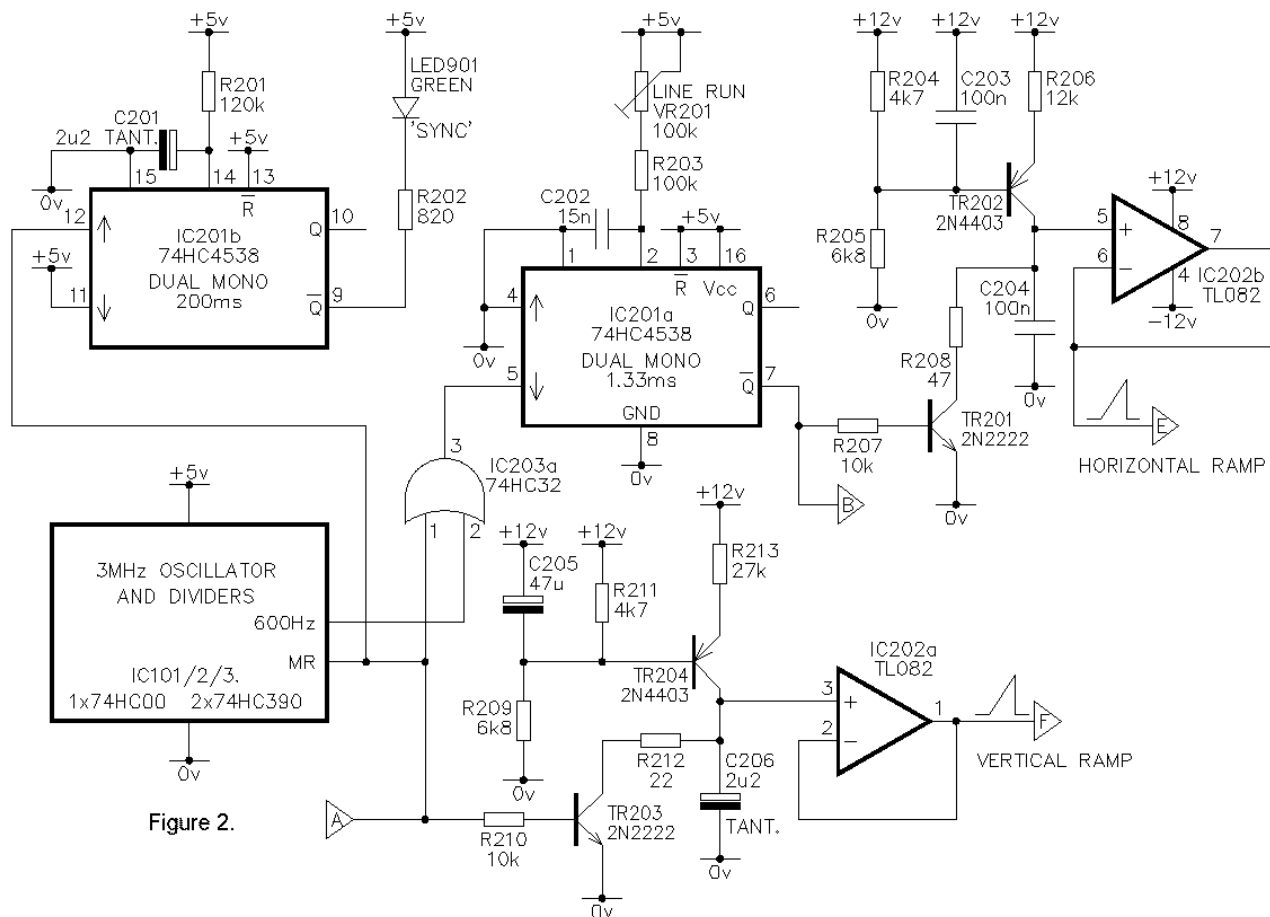
The circuits.

Figure 1 shows the input side of things where the signal from the PC is increased to 7V p/p and followed by a band-pass filter to extract the frame 24kHz burst. Flat-out my PC outputs 3.5V p/p, adjust R216 to suit other levels. IC204b is the band-pass filter that detects the 24kHz burst followed by a simple detector comprising D201 and associated components. See waveform above.



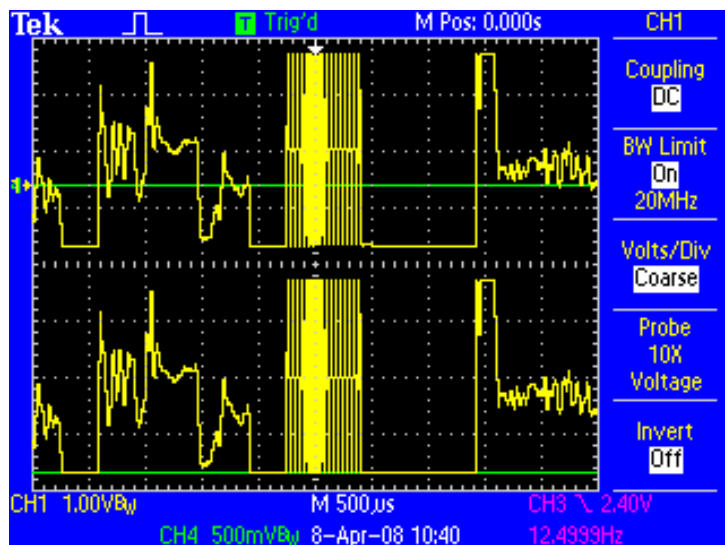
This is then cleaned up by IC205, a comparator which generates a pulse that triggers IC207a and IC207b. IC 207b is the black-level clamping monostable that enables IC206 welding the black reference to zero volts that follows the burst in line 48. I did try a LM/NE567 tone decoder, but with only 16 cycles to work with it was susceptible to false triggering from the actual video waveform.

Once the 24kHz frame sync is detected IC201b is continually retriggered to illuminate a green LED which indicates the presence of a NBTv signal with frame reference.



Due to the slight difference in clock frequencies all the counters in the division from 3MHz that generate the timing of the timebase waveforms, both horizontally and vertically, are reset at each detection of frame sync (Fig. 2). IC207a generates a pulse to add the missing line one sync when the counters are reset to zero. IC203b is a 'leftover' from previous versions of this, it's not needed. Pin 5 could be at ground or IC203b could be omitted entirely.

IC201a in conjunction with TR201 and TR202 generate the horizontal deflection waveform at 600Hz. In a similar manner TR203 and TR204 generate the vertical ramp waveform.



Black level clamping is performed by IC206 (Fig. 1) driven by the clamp pulse from IC207b. The waveforms to the left show the normal AC-coupled output of the PC at the top, the green trace indicating ground/0V. The lower one shows the black being clamped to ground.

The deflection circuits that feed the CRT plates are conventional differential stages, TR301 to TR306 (Fig. 3). C301 and C305 were not necessary in this slow speed application.

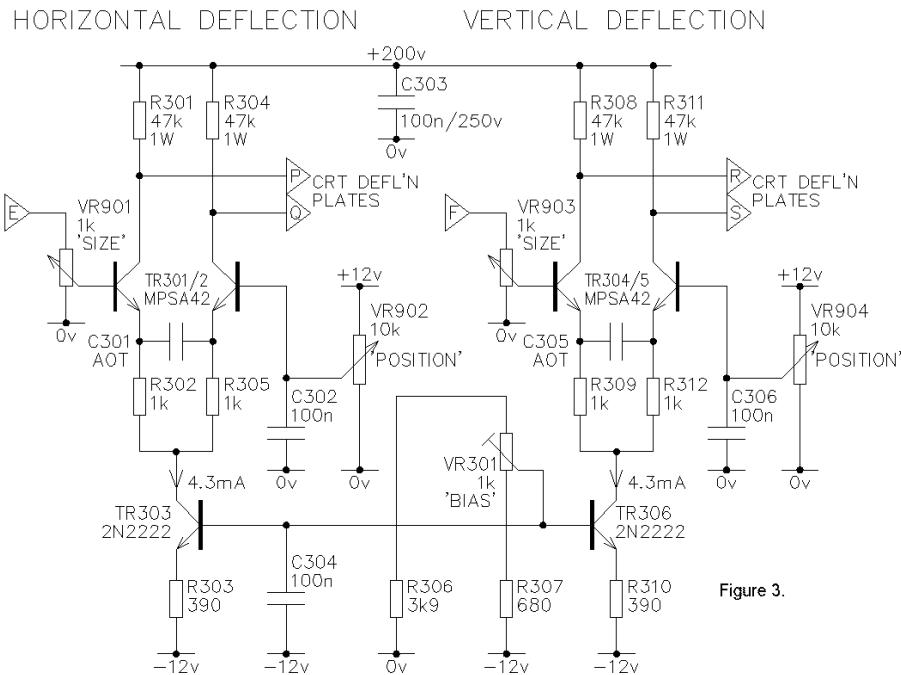
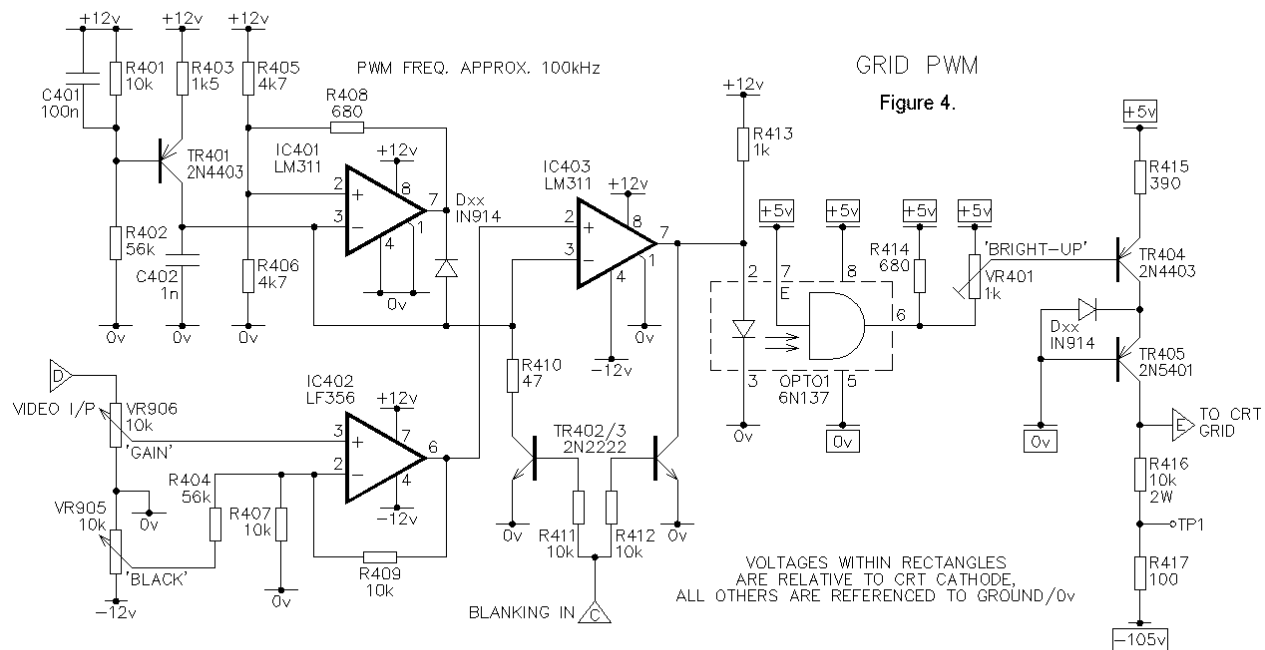
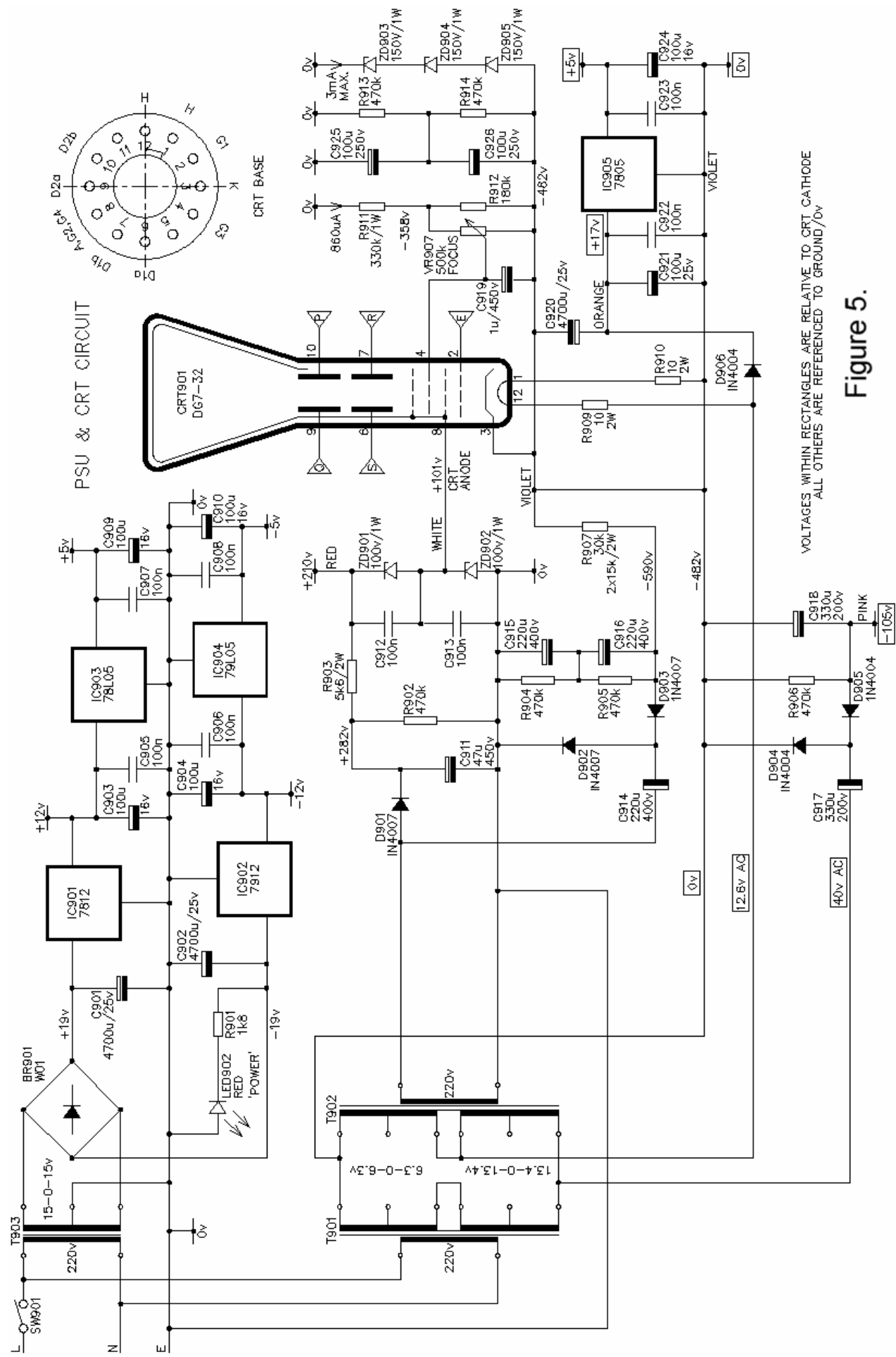


Figure 3.

Fig. 4 shows how the PWM of the grid is done; it is in essence the same as Steve Ostlers' version for his Luxeon display adapted via a fast logic opto-coupler to isolate the nasty voltages around the grid and cathode potentials of the CRT. TP1 and R417 were added to observe the PWM waveform at the grid without the scope probes capacitance slowing things down. TR402/3 stop the PWM oscillator during blanking/retrace time which makes it synchronous and shuts off the drive to the IR LED.



As ever, CRTs need a handful of voltages in addition to the low-voltage supplies that are required, hence the complexity of the PSU and CRT circuit that follows (Fig. 5). This was not helped by the unavailability of suitable transformers, hence the use of back-to-back transformers and the requirement of voltage multiplication. The transformers used have some strange voltages, but I had them to hand. R909 and R910 were added to the CRT heater circuit to reduce the inrush current when first switched on cold.



The Results.

So, after all that effort what's the upshot of it all? Pictures are worth a thousand words...



You can see the vertical burst in the first half of the last line. I deliberately didn't blank it as I wish to be able to see the visible effects as I modify it.

Further Developments.

Using a 7cm (3") tube with a nominal line-width of 0.5mm this is about the limit of resolution for a DG7-32, next it's going to be a 13cm (5") 5ADP1 with an increase in the number of lines to 60/80/96, and a minor increase in voltage to 3000V. Another advantage of the 5ADP1 is that it has a flat faceplate so the curvature distortion introduced by the DG7-32 should be reduced or eliminated.

However, seeing as the 3" display was already in operation it was a simple task to change it to being a 72-line display. This was done by reducing the frame rate to 6.67Hz, the flicker of course was greater than at 12.5Hz. Only one resistor needed changing, R213 was increased to 47k, VR201 and VR203 having enough adjustment range...but only just! The frequency dividers were altered to provide a line rate of 480Hz as opposed to 600Hz. Some sample screen-shots follow...



This display and the methods used were mainly a 'proof of concept' exercise; the display will again be torn down and used for something else.

If anyone should have any comments or questions please contact me at the e-mail address below.

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