MODIFYING A SMALL 12V OPEN FRAME INDUSTRIAL VIDEO MONITOR TO BECOME A 525/625 & 405 LINE MULTI - STANDARD MAINS POWERED UNIT. H. Holden. (Dec. 2017)

INTRODUCTION:

Small open frame video monitors were made in large quantities for industrial applications. These include use in various Vending machines, CNC machines, Industrial Computer systems and other applications where a video display was required.

Generally, but not always, the CRT's used were green phosphor (P31) types. However there are still many small P4 replacement tubes available and the monitors are readily converted to P4 or white screen types this way for TV applications. The photos below show one of these monitors. There are many generic types, these ones are Panasonic brand.

I had a few 5.5" diagonal industrial monitors, some of which I had already fitted with P4 CRT's. However, these monitors have no internal 12V power supply, so one would have to be added unless the monitor was run from a wall-wart supply which is a less favourable option. These monitors also have no front panel and no external controls and no outer case. All the controls are PCB presets.

Fortunately these monitors normally work well as they are on 525 line-60Hz or 625 line-50Hz video signals. However a height adjustment is required as a 60Hz signal produces a lower picture height than a 50 Hz one. Also, sometimes a small vertical hold adjustment is required between these two standards. Actually, there is a setting of the vertical hold where it locks well to either 50 or 60Hz syncs. And perhaps a small H. hold adjustment for perfect H picture phase (position) between the 15734 Hz and 15625 Hz line sync rates.

In other words the 525/625 line standards/systems are close enough not to be an issue, that is, if the external hold controls are present for an enclosed unit to make any required adjustments.

However the 405 line standard is quite different. To compare the line scanning frequencies and approximate durations:

625 - 15625 Hz or 64uS scan time per line

525 - 15734 (or 15750 old standard) Hz or 63.5 uS

405 - 10125 Hz or 98.7uS

At least the 405 line system has no vertical rate issues as the vertical syncs are 50Hz.

MODIFYING THE MONITOR:

The plan was to fit the monitor with a rear panel and add external controls for Brightness, Contrast, H. Hold, V. Hold and Height. This allowed for easy use on the 625 or 525 line systems.

I had some high quality 3mm thick pre-anodized aluminium plate from the Akihabara markets in Tokyo, which was almost the perfect width to make an outer case with a carry handle. The fact it didn't quite extend to the front CRT escutcheon allowed for ventilation at the front corners, combined with some 7mm holes added to the 1.5mm thick hand made rear panel. The side panels are tapered to match the upward tilt.

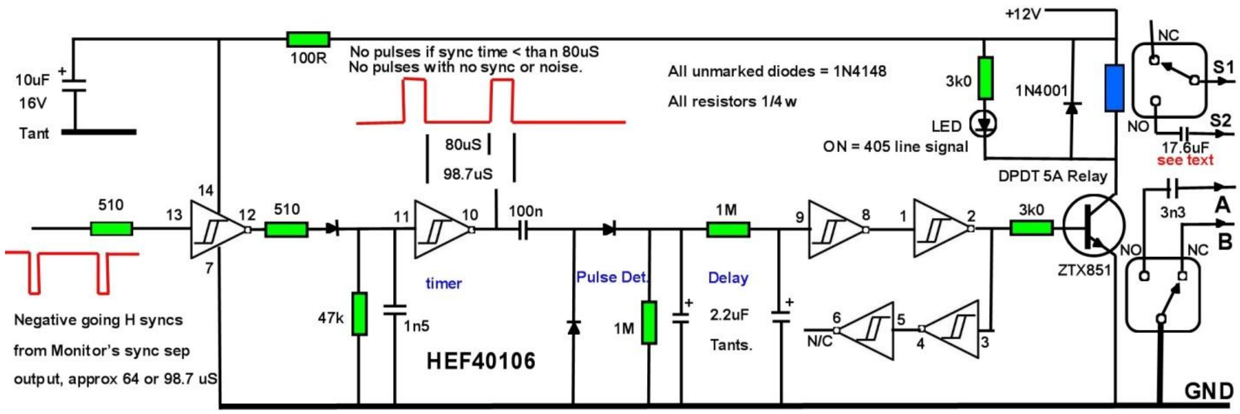
5.5" INCH 525, 625, 405 LINE TEST VIDEO MONITOR

An auto-detect circuit was designed and added to detect when the monitor was receiving 98.7uS H sync pulses (405 line video) at its video input. The output of this detector was used to modify constants in the line (Horizontal) output stage and line oscillator to enable a locked and normal width horizontal scan while still maintaining a similar EHT voltage. The circuit was arranged so that it is safe to “Hot Switch” the monitor between the 405 - 625/525 systems without risk to the line output transistor.

405 LINE AUTO-DETECT CIRCUIT.

I have seen a number of systems in the past designed to detect different video sync standards. Some have been too complicated with PLL’s and not very reliable. So for this circuit I decided to keep it as simple as possible and use readily available parts from the junk box. However the circuit has to be noise immune and not jump between states if the input signal is noise or if there is picture signal in the sync and also adopt a stable output state after a delay of a few seconds. And with no video signal input have the “default scanning state” which is for the 525/625 system.

The simple detector circuit based on a Hex inverter Schmitt trigger IC is shown below:



405 LINE DETECTOR CIRCUIT.

The monitor's separated horizontal sync pulse is inverted and used to charge a 1n5 capacitor, which fully charges during the width of the horizontal pulses. Between pulses the 1n5 discharges. If there is sufficient spacing between the pulses, in this case >80us then the threshold of the gate input (pin 11) is reached and the output of the gate (pin 10) goes high until the next sync pulse charges the 1n5 capacitor.

If the interval between sync pulses is less than 80uS, no pulses are produced at pin 10. A pulse detector circuit looks at pin 10, if pulses are present, after a delay, the relay is switched on. Noise tends to keep the 1n5 capacitor charged and if there are no incoming pulses (no video signal) the pulse detector detects nothing and the relay remains off, as it also does if it is a 525/625 line input signal. The built in delays also help prevent the circuit switching rapidly between states.

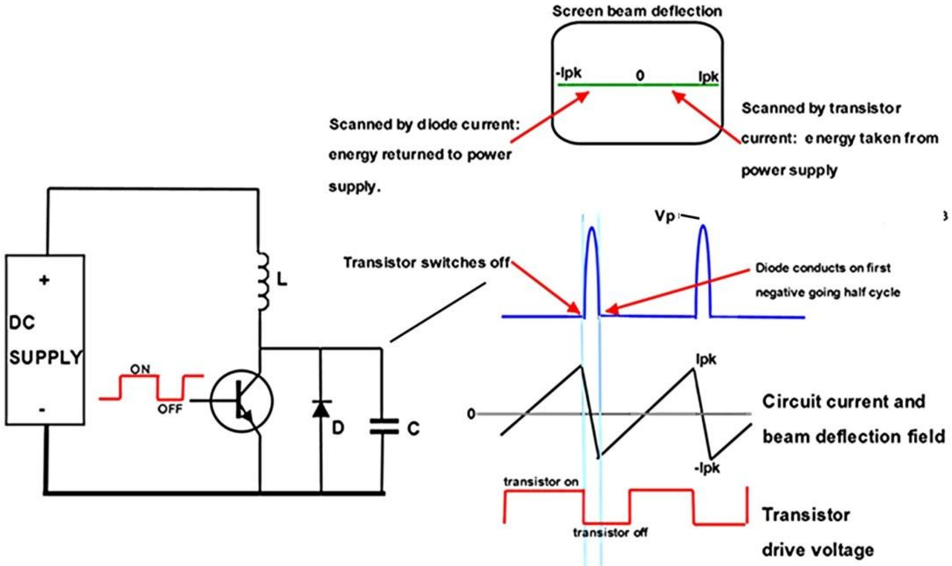
Relay output A introduces a 3n3 capacitor into the horizontal oscillator's circuit to lower the centre frequency to around 10125Hz. Contact B "un-shorts" a 3V3 5w zener diode that was introduced into the line output stage to lower the supply voltage (see below).

Due to the "break before make" nature of the relay change-over contacts, the horizontal output stage supply voltage is lowered before the horizontal frequency is lowered and when the relay changes back, the horizontal frequency is increased before the horizontal supply voltage is increased. Therefore "Hot Switching" or switching 405-625 back and forth with the set powered is safe. (I had considered electronic switching and electronic delays, but the inherent delays in the relay elegantly solved this issue).

HORIZONTAL SCAN FREQUENCY CONVERSION THEORY.

Any specific line deflection yoke and output transformer combination of inductance L can be regarded as a magnetic field energy storage device, where the maximum energy in Joules Epk, is equal to $(\mathrm{Ipk})^2$ L/2 , where Ipk is the peak current at the end of a horizontal scan line.

The diagram below summarises the events in a “typical” horizontal output/scan stage:



The inductances of the yoke and output transformer are lumped together as one value L for the example. The yoke current rises fairly linearly (over the short course of the line scan) and at the end of scan it is such that the beam is deflected fully to the right side of the CRT’s faceplate. At that point the stored magnetic energy has reached a peak value, call it Epk, for some particular video monitor or TV. The horizontal output transistor is then turned off and the collapsing magnetic field of the inductance resonates with the tuning capacitor/s C often placed in parallel with the horizontal output transistor’s connection.

Flyback peak:

About ¼ cycle into this resonance the flyback peak voltage Vp occurs and all the stored magnetic energy of the yoke and horizontal output transformer (ignoring losses) has been handed to the electric field energy of the charged tuning capacitor.

The peak voltage on the tuning capacitor's terminal Vp (and across the transistor's collector-emitter) can be as low as 150V in a small 5 or 6 inch monochrome video monitor like this one, or over 1000v in a colour monitor.

No more than ½ a cycle of resonance appears because the damper diode conducts on the next ½ cycle, which controls the collapsing magnetic field to a linear ramp to scan the left side of the raster.

Since the energy stored in the capacitor is $C(Vp)^2/2$, then for some fixed amount of initial magnetic energy at the end of scan Epk, there will be a fixed voltage peak Vp on the tuning capacitor.

Obviously the smaller the tuning capacitor's value the larger will be the peak voltage across the horizontal output transistor. Destruction of the transistor will occur if this peak voltage is too high. The peak amplitude of the flyback voltage directly affects the EHT and focus voltage often too as the peak voltages are generally rectified on the horizontal output transformer's secondary to run auxiliary circuits.

Rate of rise of current during scan time in transistor horizontal output stages:

Unlike the simplified circuit shown above where the inductance of the yoke and horizontal output transformer lumped as one value L, the rise in current in the yoke is independent from the rise in current in the horizontal output transformer (unless the yoke is run from a transformer tap). Both currents are passed by the horizontal output transistor which remains in a saturated state until the end of a scan line. This of course depends partly on how the yoke and its coupling capacitor are wired in. In this monitor, the yoke's coupling capacitor (or S correction capacitor) is not returned to ground but to the power supply positive.

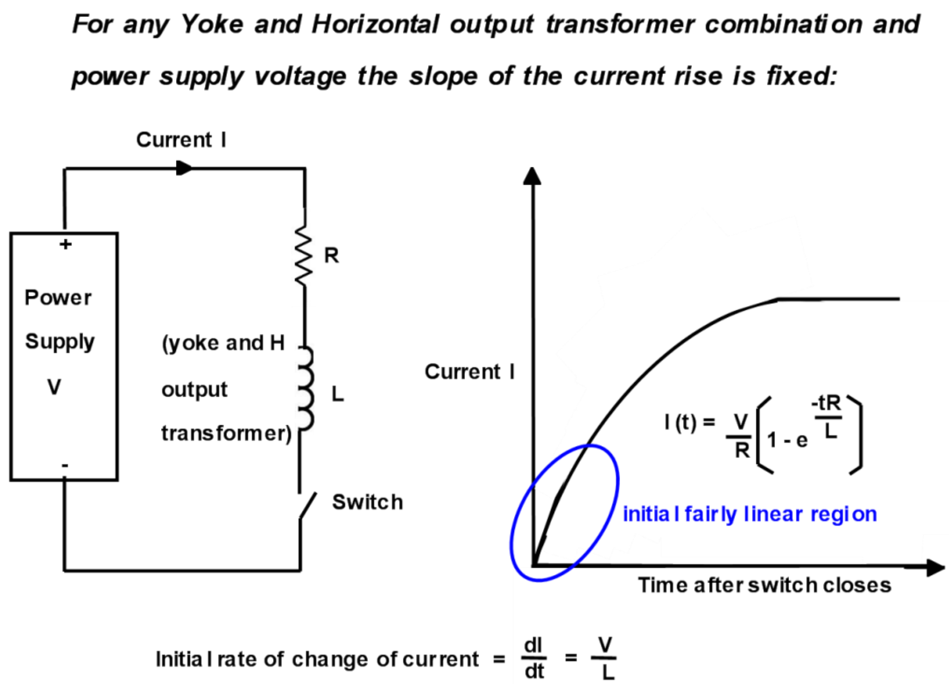
In addition, in this monitor, the transistor driver is on the high side. So during scan time, when either the damper diode and/or the transistor are conducting, stored energy in the S correction capacitor exchanging for yoke magnetic field energy, is driving the yoke.

For any scanning frequency it is important for horizontal linearity that the S correction capacitor will have the correct value (see below). When the value is correct, the linearity, or the geometry of a small horizontal line segment located in the screen centre area is the average value of any stretch on seen on the left hand side of the raster and any compression seen on the right hand side.

The actual circuits in different monitors & TV's can have different topologies with the yoke returned to either the power supply or ground when it has a series capacitor. Also the output transistor, since it is normally driven at its base and emitter with a driver transformer, can be placed in the high side near the supply rail, or in the ground side of the circuit. This gives many transistor circuits different appearances, but the principles remain the same.

The rate of rise of the current in the yoke, or slope, (at least over the short time of the scan) is V/L, where V is the power supply voltage and L the inductance of the yoke. A similar process happens in the output transformer.

This critical piece of information is obtained from differentiating the common garden equation which describes the rate of rise of current in an LR circuit switched across a power supply at t = 0.



Ignoring the presence of any S correction capacitor, from the above it is easy to see that for any specific yoke/line output transformer/tuning capacitor combination, if the peak yoke current (or the peak horizontal output transformer current) is allowed to increase by keeping the horizontal output transistor switched on longer, then the stored energy at the end of scan will increase, the picture width will increase and the peak voltage across the tuning capacitor during flyback will also increase.

Considering the 625 line vs the 405 line systems, the time to deflect the beam from screen centre to the right is 32us vs 49.35uS respectively.

So, for example, if the horizontal oscillator in a 625 line video monitor is simply "slowed down" in an attempt to gain horizontal lock, additional scan time occurs. The current is increasing nearly linearly at a rate of V/L and for an increased time of 49.35/32 it will have increased by a factor of 1.54. The peak current is 1.54 times higher, the picture width will be 1.54 times too wide and the stored energy at the end of scan 1.54^2 or 2.4 times higher. Also this makes the peak voltage on the tuning capacitor 1.54 times higher, threatening the horizontal output transistor.

Therefore, there needs to be a method to reduce the rate of rise of current with time in the yoke and horizontal output transformer primary (which is designed for a 525 or 625 line system) when the system is slowed down for a 405 line scan. In addition the S correction capacitor needs to be changed, as its resonant frequency with the yoke will be incorrect upsetting the horizontal linearity.

Unlike the simplified circuit above the circuit configuration in this type in this monitor, is such that when the horizontal output transistor is conducting and in a saturated state, or the damper is conducting, they both pass the yoke current and horizontal output transformer primary current. So in this monitor the transformer and yoke, from the AC perspective at least, act independently during scan time.

When the transistor switches off however, the stored energy in both the yoke and transformer contributes to the flyback peak and in this case Panasonic arranged two tuning capacitors, one directly on the transistor's collector-emitter and the other on the small extension winding driving the damper diode.

Since the overall total current rise during scanning from the screen centre to the right side of the CRT is proportional to V/L, it leaves two variables to manipulate: Either reducing the supply voltage V or increasing the inductance of the yoke & horizontal output transformer or perhaps both.

I decided that it would reduce the complexity of the switching between standards if the inductance of the yoke circuit and width control could be left alone and the supply voltage being the main factor manipulated. If this could be achieved it would guarantee that the Yoke's magnetic energy was identical at the end of scan in both 625 and 405 line modes. And also there would be similar stored energy at the end of scan in the horizontal output transformer, thereby keeping the flyback peak value about the same. Also in this set, the width of the picture on 625 lines was about right with minimal inductance of the existing width control, or linking it out.

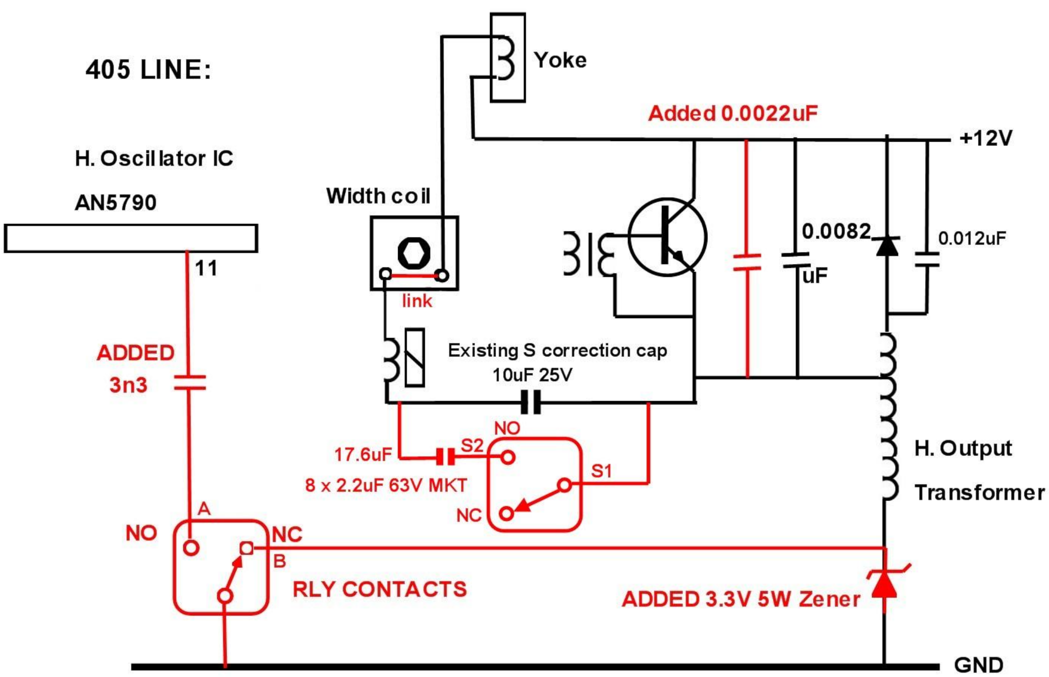
(One other method known to work for a 405 line scan conversion is to re-wire the yoke coils in series for 405 line mode. This has been done in one of these small Panasonic monitors successfully by Mr. Victor Barker in Australia)

The data suggested that the simple move would be that the 12V power supply to the horizontal output stage should be reduced by a factor of 1.54, from 12V to 7.8V to maintain the correct width and Epk energy at the end of horizontal scan when the rate is slowed from 15625 Hz to 10125 Hz.

In practice I found it was better to reduce the supply to 8.7V in 405 line mode. However, not fully compensating the rise in current with a power supply rail reduction meant that peak voltage increased a little on the tuning capacitor as Epk was a little higher in 405 than 625 line mode. Therefore the tuning capacitor's value was increased a little (as a 0.0022uF fixed value to avoid additional switching) reducing the peak voltage Vp by about 5% in 625 mode. Then a 10% increase in 405 line mode represented only a 5% increase above the "normal value" which is tolerable.

Reducing the power supply by a factor of 8.7/12 or 1/1.38 didn't fully compensate the required theoretical value of 1.54. However, when the S correction capacitor value was altered to allow for correct linearity in 405 line mode, the width, as it transpired, was perfect and exactly matched 625 line mode and had good linearity.

To subtract the 3.3V from the supply voltage the zener was added into the earthy end of the horizontal output transformer's connection. The zener also conducts in the forward direction to complete the circuit when the damper diode is conducting on the left side of the scan.



The 3.3V zener temperature was a little high at about 90 Deg C. While is rated to 200 Deg C, I felt it was better to solder it to a brass lug and screw it to the chassis to help drag heat away from the junction.

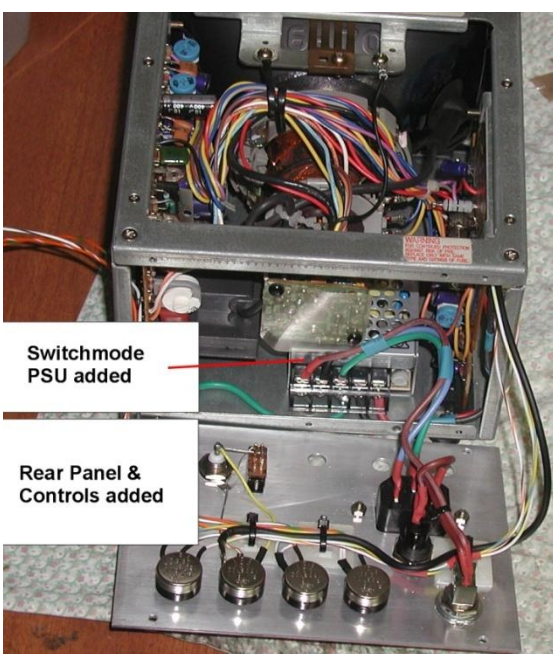
S correction capacitor:

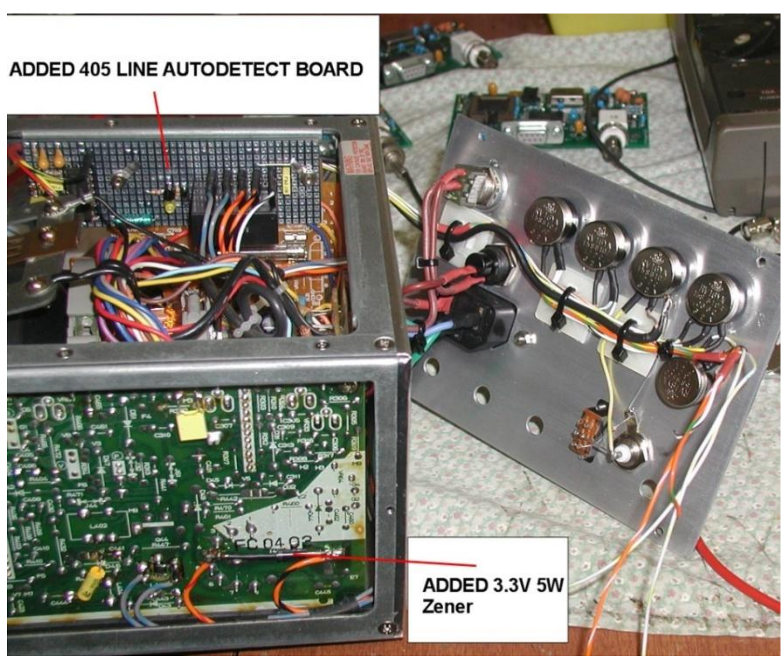
It is very important for this application that the yoke coupling capacitor has a very low ESR. In vintage transistor TV's they often used PIO capacitors, Others MKT types. In this set they use a type of modified NP low ESR electrolytic it appears. Since there was limited space to add a large sized capacitor. I did it with eight 2.2uF 63V MKT types in a row. In theory at least the S correction capacitor needs to be increased in value by a factor of about 2.4, making the 10uF become 24uF. By experiment I found 27.6uF total was about perfect.

Physical modifications:

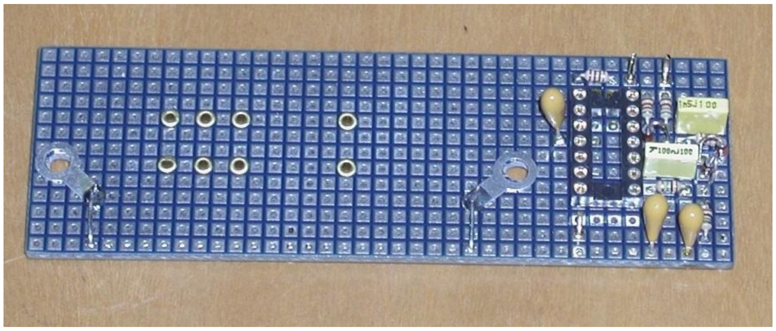
The photos below show the modifications in progress.

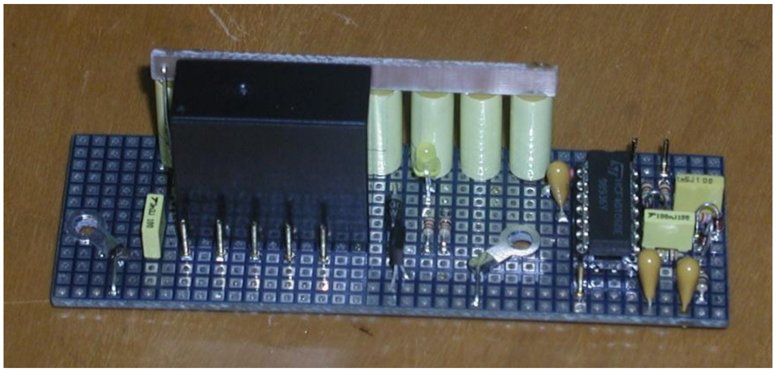
As noted a compact 12V 1A power supply was installed as well. Threads were made in the existing hole in the monitor frame using a 4-40 UNC roll tap, so as to create strong threads. A switch was also installed to select 75R input Z or "high Z" for the video input.





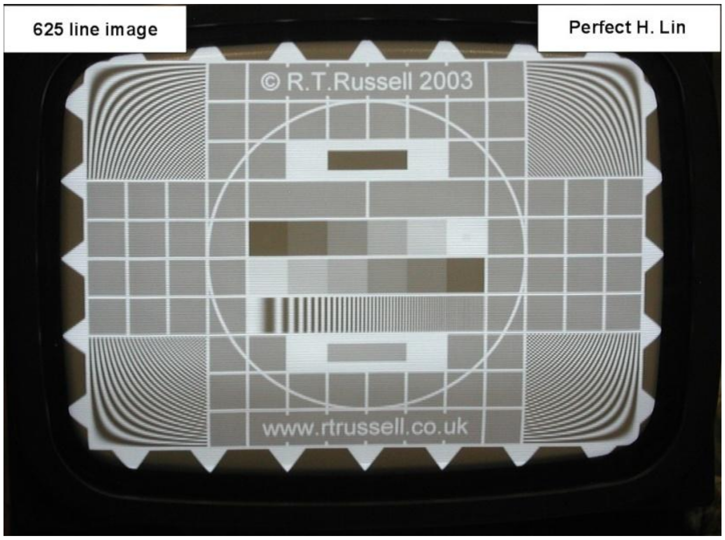
I made a second attempt at the circuit board when I had figured out how to correct the issues with the horizontal linearity. The board I used is shown below during construction. The relay pins were too large to fit through the plated through holes, so they were drilled out and replaced with 1.5mm diameter brass rivets:

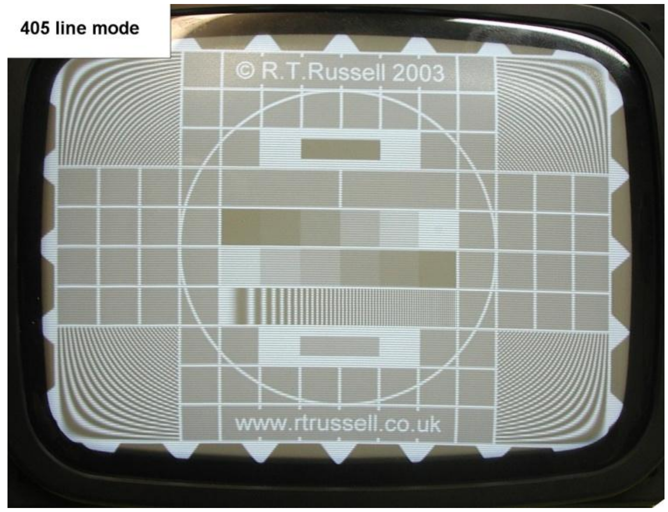




The eight 2.2uF 63V capacitors that comprise the modified S correction capacitor value for 405 line mode can be seen in a row behind the relay.

The images below show the results in 625 vs 405 line mode. There is no difference in the performance on 625 vs 525 mode so a comparative photo is not shown.

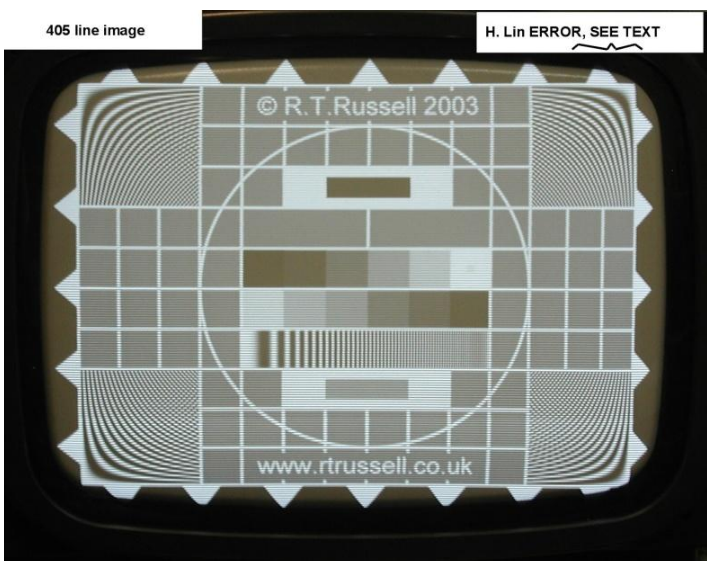




S correction cap = 10uF (standard)

S correction cap = (10 + 17.6)uF

Without modification to the S correction capacitor value, the result of the H linearity is in 405 line mode is shown below for interest. Notice the left side compression. Though, theoretically, with the uF value too small, both the left and right raster edges should be compressed, but there is also a series magnetic Linearity coil in the circuit too.



S correction cap = 10uF in 405 line mode

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