# Restoring & upgrading the Wide Band CRO

Following our article in the current Year Book, "New Life for an Old CRO", we have another story along similar lines. Not only was an old CRO brought back to its original performance, but in some respects it was actually improved.

by PHILIP WATSON

One of our most popular projects in years gone by was the Wide Band CRO, described way back in 1957. (February, March, April, May, and September.) Subsequently, in September 1962, we described a Schmitt trigger sync circuit which could be added to the original design.

In its day, this CRO was of quite advanced design, particularly as one presented for the home constructor. By all accounts, a great many were built and, judging by our mail, many are still in use. We still get requests for circuit reprints from readers who wish to overhaul their unit, but have mislaid the relevant copies of the magazine over the years.

And even by today's standards, the performance figures are still good, and more than adequate for the average workshop or service department. The only snag is that, over the years, some of the vital components may have deteriorated, playing havoc with the performance. Which is what this story is really all about.

Recently, one of our staff had occasion to bring the original unit out of mothballs and give it a birthday. Several sections had failed over the years and it was in pretty poor shape.

Its immediately obvious faults were as follows:

(1) The sync system had failed completely.

(2) It suffered from slow vertical drift as it warmed up until, after a couple of hours, the image would be beyond the range of the vertical shift control.

(3) For each setting of the sensitivity switch there would be a major change in vertical setting

(4) The time base oscillator would not oscillate spontaneously, on the lowest range, when the unit was switched on. It was necessary to switch to a higher range, then back again, in order to start it.

(5) Marked non-linearity of the time base on the second lowest range, accompanied by reduced deflection.

Fault (1) was relatively easy. A 30k wire wound decoupling resistor feeding the Schmitt trigger circuit had gone open circuit. A new resistor restored the excellent sync characteristics of this circuit.

Fault (2) was more of a challange. Studying the vertical amplifier circuit, prime suspect was the coupling capacitor between the 12AU7 cathode follower and the 6BX6 amplifier. This latter valve is directly coupled to the two 6CK6 output valves which, in turn, are directly coupled to the CRO tube deflection plates.

The vertical shift control operates in the 6BX6 grid circuit and anything which upset this circuit would alter the vertical setting. It the coupling capacitor was leaky, it could easily upset this stage.

Second suspect was the 1M grid resistor in the same stage. If it had gone high, it could create all kinds of similar problems due to grid current.

On test the resistor measured spot on but the old paper capacitor showed a leakage of around 150M. While that may not seem like much leakage, it was enough. A new plastic capacitor cured the trouble and also cured fault (3), for reasons which are easy enough to follow. (It seems likely that the capacitor leakage increased with temperature.)

We also checked the .25uF coupling capacitor between the first 6BX6 and the 12AU7. While lot better than the previous one, it did show measurable leakage. We replaced it as a precaution.

Turning to the time base circuit, we considered fault (4). The most likely culprit seemed to be a .035uF timing capacitor in the lowest range. In practice it turned out to be two paper capacitors, a .02 and a .01, in parallel, plus a .005 mica.

The two paper capacitors turned out to have a combined leakage of 25M! They were replaced with a .033uF plastic type and cured that problam.

The non-linearity proved to be a real curly one and was eventually solved, not by any logical reasoning, but by a routine check of all components. The symptoms were confusing because they seemed to indicate that the fault was confined to one range. This seemed to limit the possible culprits to the .005uF or 250pF capacitors in the timing circuits for this range. In fact, replacing both had no effect.

The form of non-linearity was rather unusual. Approximately the first quarter of the trace was stretched but, in itself, reasonably linear. Then the rate changed abruptly and remained linear for the rest of the trace.

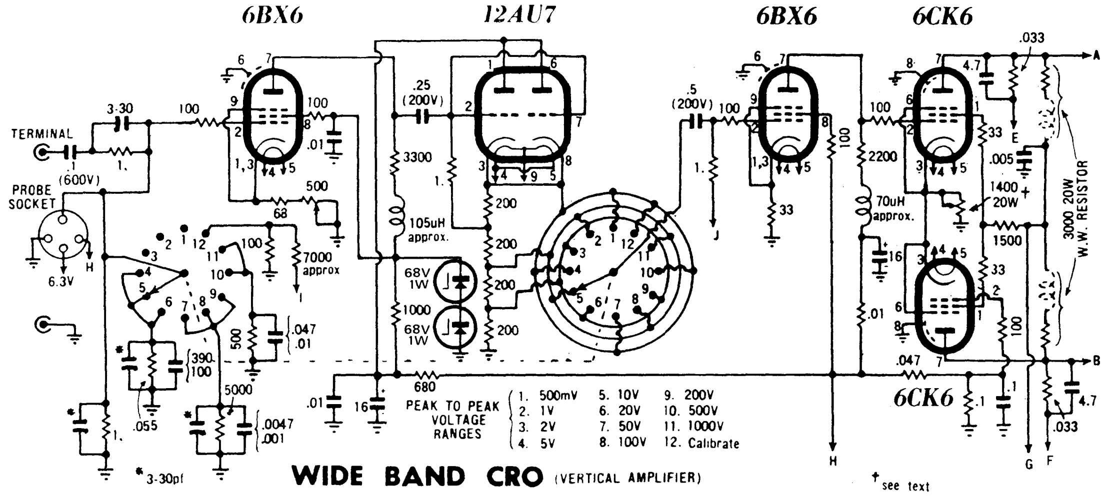
More careful study of the other ranges showed that the lowest range also exhibited the symptom, but to a negligible degree. However, this did widen the choice of suspect components.

The fault was eventually traced to the .25uF coupling capacitor—another paper type—between the two sections of the 12AU7. The first section of this valve (pins 6, 7, 8) is part of the oscillator circuit and also drives one deflection plate from its cathode. The second section (pins 1, 2, 3) is driven from this same cathode line—via the .25 capacitor—and functions as a unity gain phase inverter to drive the second plate.

The .25 capacitor was open circuit so that only one plate was receiving any substantial drive. Why it produced the precise symptoms it did is difficult to explain. Possibly, over that range of frequencies, there was enough residual capacitance to produce a differentiated spike. A new capacitor restored what is virtually perfect linearity, and also increased deflection on all ranges.

By now the CRO was back to virtually new condition and putting up a really good performance. But it also reminded us that it did have one nasty habit; a basic fault which reflected the limited range of components available to the designer in those days.

The fault was a sensitivity to mains voltage pulses or surges. These would cause the image to kick up or down the screen; an effect which could be quite annoying when trying to measure the height of a pattern. It was worst in industrial situations where lift motors, etc., could create




*The modified circuit showing the simple changes to the plate and screen supply to the first 6BX6. Image stability is improved quite dramatically.*

quite severe surges. It was much less of a problem in the average domestic situation.

Since we had thoroughly familiarised ourselves with the vertical amplifier circuit again, we considered the possibility that it might now be practical to minimise this problem.

Studying the circuit, we could not escape the conviction that the disturbances could only be getting in via the 150V HT line, ultimately appearing at the plate and screen of the first 6BX6. From there on the high amplification and extended low frequency response of the following stages would do the rest.

At first glance this theory may seem untenable because the 150V rail is pegged by a VR150 voltage regulator tube. The point to appreciate is that no such regulator device is perfect; it can significantly reduce voltage changes, but it cannot eliminate them. And it would need only a few millivolts change to produce a significant movement on the CRO tube.

Assuming this theory was correct, what could be done about it? These days zener diodes have taken over from VR tubes and have many advantages, not the least of which is low cost and availability in a wide range of voltages. As a result it is not unusual to find voltage regulator circuits involving two, or even three, stages.

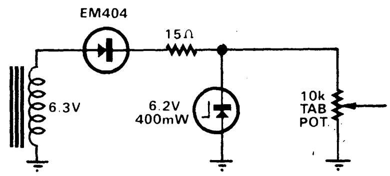
In this case it seemed logical to take the already pegged voltage and feed it through a second regulator stage to supply the plate and screen of the first 6BX6. If the theory was right it would have to improve matters.

The highest voltage zener readily available is 75, but two (or more) units can be connected in series. It was decided to connect two 68V types in series to give 136V. It was reasoned that a drop of 14V would not seriously upset the performance of the stage.

Before trying the idea, we set up a reasonably repeatable pulse producing system. This was simply a 1kW radiator connected to the same power point as the CRO and which, at switch on, could kick the image up the screen by up to 25mm. Then we lashed up the circuit, clipped in temporarily, and repeated the test.

We were most gratified to find that the kick had now been reduced to barely 1mm; in fact, hardly noticeable unless one was watching for it. While we hesitate to use the word "cured", we feel that the problem has at least been controlled.

Note: It should be appreciated that this problem can still occur if surges appear in the supply rail of the equipment under test and are fed to the CRO along with the signal. Such situations are relatively rare, but they are not the fault of the CRO.




*The modified voltage reference circuit.*

In more permanent form we mounted the few components on a five terminal tag strip and mounted it above the chassis alongside the 12AU7 and 6BX6 sockets, just behind the front panel. There was even a spare hole in the chassis to take the necessary screw!

Another useful improvement, which is fairly easy to implement, concerns the calibrate function. In the original design the 6.3V heater line was used as a reference. This was fed to a voltage divider (7000 and 100 ohms) which delivered the correct voltage to provide full graticule deflection when the attenuator switch was set to "calibrate".

The main limitation of this arrangement is that it is at the mercy of line voltage variations. While these are not usually serious, the writer felt that would be nice to have a more stable reference, if this could be provided without much effort.

In fact, it is quite simple and two possible approaches were considered. The classic one is to use two zener diodes, with a voltage rating somewhat less than the peak voltage, connected in series back to back. These will then clip each half cycle at the zener voltage, plus the voltage across the reversed zener, about 0.6V.

The second approach is to first rectify the AC with a single diode, producing half wave pulses, then to clip these pulses with a single zener.

There is not much to choose between the two arrangements, in terms either of cost or performance. Both will produce a crude attempt at a square wave but one which has essentially constant amplitude.

The easiest way to use such a pattern is to switch off the time base and produce a vertical line, the height of which becomes the reference.

If the wave shape is important the following points can be useful. The lower the clipping voltage the straighter will be the vertical component. On the other hand, at voltages below about six, zeners have a more rounded "knee" characteristic which gives a rounded characteristic to the clipping.

For a number of reasons, including what happened to be readily to hand, we used a rectifier and single diode arrangement. We tried several zener values, finally settling for 6.2V which gives a reasonably flat clip.

Fairly obviously, the reduced peak to peak voltage will call for a modification of the original 7000/100 ohm voltage divider network to produce exact full scalle deflection in the calibrate position. This may be done by carefully selecting individual resistors, in parallel or series combinations, on a trial and error basis, or by substituting a tab pot, say 10k.

Either way, the final adjustment will need to be made against some kind of reliable voltage reference, such as the peak-to-peak voltage reference described in the January 1977 issue.

The result of these repairs and modifications is a particularly useful CRO, in spite of its age. If offers a perfectly linear time base, a response from a few Hz to 3MHz, a calibrated input attenuator and a rock steady image—to name just a few of its major features. So, if you have such an instrument lying idle, dig it out and give it an overhaul; you'll find it well worthwile.