

# The Poor Man's Caesium Clock

By Dave McQue, G4NJU\*

**F**REQUENCY COUNTERS with lots of digits are cheap today. However, you should not confuse resolution with accuracy.

Frequent checking against a known Standard is required. Now, if you have a TV or video recorder with a SCART socket, you can have a Standard.

I had always wanted an off-air standard, but jibbed at the complexity and cost of one using the signals from Droitwich on 198kHz. A recent article in *CQ TV* provided the spur; it described an outline circuit for an off-air standard using the commercial TV channels. Again, this was first suggested in the *RSGB Microwave Newsletter*.

The unit that I have built is a development of the circuit in *CQ TV*, with some refinements.

## BACKGROUND

AS LUCK WOULD have it, I was able to purchase a second-hand Droitwich-locked standard to compare with my TV locked version. Droitwich should be good for better than 1 part in  $10^9$ . A comparison of the locked 10MHz output of this and the Poor Man's Caesium Clock, using a double beam scope (after both had been switched on for an hour or so) showed only a slow random phase variation between the two.

All four main terrestrial TV channels now appear to have their line frequency locked to a Standard. The TV line frequency is 15,625Hz,

ie 1MHz divided by 64. In my unit a 10MHz crystal oscillator is divided by 1280 to form one input to a phase detector, while the separated line frequency is divided by two for the other input. The low pass filtered



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connected to the relay chassis by termination on solder tags. The inner conductors, projecting 2cm from the braid, connect to the moving contacts of the relays via the short flexible wires which originally connected to the relay tags. The liberated tags are used for mounting the diodes.

Several manufacturers make relays mechanically compatible with those specified, but they do not all use insulation material which will survive the RF voltages encountered here.

Fig 2 shows the circuit for band selection and Fig 3 the arrangement of how the tuning lines are connected from the relay contacts to the parasitic elements.

The 203BA antenna is assembled following the makers instructions, except for substitution of the larger boom clamp brackets and polythene insulating sleeves at the parasitic elements. It is important not to excessively deform the boom by overtightening the locking screws in the clamp brackets, because this may otherwise prevent insertion of the relay chassis.

Clamps are made from 6mm wide, 18 gauge

aluminium strip for electrical connection to the 1.125in diameter elements, which is preferable to weakening the tubes by drilling them. Stainless steel nuts and bolts protected by self amalgamating tape prevent corrosion at the connections.

The original plastic boom end caps are punched to allow flexible, element-to-relay connection wires to pass through. These are

spaced 2.5cm apart and as far from metalwork as possible. The wires should be a tight fit to keep out water. A hole is also made at the lower edge for condensation drainage. Two more holes are made for fixing the relay chassis and extraction handle to the end cap. These holes are located after trial fitting the chassis into the boom.

The chassis is retained and grounded by a single stainless steel No. 8 self tapping screw, passing through a 4mm clearance hole in the underside of the boom. A refinement would be a captive threaded bush and screw in this position.

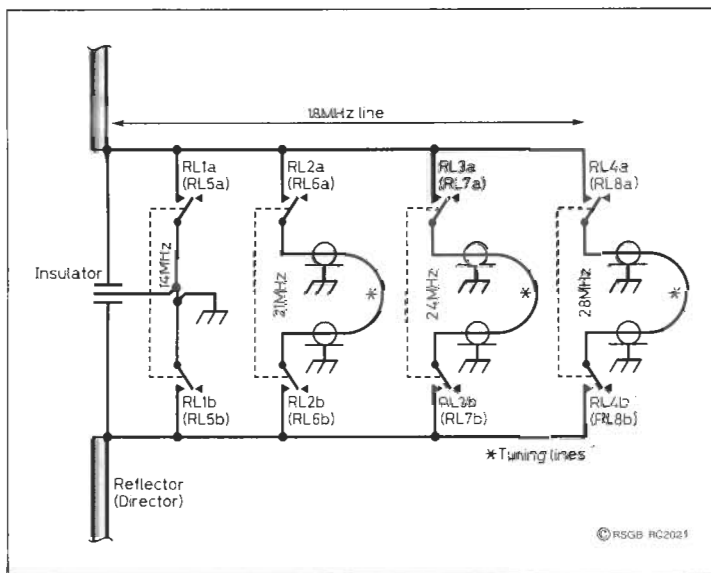


Fig 3: How the tuning lines are connected to the relay contacts. A similar arrangement exists for both the reflector and director.

## REFERENCES

- [1] Telex/Hy-gain antennas are available from Lowe Electronics Ltd, Chesterfield Road, Matlock, Derby DE4 5LE. Tel: 01629 580800.
- [2] Available from Telex Communications inc. 9600 Aldrich Avenue, Minneapolis, MN 55420, USA. Tel: 00 1 612 884 4051.
- [3] RS Components items are available via Electromail, PO Box 33, Corby, Northants NN17 9EL. Tel: 01536 204555.

▶ output from the phase detector is fed to a varactor diode, which fine tunes the crystal oscillator into lock.

HOW IT WORKS

A COMPOSITE VIDEO signal is taken via 75Ω coax from pin 19 of a SCART plug, with pin 17 connected to the braid. Within the Poor Man's Caesium Clock - Fig 1 shows the circuit diagram - the cable is terminated by R1, a 75Ω resistor. R2 and C1 form a low pass filter, before the signal is applied to IC1, an LM1881 sync separator chip.

The output is line sync pulses, unfortunately with half line pulses during the frame blanking interval (flyback time). To deal with this, one half of IC2, a 74HC74, is arranged as a 40

microsecond monostable - to mask the half line pulses, so that its output is 15,625 pulses per second. The other half of IC2 is connected to divide by 2, so that its output is a symmetrical square wave at 7812.5Hz (ie 1MHz divided by 128). This signal is one input to the XOR gate, one quarter of IC3, a 74HC86, used as a phase detector.

The 10MHz crystal oscillator uses one inverter of IC4, a 74HCU04. This has to be an *unbuffered* version of the 04. It ensures a less noisy oscillator than for the normal, buffered version. Course tuning of the oscillator is achieved with VC1, a 65pF trimmer, with the BB515 varactor diode for fine, electronic tuning. The other inverters of IC4 are used as buffers. IC5 and IC6, 74HC390 and 74HC393

chips, are arranged to divide by a total of 1280, to provide a symmetrical 7812.5Hz signal to the other input of the phase detector. The mean voltage at the output of the phase detector will vary from 0 to the supply rail. It will be half way when the two inputs are in phase quadrature. A further gate is used to drive the phase indicator meter. R5 and C5 form a low pass filter, to smooth the output from the phase detector. The meter can be any 1mA or less FSD meter, as its only purpose is to indicate variation. If it is a centre zero model, it is returned to the junction of R7 and R8; if a normal end zero version, return it to 0 volts instead, so that it will still have a near central indication. Choose R6 for a full scale deflection with its end temporarily

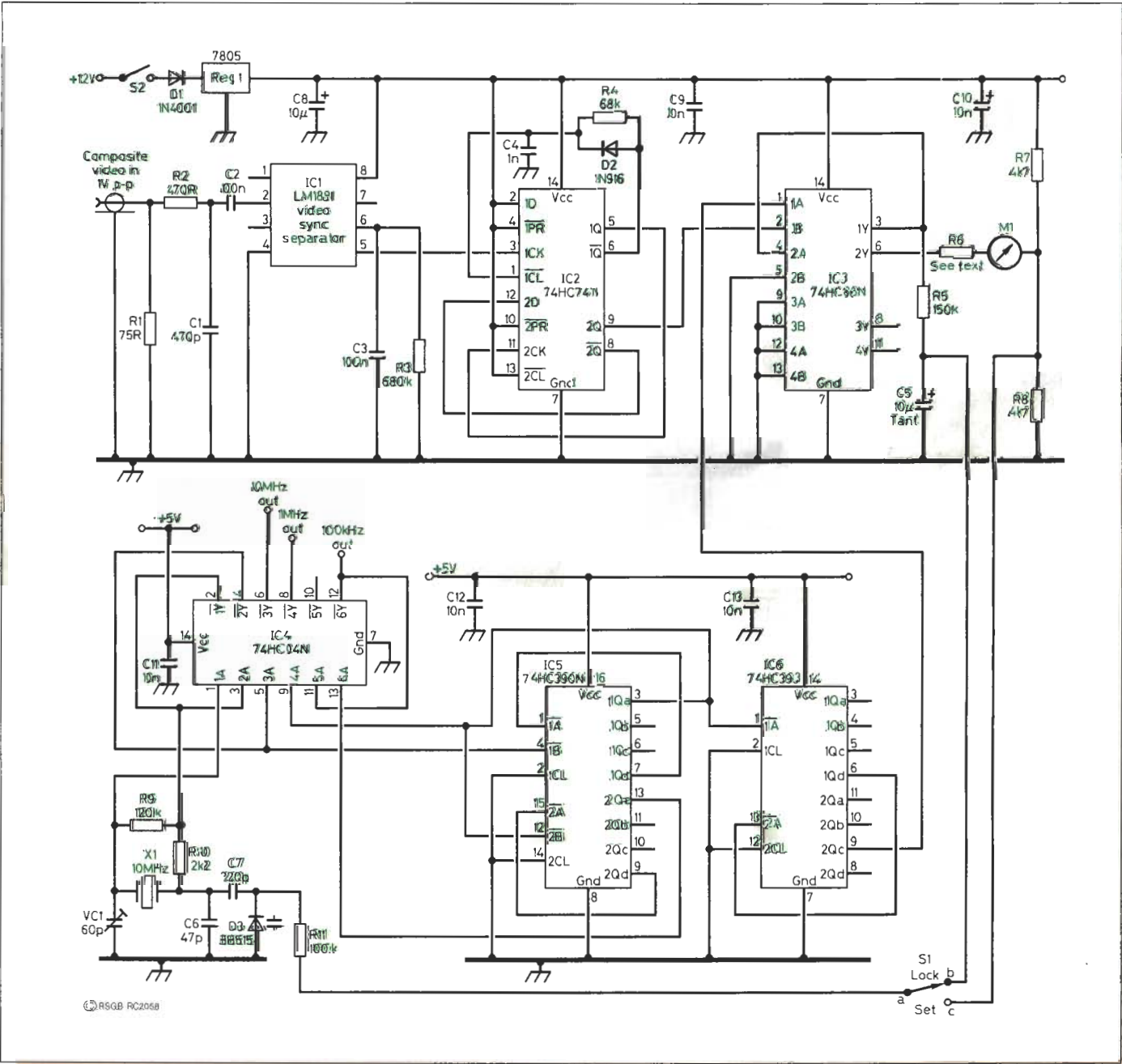


Fig 1: Sync pulses are separated from an off-air TV video signal, and processed to lock a 10MHz crystal oscillator.

# Components

Resistors - all 0.25W 5% (eg Maplin 'G' series)

|     |               |
|-----|---------------|
| R1  | .....75R      |
| R2  | .....470R     |
| R3  | .....680k     |
| R4  | .....68k      |
| R5  | .....150k     |
| R6  | .....See text |
| R7  | .....4k7      |
| R8  | .....4k7      |
| R9  | .....120k     |
| R10 | .....2k2      |
| R11 | .....100k     |

## Capacitors

|          |                               |
|----------|-------------------------------|
| C1       | .....470pF (RA38R)            |
| C2, C3   | .....100n (RA49D)             |
| C4       | .....1nF (RA39N)              |
| C5, C8   | .....10µF/16V Tantalum(WW68Y) |
| C6       | .....47pF (RA35Q)             |
| C7       | .....220pF (RA37S)            |
| C9 - C13 | .....10nF (RA44X)             |
| VC1      | .....65pF trimmer (WL72P)     |

## Semiconductors

|      |                         |
|------|-------------------------|
| IC1  | .....LM1881 (UL75S)     |
| IC2  | .....SN74HC74N (UB19V)  |
| IC3  | .....SN74HC86N (UB23A)  |
| IC4  | .....SN74HCU04N (UB04E) |
| IC5  | .....SN74HC390N (UB84F) |
| IC6  | .....SN74HC393 (UB85G)  |
| D2   | .....D1 IN4001 (QLY3Q)  |
| D3   | .....BB515 (VR23A)      |
| REG1 | .....7805 (CH35Q)       |

## Miscellaneous

|                   |                                       |
|-------------------|---------------------------------------|
| S1, 2             | Single pole change-over (FH00A)       |
| X1                | 10MHz crystal (FY78K)                 |
| 'Scart' Connector | (FJ41U)                               |
| Skt1 - 4          | Panel mounting 50W BNC Socket (HH18U) |
| Aluminium case    | (LF16S)                               |
| M1                | 100-0-100µA panel meter (RW98G).      |

Almost any moving coil can be used, as only an indication of movement is required. A 'tuning Indicator' type instrument would be adequate.

Codes in brackets are Maplin part numbers.

connected to the supply rail before connecting it to pin 6 of IC3.

A suitable power supply is four AA dry cells for 6 volts, 4 NiCads for 4.8 volts, or from a higher external supply when a 5 volt regulator (Reg 1) is fitted.

I sent details of my prototype Veroboard to Dr Kevin Scott, MM0BPX, who kindly produced the artwork for the printed circuit board (Fig 2) in this project and built the version shown in the photo on page 35. He confirms a stability better than one part in 10<sup>6</sup> - way beyond the achievable setting accuracy of most hand-held frequency counters.

## SETTING UP

TO SET UP the unit, connect it to an active TV and put S1 in the 'Tune' position.

Adjust VC1 for the slowest movement of the meter, then switch to 'Lock'. Wait for the meter to settle, then a very gentle tweak of CT1 to put the meter needle near the centre of the scale and that's it!

Every time you switch on, the meter needle will oscillate, then settle. If it doesn't, check that you have a TV signal.

Note: The LM1881 sync separator does not like noisy video, so make sure that the TV is getting a good signal from an outside antenna.

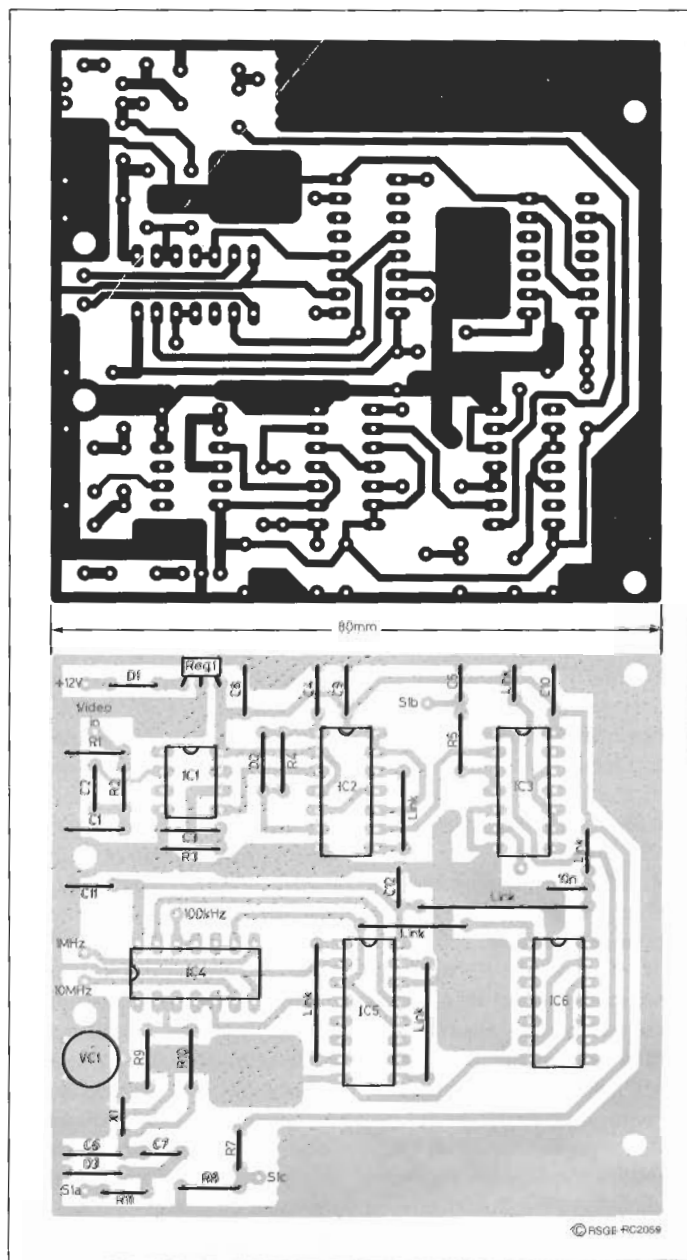


Fig 2: Track layout and component overlay of the single-sided PCB.

## POOR MAN'S CAESIUM CLOCK

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BESIDES THE necessity reduce the value of R10, in some cases there is a problem with some versions of the 1881 chip not producing back porch pulses. This is solved by taking the negative-going composite sync pulses on pin 1 of the 1881 to pin 11 of IC4 and connecting pin 10 of IC4 to pin 3 of IC2; cutting the track between pins 11 and 12 of IC4 and also the track to pin 5 of IC1.

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