The Poor Man's Caesium Clock

By Dave McQue, G4NJU*

FREQUENCY 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.

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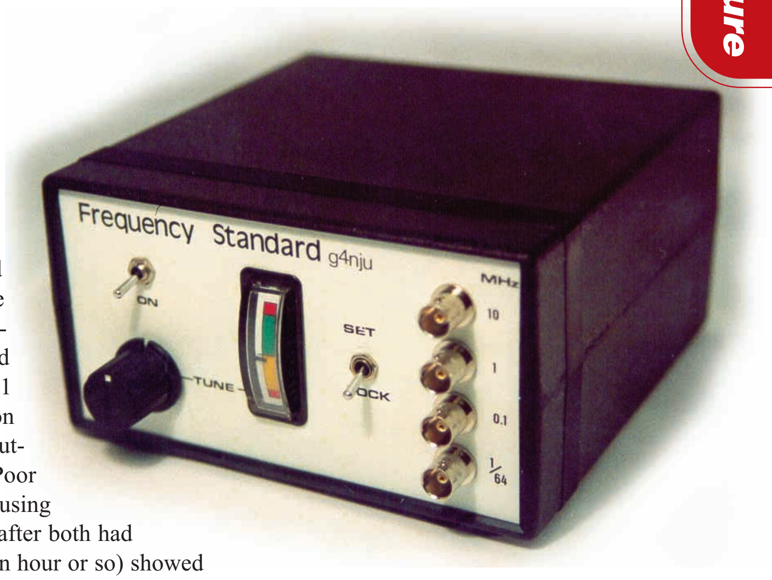
BACKGROUND

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.

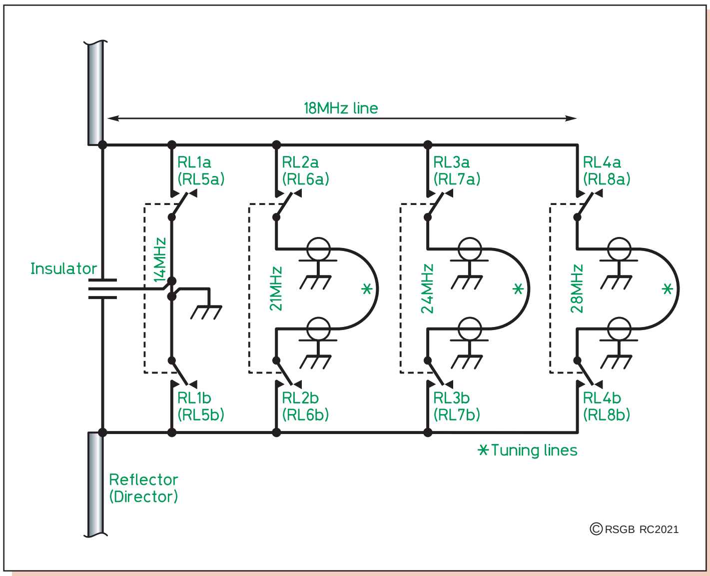


Fig 3: How the tuning lines are connected to the relay contacts. A similar arrangement exists for both the reflector and director.

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.

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

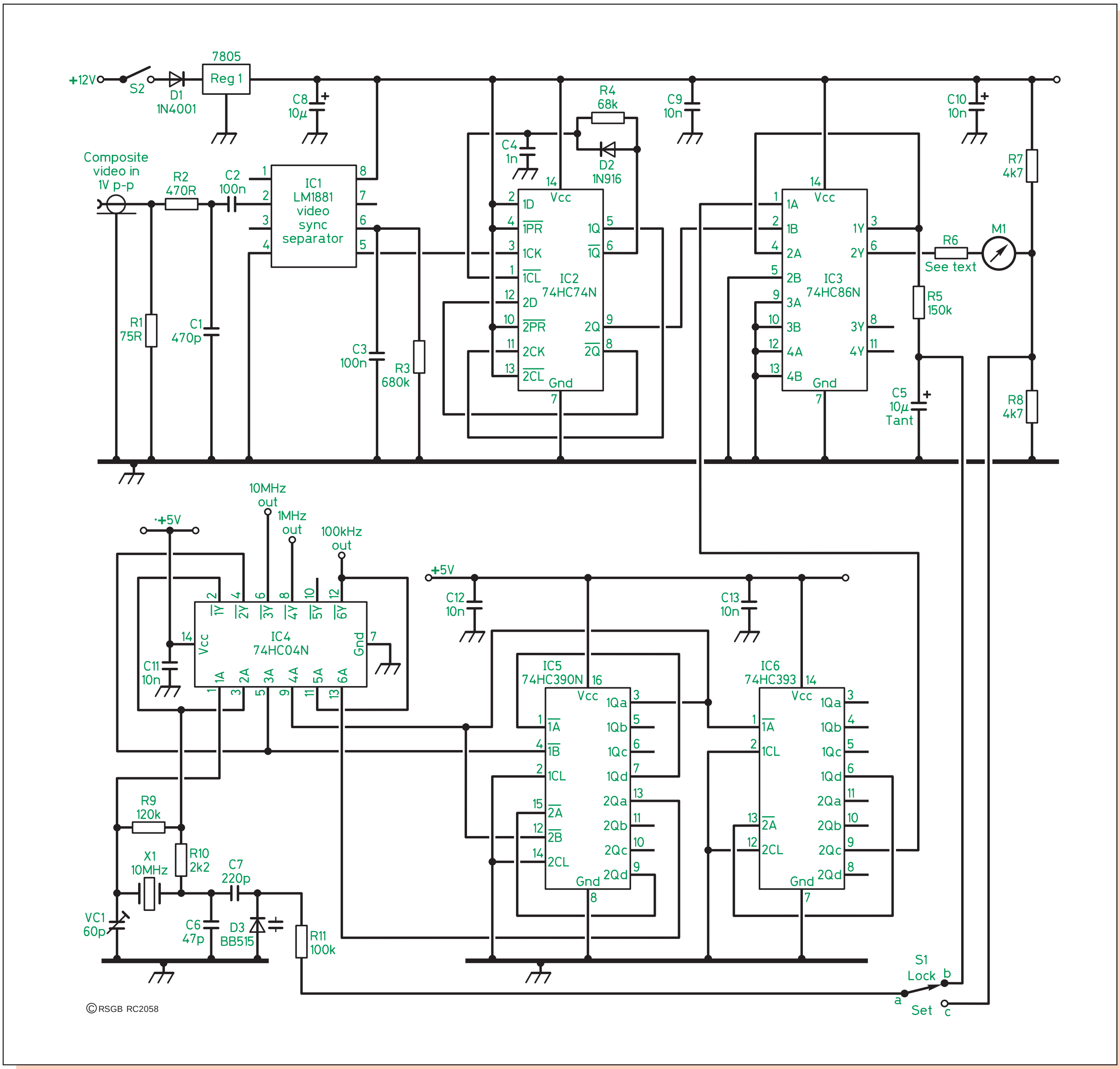


Fig 1: Sync pulses are separated from an off-air TV video signal, and processed to lock a 10MHz crystal oscillator.

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 10^8 - 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. ♦

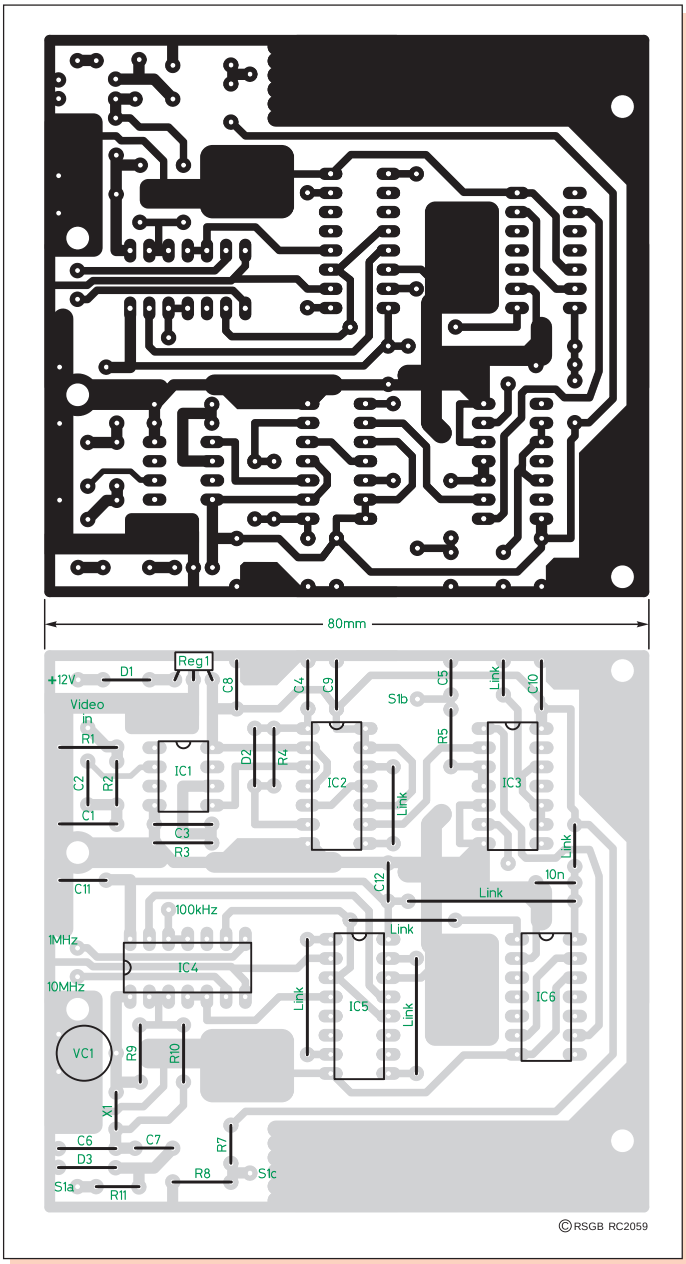


Fig 2: Track layout and component overlay of the single-sided PCB.

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.

RadCom Helplines FOR MEMBERS

● Stephen, GM3ZAS, is looking for the software required to enable using a **Hayes** compatible plug-in telephone fax modem to be used on an **Amstrad PC1640DD**. Stephen, GM3ZAS, tel: 01292 478354.

● Harry, G0UES, would like to obtain a copy of the manual or instructions for the **Storno 4000**. Would pay photocopying fee and postage, and be very grateful. G0UES, QTHR, tel: 01983 293853.

● Ian, G4MLW, is looking for a handbook or circuit diagram of the **Zetagi BV2001** linear amplifier. All costs covered. G4MLW, QTHR, or e-mail ianfjones@compuserve.com

● Ted, G8LHJ, is looking for an RF test probe model **309-CU** for the **Heathkit** IM-18D valve voltmeter. Also, a **mains plug** for a **Yaesu FT901DM**. Finally, the **circuit** diagram for the **Racal RA71** (the American version of the RA17L). G8LHJ, QTHR, tel: 0151 632 0614.

● John, GM3LBX, requires circuit details of the **Marconi AA14101-1** HF amplifier. GM3LBX, QTHR, tel: 01880 820842.

● R K Rai needs information on the **Motorola** HF receiver **Micom-1**. Tel: 0181 813 9193

Helplines is a free service to members. Requests for help are published in the order they are received. We regret it is not possible to provide an undertaking of when any submitted request will be published.

COMPONENTS

Resistors (all 0.25W metal film)
R1 470k
R2 470R
R3 470k
R4 470R

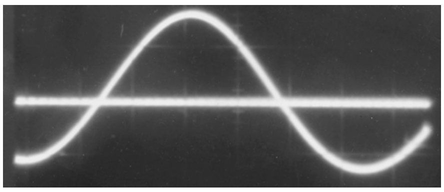
Capacitors
C1 300pF polystyrene
C2 300pF polystyrene
C3 0.1µF polyester
C4 100pF ceramic
C5 100pF ceramic
VC1 0-40pF trimmer

Inductors
RFC1 470µH
RFC2 100µH

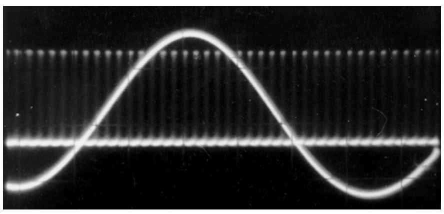
Semiconductors
TR1 2N3819
TR2 2N3819
D1 1N4148

Miscellaneous
X1 1MHz crystal

X1 and VC1 are the only critical components. All others may be substituted by similar types.



The second harmonic signal (30.125kHz) displayed.



1MHz pulses on the 'scope second channel.

PICKUP COIL

THE LTB SIGNAL is picked up by a ferrite-cored antenna which is wound with about 400 turns of Litz wire on a SRBP former (see the photo below). Before starting the winding, make two nicks in one end of the former and bond in two short pieces of 1.5mm diameter tinned copper wire.

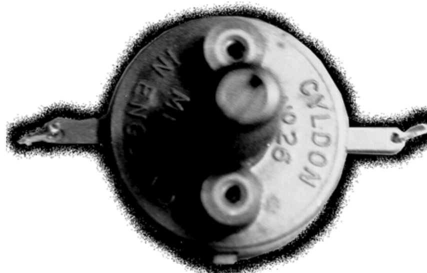
In order to solder Litz wire, the insulation must be removed by burning it off in a cool (methylated spirit) flame. I put a small quantity of meths in a metal bottle top, ignite it, burn off the insulation, then quench the wire in the spirit, putting out the flame by placing a piece of wood or metal over it. The wire should be bright and clean.

Quickly wrap it round one of the tags and solder it. Note that Litz wire is very weak, especially when it has been annealed (softened) by heating. Now wind the first layer of as many turns as possible on a layer of Kleenex®, but without getting closer than 6mm to the end of the former. After that, put on a strip of Kleenex and wind the second layer, followed by Kleenex, another layer and more Kleenex. When you have wound about 400 turns, stop, cut the wire, prepare the end as for the start, and solder to the other tag.

Finally, give the assembly a good soaking in polystyrene dope (polystyrene model makers' cement, or see below for a DiY dope recipe). Dry it thoroughly, preferably on a warm radiator (put it on some polythene film to avoid it sticking to the radiator and causing problems with the 'Station Manager'!), but not until most of the solvent has evaporated. My pickup coil had an inductance of 9.2mH, a self-capacitance of 125pF and a Q of about 80 at 70kHz (measured on an elderly Marconi Q meter).

THE CIRCUIT

TO USE THE pick-up coil, fit a trimmer capacitor (the photos top right show two sides of the one I used, but any compression trimmer of about 2000pF will do) in parallel to tune it to 30.125kHz and connect it to the Y input of the 'scope (tuning for maximum display height). In my case, I put the pick-up coil on top of a 250mm black and white TV (a Ferguson type 3840) in the shack and used a (cheap) double beam 'scope. Although the waveform of the LTB is non-sinusoidal, it appears as a sine wave because the pick-up is tuned. If you want to pick up the fundamental, a further 4.7nF or so of parallel capacitance is needed; a little experimentation would be needed here.



Two views of the trimmer used.

My 1.000MHz oscillator is of conventional design (**Fig 1**) with an added harmonic generator. The trimmer on the oscillator is adjusted until the 1MHz pattern remains stationary, as shown in the photo below left. End of calibration.

NOTE

THIS METHOD could equally be used with a 10.000MHz crystal oscillator and a divide by ten IC (eg a 7490).

REFERENCE

[1] 'The Poor Man's Caesium Clock', by Dave McQue, G4NJU, *RadCom* January 1999, p35 (but see also April p31 and June p17). ♦

DiY POLYSTYRENE DOPE

BREAK-UP SOME *clear* polystyrene. I use the containers for my wet-shave blades, but any polystyrene (eg old audio cassette tape cases) will do. Put it in a glass jar with a well fitting lid, cover with cellulose thinners, then screw down the lid tightly. Leave for day or three, agitating form time to time. When it has all dissolved it *should* have the consistency of light oil. If it is too thick, add more thinners; if too fluid, add more polystyrene.

A simple test for polystyrene is to drop a piece onto a hard surface. Polystyrene goes 'clink', rather than 'thud'!

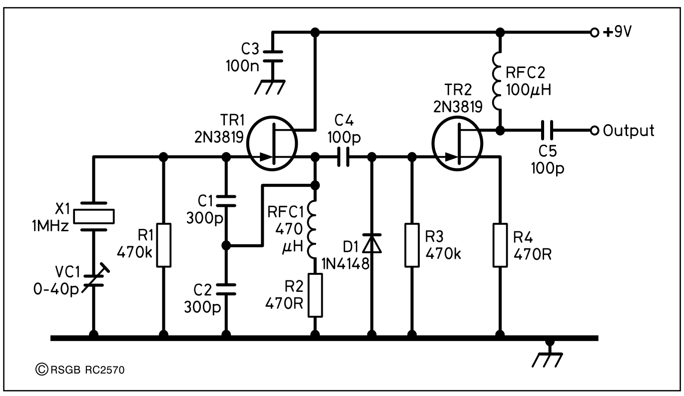
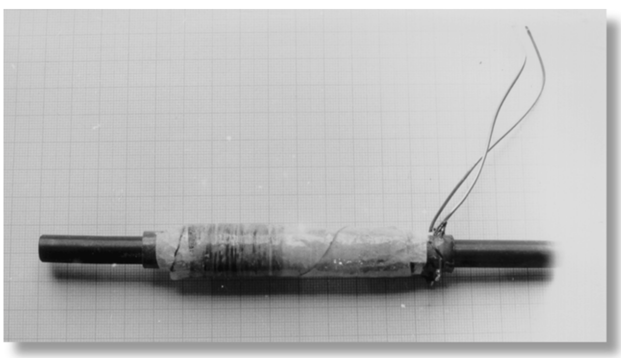


Fig1: Circuit of the 1MHz crystal oscillator.



The completed pick-up coil (the background is 1cm squares graph paper).