TRANSISTOR CRYSTAL MARKER UNIT

By

P. Cairns, M.I.P.R.E., R.Tech.Eng., G3ISP

Capable of accepting crystals between 50 and 500kHz, this marker oscillator provides high level calibration 'pips' up to higher than 30 MHz.

THIS ARTICLE DESCRIBES A FREQUENCY MARKER crystal oscillator for use with virtually all types of communications receiver. The purpose of such marker units is to enable a very accurate h.f. oscillator of known frequency and high harmonic content to be switched into the receiver aerial input. With the receiver b.f.o. switched on, an audible beat note is then heard at regular frequency intervals across all bands of the receiver. Popular choice of frequencies for such markers are 100, 250 and 500kHz, though 1MHz is occasionally used. Crystals are in standard use for these devices as they allow high frequency stability to be achieved over an almost indefinite period. The specification of the marker unit to be described here is given in Table I.

MARKER FREQUENCY

The choice of frequency made by the writer was 250kHz, this representing a fair compromise between too wide and too narrow a marker interval. As most communications receivers are calibrated in at least 0.5MHz intervals this allows not only these points to be checked but also the 1MHz points. Any 250kHz markings between these two points can also be checked. Calibration between 250kHz steps is by means of the vernier or logging scale of the receiver, the number of degrees between any two 250kHz points being divided into the appropriate number of kHz. Thus, if the range between two marker points is logged as 10 degrees, each degree represents 25kHz.

TABLE I

General Specification

Output.	50kHz to 500kHz; frequency and accuracy determined by crystal. Maximum output 6 volts peak-to-peak square wave. Rise time approximately 50nS.
Supply.	With low voltage circuit, 9 – 12 volts d.c. Current drain at 9 volts: 9.5mA. With high voltage supply circuit, 150 – 330 volts d.c.
Dimensions.	$1\frac{1}{2}$ by $1\frac{1}{2}$ by 2in. high. Components mounted on standard octal plug.

As some constructors may however already have crystals of other frequencies to hand (100kHz are quite common), or may prefer another choice of frequency to line up with a particular receiver's dial markings, the circuit was designed to function with crystals of any frequency between 50kHz and 500kHz. Several crystals of both these frequencies, together with others which lay between these extremes, were tried out in practice with complete success.

While the actual crystal used and specified by the writer is mounted in a B7G based glass envelope, other types of crystal having the standard $\frac{1}{2}$in. or $\frac{3}{4}$in. two-pin spacing can be employed. The accuracy of the marker frequency will of course depend upon the accuracy and type of crystal used. Most crystals of the type used for frequency markers in the 100-500kHz range have accuracies of better than 0.1%. This is quite adequate for most general communications purposes. Frequency checks were carried out on a batch of assorted crystals, many of them ex-suplus, the frequencies being measured on a digital counter. The worst error measured was –0.13% while the least error was –0.015%. The crystal used by the writer had a measured frequency of 250,049Hz. (+ 0.02%).

The cost of the crystal depends of course very much upon the type and accuracy required. Surplus types are generally available in the 75p to £1.50 range. New types of higher accuracy are available, and cost a number of pounds.

The inclusion of a crystal marker in a commications receiver can be a decided advantage allowing, as it does, a constant and accurate check on dial and frequency markings on all bands. To ensure adequate output at the higher frequencies, a waveform having a high harmonic content is desirable. This means a fast rise time. The waveform rise time of the unit described is in the region of 50nS, thus allowing calibration checks well in excess of 30MHz. An oscillogram showing the output waveform appears in one of the accompanying photographs. While some receivers have a self-contained marker unit, many manufacturers advertise them as optional extras for their range of receivers, and prices noted on the commercial market vary between £6 and £9.75. The

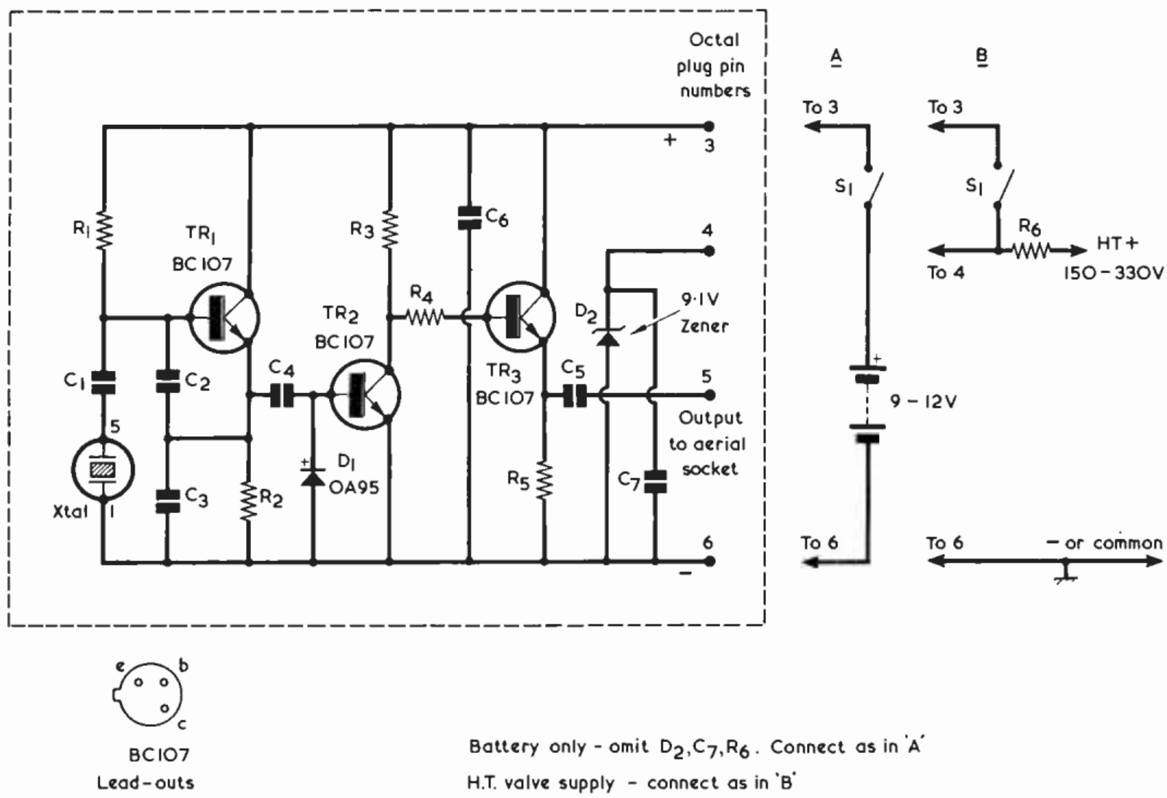


Fig. 1. The circuit of the marker unit. The components within the dashed outline are mounted on the octal plug. S1 and R6 (if used) are positioned, externally, in the receiver with which the marker unit is employed

COMPONENTS

Resistors
(All ¼ watt 5% unless otherwise stated)
R1 220kΩ
R2 4.7kΩ
R3 1kΩ
R4 10kΩ
R5 1kΩ
*R6 10kΩ – 18kΩ (see Table II), 12 watt wirewound, Cat. No. R17A (Home Radio)

Capacitors
C1 470pF silvered mica
C2 0.01μF polyester
C3 100pF silvered mica
C4 0.002μF polyester
C5 1–5pF ceramic (see text)
C6 0.33μF polyester
*C7 1μF polyester

Semiconductors
TR1 BC107
TR2 BC107
TR3 BC107
D1 OA95
*D2 9.1V 5% 400mW zener diode type BZY88–C9V1
*Not required with 9–12V supply

Switch
S1 s.p.s.t. toggle

Crystal
250kHz crystal, or frequency as desired (see text)

Miscellaneous
Crystal holder, to suit crystal used
Veroboard, 0.15in. matrix (see Fig. 2)
Octal plug and socket

cost of the unit described, less crystal, is at the time of writing just short of £2.

CIRCUIT DIAGRAM

The complete circuit diagram is shown in Fig. 1. The two types of power connection available are also illustrated. With transistor receivers using batteries or a 9–12 volt power unit, components D2, C7 and R6 are omitted. For use with mains valve receivers having a conventional h.t. supply, these components are included, R6 functioning as an external dropper resistor. To allow for a wide range of possible h.t. voltages the value of R6 should be selected from the values shown in

TABLE II

Values of R6 for varying h.t. supply voltages

H.T. Voltage	*Value of R6*
150 – 190	10kΩ
190 – 230	12kΩ
230 – 280	15kΩ
280 – 330	18kΩ

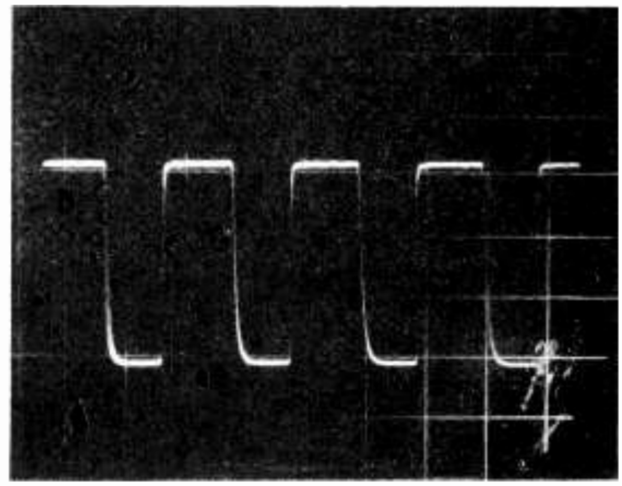
Table II. The extra current drawn from the h.t. supply is of the order of 17mA.

The circuit in Fig. 1 shows TR1 connected as a Colpitts oscillator in the emitter follower mode. The oscillatory circuit is provided by the crystal which is working in the parallel mode of resonance, C1 providing series blocking and R1 base bias. The output is developed across the emitter load R2 while the necessary positive feedback is achieved across the capacitor divider C2, C3, the centre point being tapped into the signal output from the emitter.

The oscillator output is fed via the coupling capacitor C4 to the base of the squaring amplifier TR2. D1 and the base-emitter junction of TR2 provide symmetrical clipping of the input waveform, D1 also providing a d.c. return for TR2 base. This clipped waveform is amplified by TR2, the drive being sufficient to run this stage between cut-off and saturated conditions and thereby allowing a very fast rise time to be achieved. The squared output signal which is developed across the collector load resistor, R3, is d.c. coupled via the limiting resistor R4 into the base of TR3.

TR3 is an emitter follower output transistor, this providing a very low output impedance and so ensuring negligible loading effect by the receiver aerial input circuit. This stage also gives isolation between the aerial circuit and the oscillator and squaring amplifier. The output developed across the emitter load, R5, is coupled to the receiver aerial circuit via capacitor C5. The value of this component determines the degree of marker signal fed into the receiver and its value will depend to a large extent upon the sensitivity of the receiver in use. Details for setting this capacitor value are given later.

When used with battery or 9–12 volt power units the supply is simply connected to the supply via S1, as shown by 'A' in Fig. 1. C6 provides decoupling of the supply line. In the case of mains-derived valve h.t.



Trace given at 250kHz by the prototype. Signal amplitude is 6 volts peak-to-peak

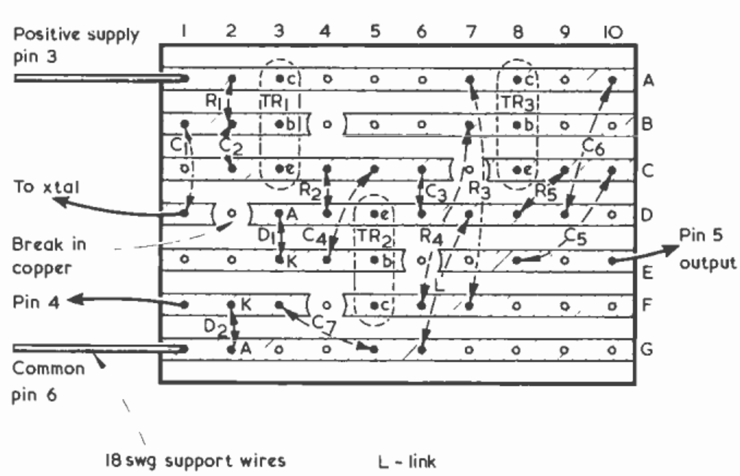
supplies, the marker supply is taken from the zener stabilizer, D2, which is fed via the appropriate dropper resistor, R6, as illustrated by 'B'. S1 is again used to turn the unit on and off. The zener diode and dropper resistor are decoupled by C7.

CONSTRUCTION

The type of construction employed by the writer achieves a high degree of compactness, the use of Veroboard allowing reasonably constant results to be given in different units built up to the circuit. The parts are mounted on an octal base, which allows the unit to be easily removed for servicing or for use with another receiver. Most commercial marker units are of the plug-in type. Other types of construction and mounting can be used, however, the circuit not being excessively critical as regards to layout.

The complete circuit, except for R6 and the crystal, is wired on a piece of Veroboard measuring some 2 by 1½in., this being cut to provide the strips and holes shown in Fig. 2. The component layout on this board is also given in Fig. 2. Note the letters 'A' and 'K' alongside the connection points for D1 and D2. These indicate the anode and cathode ends of each diode

Fig. 2. The Veroboard, with the copper side towards the reader



respectively. A 5pF capacitor may be temporarily fitted in the C5 position.

After fitting the components, the Veroboard is mounted vertically on the edge of the octal plug by means of two lengths of 18 s.w.g. tinned copper wire. This octal plug is mounted in the centre of a 1½in. square piece of ⅛in. Paxolin, which forms a base plate. The 18 s.w.g. wire is soldered between the outer copper strips on the bottom of the Veroboard, these being positive and common supply lines, and the appropriate pins in the octal plug, which are pins 3 and 6 respectively. The support wires are bent to shape so as to allow the Veroboard to sit comfortably on the upper edge of the plug base while allowing the ends of the wire to be located directly into the appropriate plug pins.

The crystal holder is mounted in a similar manner on short lengths of 18 s.w.g. support wire, the wires being terminated in pins 2 and 7 of the octal plug. These two pins are unused, and no connections are made to the corresponding tags of the valveholder into which the assembly is plugged. The author used a crystal on a B7G base, and the 18 s.w.g. support wires were taken to pins not employed for the crystal connections. The latter are pins 1 and 5. If a 2-way crystal socket is used, the 18 s.w.g. wires could be soldered to the same pins as are used for circuit connection. Wiring between the crystal socket and the Veroboard and between the Veroboard and pins 4 and 5 of the octal plug is carried out with short direct lengths of p.v.c. covered wire. The earthy side of the crystal may connect to the 18 s.w.g. support wire soldered to pin 6. Figs. 3 and 4 give top and side views of the assembly.

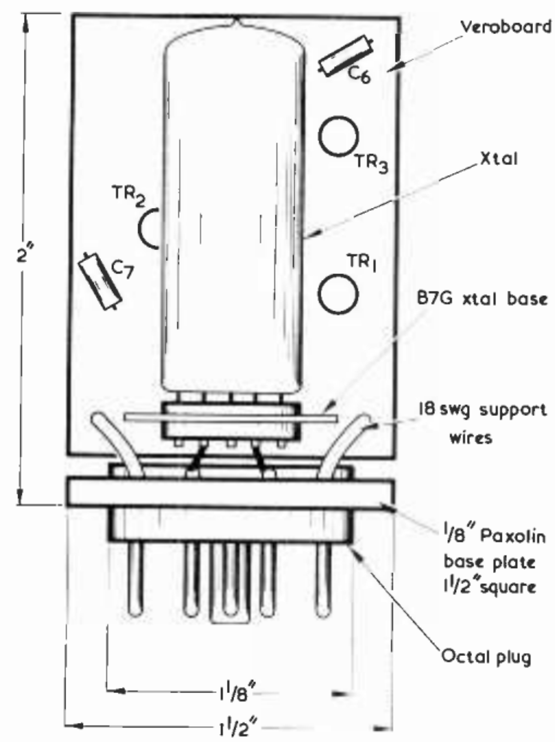


Fig. 4. The octal plug assembly as seen from the crystal side

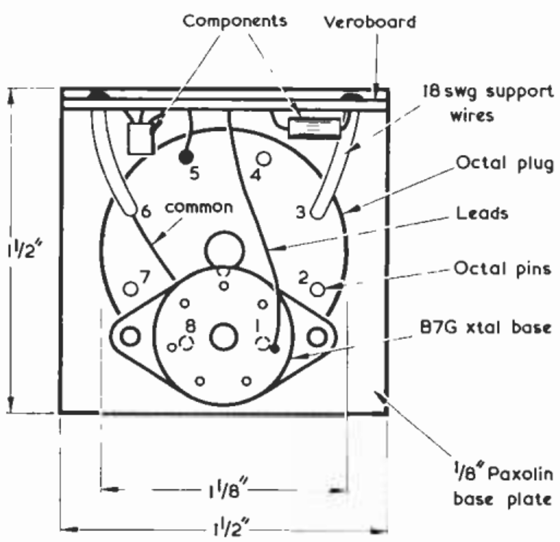
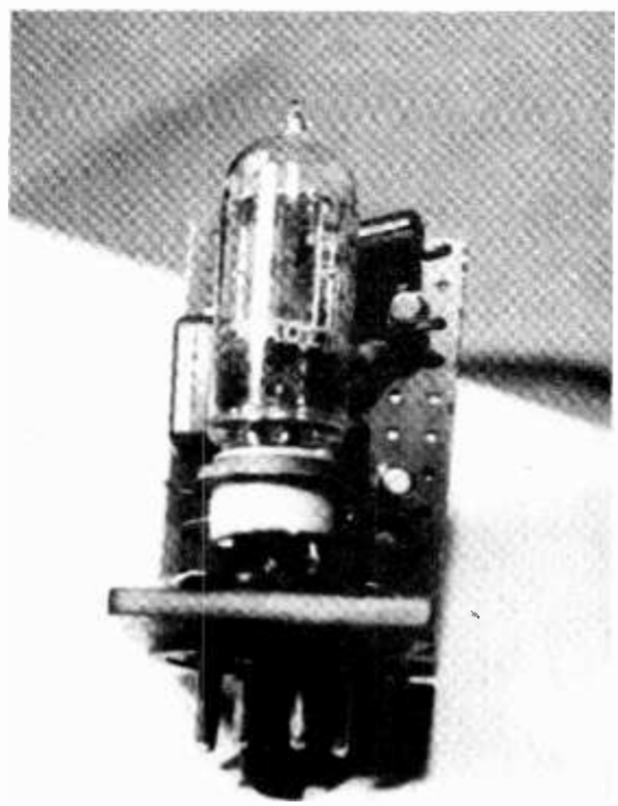


Fig. 3. Top view of the assembly on the octal plug

The corresponding octal valveholder is fitted at a convenient point in the receiver with which the marker unit is to be employed. Connections are then made to tags 3 and 6, or to tags 3, 4 and 6, of the valveholder, as indicated by 'A' or 'B' in Fig. 1. If R6 is used, it should be positioned away from the oscillator section of the receiver.



A view of the unit from the side on which the crystal appears

Side view of the completed marker unit, with the parts mounted on the octal plug

TESTING

When the unit is completed and connected into the receiver, the supply is switched on and the functioning of the unit checked. If an oscilloscope can be brought into use the waveform can be checked by connecting the Y1 input between TR3 emitter and the common supply line. If no oscilloscope is available the output from socket tag 5 is taken to the receiver aerial input socket. The receiver b.f.o. is switched on and the receiver tuned to a suitable point on the dial. For a 250kHz crystal, 500, 750kHz and 1, 1.25, 1.5, 1.75MHz, etc., are suitable points at the lower end of the tuning range. When the receiver is tuned over these points a strong beat note should be heard. It will be necessary to reduce the r.f. gain to a relatively low level to prevent overloading the receiver.

Having proved that the marker unit is functioning correctly it only remains to set the value of C5 for the best level of coupling into the aerial circuit. With the marker unit switched on as just described, select the high frequency end of the receiver h.f. band. In most types of standard receiver this will be in the region of 30MHz. The r.f. gain can be increased to near-maximum. Tune about this point until the beat note is heard. With a 250kHz crystal, beats will be noted on 29.5, 29.75, 30, 30.25 and 30.5MHz, etc. The aerial should be disconnected during these tests. The strength of the beat note around 30MHz will depend to a large extent on the sensitivity of the receiver in use. Thus, the value of C5 can only be selected under test.

With conditions set up as just described, reduce the value of C5 until the beat note falls to an average level of audio output with the receiver set to maximum r.f. gain. With highly sensitive receivers, values in C5 of even 0.5 or 1pF may still be too large, and the output lead from tag 5 of the valveholder may have to be even more loosely coupled to the aerial input. In this instance the lead from tag 5 is brought into close proximity with the aerial input socket or lead, but no direct connection is made. In some cases the coupling lead from tag 5 may have to be screened to prevent stray coupling to other circuits.

With the value of C5 set, the unit is complete and ready to be switched into service at any time. Not only does the use of a frequency marker allow instantaneous calibration checks at the press of a switch, but it will also indicate any long term deterioration in receiver alignment.

While the crystal marker described so far has only been considered as a permanent sub-unit for internal use with a receiver, it could of course be built in a separate case with internal battery or power supply. Such a unit could then be employed not only with a number of different receivers but also as a general purpose frequency standard. The modified circuit in Fig. 5 can be used with the unit, allowing not only a variable output for general use but also for receiver/marker aerial coupling arrangements which obviate the necessity of having to make any internal connections to the receiver. Such a unit will find many uses in the short wave listener's shack and on the test bench.

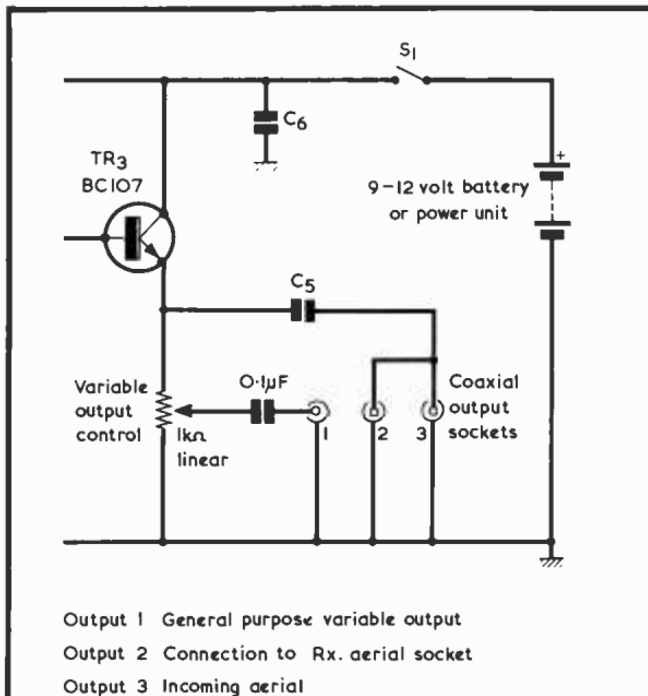


Fig. 5. An alternative output circuit which enables the marker unit to be employed as a self-contained item of equipment

CRYSTAL AVAILABILITY

As stated earlier in this article, the unit may employ crystals having frequencies other than 250kHz. 100kHz crystals are available from Home Radio. 250kHz S.T.C. Crystals Type 4013/CT on a B7G base are available in 1-off quantities from ITT Components Group Europe, Standard Telephones and Cables Ltd., Quartz Crystal Division, Edinburgh Way, Harlow, Middlesex. Also, 250kHz Crystals Type QO1655C, similarly on a B7G base, are available in 1-off quantities from Specialized Components Division, Marconi Communication Systems Ltd., Radford Crescent, Billericay, Essex. A large range of surplus types, some with 'round figure' frequencies, are generally available from Henry's Radio. ■