10 WATT TRANSISTOR TRANSMITTER

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A Design for Top Band using two AUY10s

LIVING as the writer does on a houseboat, Amateur Radio has its own special problems. By far the largest of these is power economy. The power supply at G3DXO is one 4½ h.p. petrol engine that drives two generators—one generator to charge a bank of 24 volt 200 A.h. batteries, the other to give a direct 240 volts d.c. for short term duty such as pumping water and vacuum cleaning.

For one reason or another, Amateur Radio is best carried on in a certain amount of peace and quiet, and so the whole station is run from the storage batteries. The overall efficiency of any 10 watt transmitter using conventional thermionic valves and rotary converters rarely exceeds

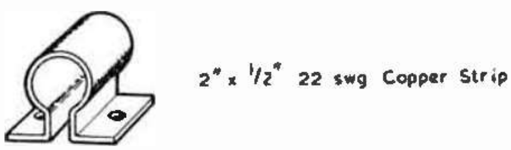

Fig. 1. Heat sink for TR2 and TR3.

25 per cent (usually very much less) so that a completely-transistor transmitter having a nil standby power requirement, even though the actual p.a. may be less efficient, has an overall efficiency that makes its valve counterpart look about as wasteful as going shopping in a steamroller!

The transmitter is divided into two parts. The drive unit, consisting of crystal oscillator and two buffer amplifiers, uses silicon transistors type 2S712. The output is taken via link coupling to the p.a. stage, which is made up as a separate assembly. The 2S712 transistor is manufactured by Texas Instruments Ltd. of Bedford, and the price at the time of writing was £1 11s. 2d.

A convenient way to make up the first three stages is to lay out the components, as near as possible to the positions as in the circuit diagram, on a piece of paper about 6 in. × 3 in., then to mark the positions of the ends of all the resistors and capacitors. Transfer the markings to a piece of paxolin sheet of the same dimensions as the paper. Holes may then be drilled, through which the wire ends may be passed, and the circuit wired up on the reverse side of the paxolin sheet. The coil formers, which can be almost any receiver-type bakelite or polystyrene former having the required dimensions, can be mounted on the paxolin board. TR1 may be wired in without a heat sink, but TR2 and TR3, however, should have a heat sink. These can be made up by bending a 2 in. length of ½ in. × 22 s.w.g. copper strip to the form shown in Fig. 1.

Fig. 2 shows the complete assembly of the drive unit, and it will be seen that the drive is carried to the p.a. stage on two twisted pairs of wire. These may be any length to suit the convenience of the station. In the case of G3DXO the p.a. stage is situated in the window of the deckhouse, adjacent to the aerial feeder, while the drive unit and the receiver are at the operating position on the other side of the deckhouse, some 10 ft. away.

P.A. Transistors

The Mullard AUY10, though a germanium device, was used as a basis for the output stage because of its cheapness. According to the Mullard literature, the AUY10 is a germanium junction transistor of the *p-n-p* alloy-diffused type, intended for use in very high speed core driving applications. The frequency at which $h_{fe} = 1$ is stated as 60 Mc/s min., which means that at 2 Mc/s a useful gain can be obtained. It is possible to reach almost the theoretical maximum of 70 per cent efficiency using a pair of these devices in class B. The dissipation is quoted as 4·5 watts for the case temperature of $\leq$ 50°C. In practice, however, with a heat sink of 3 in. × 2 in. × 16 s.w.g. copper, the temperature can be kept down to just a few degrees above ambient, running at 10 watts input. On a dummy load the writer's transmitter has maintained 24 watts input for 1 hour without any sign of overheating or thermal runaway.

The p.a. circuit is a conventional class B except that it is turned upside down as it were, to fulfill two purposes: one to make the circuit compatible with the first three stages by using a power supply that is positive with respect to earth, and secondly, since the collector of the AUY10 is connected internally to the case, the case may now be earthed. In this design the heat sinks are bolted to the frame of the p.a. tuning capacitor and form the support bracket for the p.a. coil. The tuning capacitor is a standard 500 pF four-gang receiver-type component, two sections being paralleled together to make a 1000 pF two-gang capacitor.

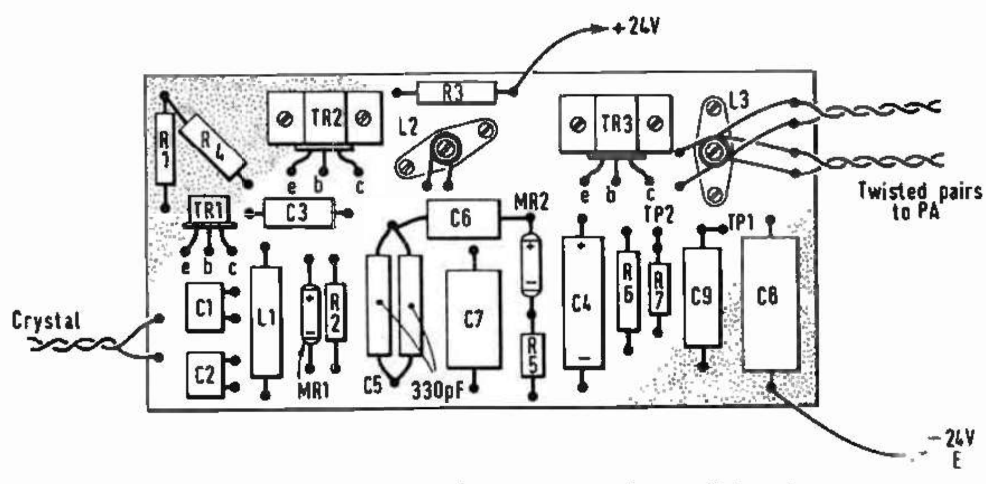

Fig. 2. Suggested layout of components on the paxolin board.

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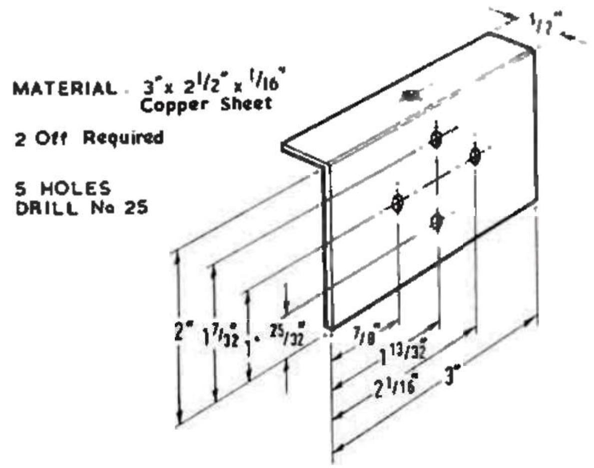

Fig. 3. The larger type of heat sink required for each AUY10.

P.A. Coil

The p.a. coil is made up of 26 turns of 16 s.w.g. tinned copper wire on a 2½ in. diameter former. The winding length is 3½ to 4 in. Short stubs of wire are soldered to each turn to provide taps. The centre tap carries the 24 volt positive supply, the emitters being connected at 3 turns on either side of the centre tap. Make up the two heat sinks for the AUY10's as shown in Fig. 3. Two-way stand-off insulators may be fitted to the 4BA fixing screws on the back of heat sinks to carry the 1 ohm resistors and to carry the twisted pair links to the drive unit. A sketch of the p.a. assembly is shown in Fig. 4.

Modulotion

High level modulation is applied to the p.a. by conventional means. At G3DXO, very satisfactory modulation is obtained by utilizing an old 50 c/s heater transformer: three 6·3 volt 5 amp windings were connected in series to provide the secondary, while the primary is a single 6·3 volt winding. A 10K 1 watt resistor is connected across the original mains primary winding to avoid sparking over on peaks of modulation.

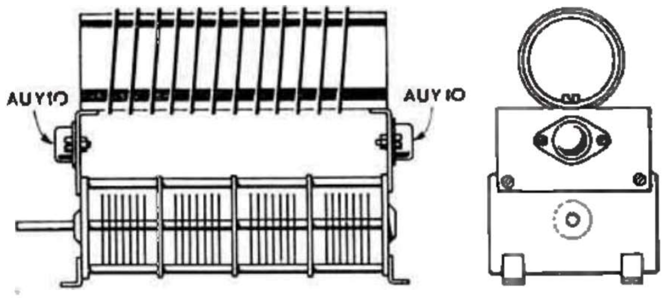

Fig. 4. The p.a. assembly.

A pair of OC28's as a class B modulator give adequate modulation. The output impedance of two OC28's in class B is 3·75 ohms approximately.

Two AUY10's driven to 400mA at 25 volts = 10W = 60 ohms.

Therefore the correct turns ratio for the modulation transformer is:

$$\sqrt{\frac{60}{3{\cdot}75}} = 4 \text{ to } 1.$$

The complete circuit diagram, Fig. 5, with component notes, should be all the information that the average amateur requires. No details of a modulator or a cabinet are given.

The crystal oscillator does not key well in the G3DXO transmitter, therefore for c.w. use it is suggested that the second stage is keyed in the emitter circuit. Almost any old-fashioned diode may be used for MR1 and MR2; probably a semi-conductor type such as the Mullard OA5 would do. The writer found his on a bit of old printed board that was a bit of a computer or something! However, he would be pleased to give personal assistance to anyone who might find it difficult to get the transmitter going.

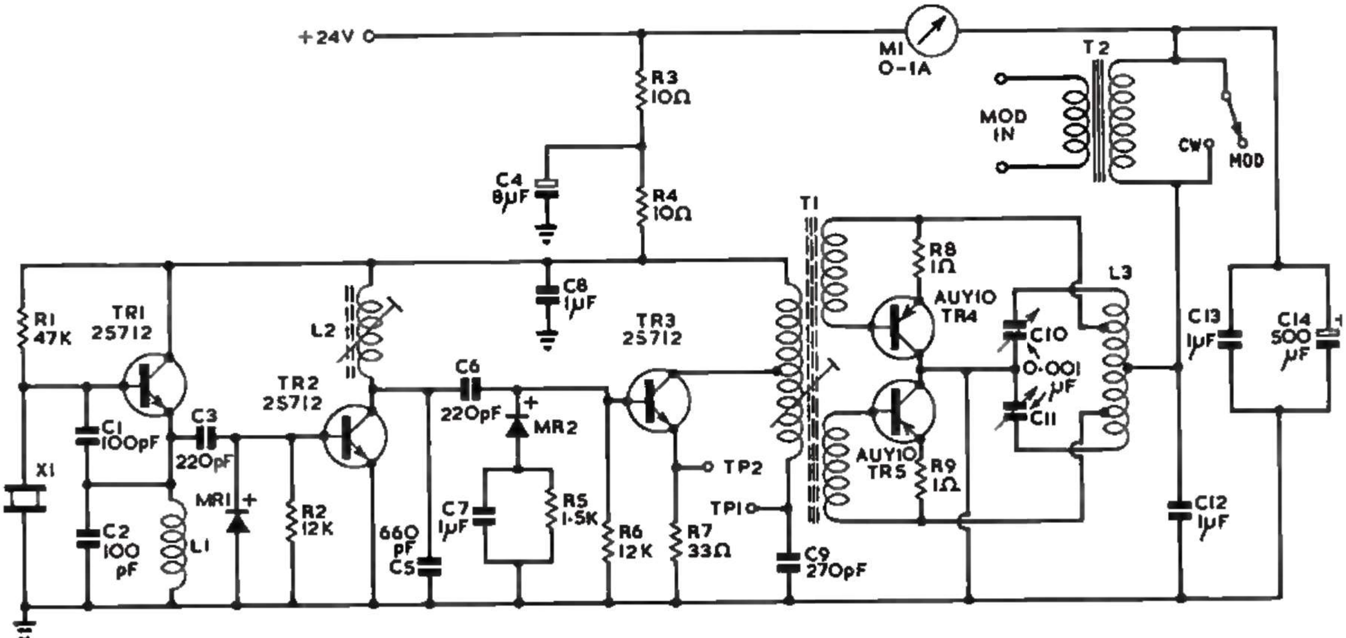

Fig. 5. The complete circuit of the Top Band transmitter. For c.w. operation, the emitter circuit of TR2 should be keyed, rather than the oscillator.

Testing and Tuning

Having assembled the drive unit it is probably best to check it with a dummy load before connecting up the p.a. In fact, by substituting a larger air spaced coil for the final 2S712 and replacing C9 with a variable air spaced capacitor to tune with about 400-500 pF the circuit becomes a useful QRP transmitter, running about 1 watt.

The circuit may be first tuned up on reduced h.t. The crystal oscillator should oscillate with anything upward of 6 volts applied. A small torch bulb of, say, 3·5 volts should be connected across each of the output windings of T1. Tune L2 and T1 cores for maximum output. If no glow is seen on the torch bulbs with 12 volts input, first ascertain that the crystal oscillator stage is working by listening on the station receiver. Slight modifications may be required to L1 for some crystals. The writer has only three Top Band crystals of the Government surplus variety, but they all perform well.

If an oscilloscope is available the circuit is best tuned by looking at TP1, where with 24V input a peak-to-peak sine wave of some 80V should be seen, or at TP2 where approximately 6V peak-to-peak should be seen. Corresponding d.c. measurements should also be made, whether or not an oscilloscope is used, and should be as follows:

(Taken with a high resistance meter such as AVO Model 8.)
Base of TR1 +0·4 volts.
Base of TR2 +1·3 volts.
Base of TR3 +1·7 volts.
TP2 +1·25 volts.

The total input current to all three stages should not exceed 70mA. If it does exceed this figure L2 should be detuned slightly to achieve this. At 12 volts input the current should be approximately 20 mA with a peak-to-peak output of 15 volts at TP1.

(NOTE: The peak-to-peak output voltages depend upon the output load—the figures given represent the no-load condition.)

When the first three stages are working satisfactorily the p.a. may be connected. Before the supply is switched on a 24 volt 12 watt lamp should be connected across three turns of the p.a. coil somewhere about the centre to serve as a load, and the p.a. capacitor set to about half-mesh. The link coupling should at this stage be disconnected.

Switch on the 24 volt supply and check that no current is indicated on M1. Switch off and connect one of the output windings of the drive unit via the link coupling to the p.a. Detune the core of T1 by some three or four turns, then switch on and adjust the core of T1 for an indicated current in M1 of 200mA. Tune p.a. capacitor until lamp glows, and readjust core of T1 for 200mA. Switch off and connect second link from drive unit, switch on, and if brilliance of load lamp decreases the phasing is incorrect and the second pair of the outputs from the drive unit should be reversed. If the phasing is correct, indicated by increased brilliance of load lamp, the p.a. tuning capacitor should be readjusted for maximum dip, and core of T1 adjusted until 10 watts input is obtained. (About 400mA).

After the p.a. has been running for a few minutes a check should be made to ensure that neither of the AUY10's is overheating. They should both be at the same temperature, just warm to the touch, but not sufficiently hot to burn your finger. Do not bother to prod around with a neon tube for signs of r.f. With a crystal of between 1900 and 2000 kc/s the p.a. should tune with almost maximum capacity. The p.a. tuning should now be checked for spurious oscillations—there should be none if you have laid it out well, though with almost minimum capacity it should be possible to detect doubling in the p.a. There should be no confusion, however, as the output at double frequency is much less than on the fundamental.

Modulation may now be applied, and any of the usual means of checking modulation may be used. *WARNING* Do not modulate the p.a. without a load as you may damage the AUY10's.

When the transmitter is working satisfactorily into a dummy load the aerial may be connected. In the G3DXO installation the aerial is 100 ft. end-fed, connected directly to the p.a. tuning coil at two turns from the centre tap, which together with a good straight earth of 16 s.w.g. copper wire direct to the water gives excellent results. Any of the usual methods of coupling an aerial may, however, be used, though it may be difficult to obtain a sufficiently tight coupling to the p.a. A suggested scheme for a whip aerial is given in Fig. 6. This arrangement has also given excellent results.

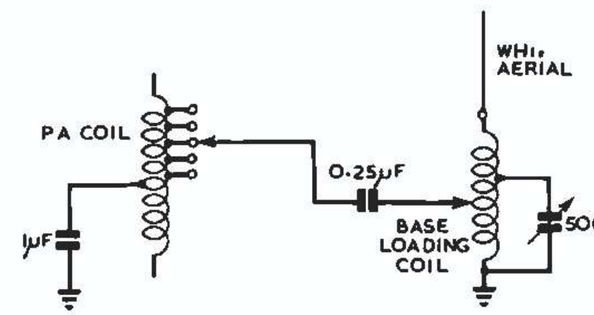

Fig. 6. A satisfactory method of connecting a whip aerial to the p.a.

A 1 amp fuse should always be kept in series with the 24V feed to the transmitter to guard against accidental shorts or thermal runaway.

COMPONENT NOTES

L1, about 100 turns 36 s.w.g. enamelled wire on a ⅜ in. former 1 in. long.
L2, 30 turns 28 s.w.g. enamelled, 3/16 in. diameter ½ in. long former, dust core tuned.
L3, 26 turns of 16 s.w.g. tinned copper, 2¼ in. diameter 4 in. long former.
T1, *primary*, 45 turns 28 s.w.g., tap at 15 turns from cold or h.t. end, former 3/16 in. diameter ½ in. long, dust core tuned. Secondaries 1 and 2, 2 turns loosely coupled to cold end.
C10, C11, made up by strapping two sections of a four-gang 500 pF receiver-type capacitor. (Should tune Top Band with nearly maximum capacity).
C1, C2, C3, C5, C6, C9 should be mica dielectric.
C7, C8, C12, C13, paper dielectric.
T2, in the prototype, was a heater transformer with four 6·3V secondaries. *Primary* is one 6·3V winding; *secondary* three windings in series giving 3 : 1 to match the modulator output impedance (if a mains transformer is used, the primary winding should have a 10 K ohms resistor wired across to prevent flashing on peaks of modulation).
MR1, MR2 in prototype were CV448. These components together with C7 and R5 may be omitted if sufficient drive is available to drive the AUY10s to 10 watts without them.
R8 and R9, 3 watt wire wound.
R7, ½ watt carbon.
All other resistors may be ¼ watt carbon.

Morse Code Proficiency Tests from G3BZU

The Royal Naval Amateur Radio Society is dispensing with its QRQ Morse practice transmission on 1880 kc/s at 19.00 GMT on the first Tuesday in each month, which will be replaced with a qualifying run. This has been done in view of recent skip conditions, which make Top Band easier to copy by UK stations than 80 metres. The 20.00 GMT transmission on 3550 kc/s has not been changed, although it will, of course, consist of different text to the 1900 GMT run. Details of these tests were published in the November, 1962 issue of the RSGB BULLETIN.