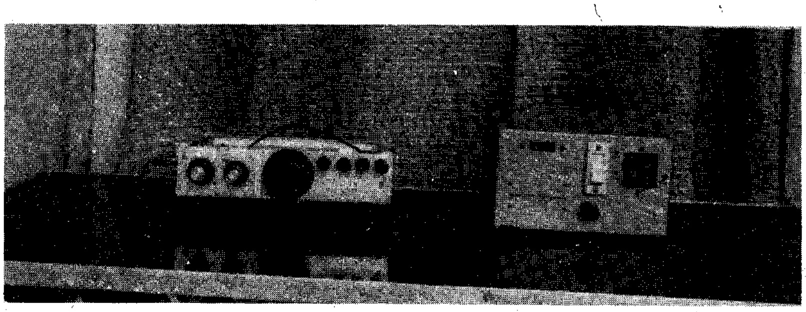
The VU2ATN QRP Transceiver



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The transceiver described here is intended for two categories of hams—those who can not afford an imported commercial equipment and those who are tired of operating sophisticated readymade set. It provides an interesting diversion to the hams who are on lookout for a simple QRP CW transceiver. However, they should possess sufficient zeal, enthusiasm and should be ready to face the challenge and uncertainty associated with QRP operation.

The principle of operation

The block diagram of a simple transceiver is shown in Fig. 1. The receiver section is based on direct conversion principle. The signals corresponding to 14 MHz band are converted to audio frequency range in a single step, thus, avoiding multiple conversion technique. Elegant CW note or audio signals corresponding to incoming SSB transmission are available at the high impedance headphone output.

Suppose the incoming signal frequency is 14101 kHz. To produce a beat note of 1 kHz, the local oscillator (in this case the VFO and the quadruppler combination) must be tuned to 14100 kHz or 14102 kHz. Thus, the same signal can be heard twice as the local oscillator is tuned from lower to higher side. For each setting of the local oscillator frequency (LOF), audio output frequency shall be available corresponding to incoming signal which is slightly lower or higher than the LOF. Therefore, the bandwidth is twice that of an equivalent superheterodyne receiver.

The phenomenon of double response is a disadvantage in the direct conversion receiver. But considering the simplicity of the principle, the technique is entirely acceptable and an effective equipment can be built by using it.

The transmitter utilises the same local oscillator, i.e. the combination of the VFO and a quadruppler. Then there are two keyed amplifiers stages. Finally, a broad band amplifier gives output to the antenna through a low pass filter.

The transmitter/receiver control circuit performs following four functions:

1. Provides antenna change-over during receive/transmit operation.
2. Provides keyed DC supply to transmitter amplifiers.
3. Mutes receiver audio during transmission.

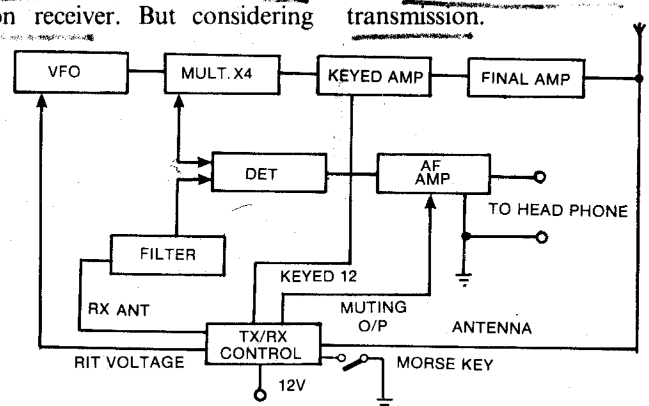

Fig. 1: Block diagram of QRP transceiver.

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PARTS LIST

Semiconductors:	
IC1	— 1496, balanced modulator/ demodulator
IC2	— 741, op-amp
IC3	— 555, timer
T1	— BFW11, n-channel field effect transistor
T2, T3, T7, T14	— 2N2222A, npn switching transistor
T4, T6	— BF194B, npn RF transistor
T5, T10, T11	— BC148B, npn transistor
T8	— 2N2218A, npn switching transistor
T9	— SL100, npn high voltage transistor
T12, T13	— SK100, pnp high voltage transistor
T15	— ECP055, pnp power transistor
D1, D2, D3, D4	— 1N914, high speed silicon whiskerless diode
D5, D6, D7, D8, D9	— 1N4148, silicon switching diode
D10	— 8.1V, 400mW zener diode
D11	— 1N34, detector diode
D12-D15	— 1N4003, silicon rectifier diode
Resistors [all 1/4W, ±5% carbon, unless stated otherwise)	
R1, R4, R48, R52, R54	— 100-kilohm
R2, R17	— 47-ohms
R3, R20	— 33-ohms
R5, R24, R26-R29, R33, R40, R41 R44-R46, R60	— 1-kilohm
R6	— 12-kilohm
R7	— 1.5-kilohm
R8, R42, R51	— 47-kilohm
R9, R18	— 270-ohms
R10, R50	— 4.7-kilohm
R11	— 56-kilohm
R12, R37, R49, R53, R55, R57, R58	— 10-kilohm
R13, R43	— 3.3-kilohm
R14, R19	— 100-ohms
R15	— 27-kilohm
R16, R39	— 5.6-kilohm
R21, R23	— (See text)
R22	— 22-ohms
R30	— 1.2-kilohm
R25, R32	— 820-ohms
R31	— 3.9-kilohm
R34	— 39-ohms
R35	— 10-ohms
R36, R56	— 22-kilohm
R38	— 6.8-kilohm
R47, R59, R62	— 2.2-kilohm
R61	— 50-ohms, 1/2W
R63	— 10-ohms, 2W
VR1	— 1-kilohm, preset
VR2	— 20-kilohm, potentiometer
VR3	— 10-kilohm, potentiometer
Capacitors:	
C1	— 500pF, polyester or styroflex
C2	— 150pF, polyester
C3, C5	— 1000pF, polyester
C4, C6, C19 C47, C63	— 0.05μF, ceramic disc
C7, C8, C34, C39, C50-C52, C55, C62	— 0.01μF, ceramic disc
C9	— 2.2pF, ceramic
C10	— 150pF, meshed trimmer
C11, C16	— 50pF, ceramic
C12, C22	— 0.001μF, 50V ceramic
C13, C18, C21, C24, C25, C35-C38, C42, C53, C56, C57, C60, C67	— 0.1μF, 50V ceramic disc
C14, C15, C29, C31, C33	— 100pF, polyester
C20	— 47pF, ceramic
C23	— 47μF, 35V electrolytic
C26, C28	— 220pF, ceramic
C27	— 470-pF, ceramic
C30, C32	— 3.9pF
C40	— 15μF, 25V electrolytic
C41	— 1μF, 10V electrolytic
C43	— 100μF, 16V electrolytic
C44, C46-C49	— 10μF, 63V electrolytic
C45	— 25μF, 25V electrolytic
C51, C52, C55	— 0.01μF, ceramic disc
C54	— 3.3μF, 15V electrolytic
C58, C59	— 0.005μF, polyester disc
C61	— 470μF, 16V electrolytic
C64	— 2200μF, 35V electrolytic
C65	— 0.33μF, polyester disc
C66	— 50pF, gang
Miscellaneous:	
X1:	— 18V-0-18V, 1-amp secondary transformer
L1	— Slug-tuned 37 turns close wound with 32 SWG enamelled wire
L2 : W1	— 25 turns closewound with 30SWG
W2	— 3 turns with 30 SWG over the cold end of W1
L3 : W3	— 18 turns closewound with 30 SWG
W4	— 4 turns with same over the cold end of W3
L4 : W5	— 24 turns of 30 SWG and tapped at 3 turns from the cold end
W6	— 4 turns link with 30 SWG over the cold end of W5
L5, L6	— 9¾ turns with 30 SWG
L7 : W7	— 2 turn-link with insulated hook-up wire loosely wound over the cold end of
W8	— 10 turns close wound with 30 SWG wire to be slug-tuned
L8, L9	— 10 turns close wound with 30 SWG wire to be slug-tuned
RFC1	— 1mH, RF choke
RFC2	— 100μH, RF choke
RFC3	— 8 turns with 36SWG on TV balun ferrite core
RFC4	— 13 turns with 36SWG on TV balun ferrite core
	— PCB, heatsink for T9, aluminium box for VFO, banana plugs, sockets, earphone plugs, knobs, hook-up wire, shielded wire
RFC5	— 47μH choke

NOTE: L2, L3, L4 are slug tuned and L5, L6 are without slugs.

4. Provides RIT voltage during reception.

Change-over from receive to transmit and vice-versa is completely electronic. It is noiseless, fast and extremely smooth in operation.

The circuit details

Complete circuit diagram of the transceiver is shown in Fig. 2. Variable frequency oscillator (VFO) is a parallel-tuned colpitts oscillator built with n-channel FET BFW11 and is buffered by untuned direct coupled amplifier stages. The stability of the VFO is important for proper operation and styroflex/polysterene capacitors are used to ensure the same. The entire VFO should be housed in a mechanically strong aluminium box to avoid stray interference and render stability.

The tuning and the bandset capacitors C66 and C10 are not easily available in the radio market and a traditional source is the surplus market. They are probably manufactured by BEL. But buying a piece or two from them (if at all possible) shall obviously upset the budget of the total rig!

The VFO with the components as per circuit and the bandset capacitor C10 and coil L1 are set to tune from 3.5 MHz to 3.55 MHz. The quadruppler ahead of the VFO is a class A amplifier with output circuit tuned to the fourth harmonic. It delivers an output in the range of 14.00 to 14.20 MHz which is further distributed to Tx (transmitter) chain through C14 and to pin 10 of detector IC through C15.

The receiver detector is a variation of double balanced mixer built around IC1496. In addition to signal from local oscillator, incoming signals through front end band pass filter are also fed to pin 1 of the detector. The resultant audio is amplified by transistor T5 and IC2.

In the transmitter chain, the final amplifier comprises T9 operating in class C. Its output is coupled to antenna through a low pass filter consisting of coils L5, L6 and capacitors C26, C27 and C28. In the control circuit, under key up condition, pin 3 of IC3 remains at 0V. Both D3 and D4 are forward biased and the antenna is connected to receiver input. The RIT transistor T14 remains 'off' and RIT voltage is adjusted by VR3 mounted on the front panel.

At the same time no side-tone is available at the headphone. When the key is depressed pin 3 of IC3 goes up to 2.8V. Both D3 and D4 are reverse biased and the antenna is connected to transmitter output only. The RIT transistor is now 'on' and no adjustable RIT voltage is available during transmission. The muting circuit transistor T12 is also switched on and pin 3 of IC2 is almost at ground potential. Thus no audio output is available from IC2. At the same time keyed +12V DC is available for T7 and T8. Side-tone output is applied to the headphone input simultaneously.

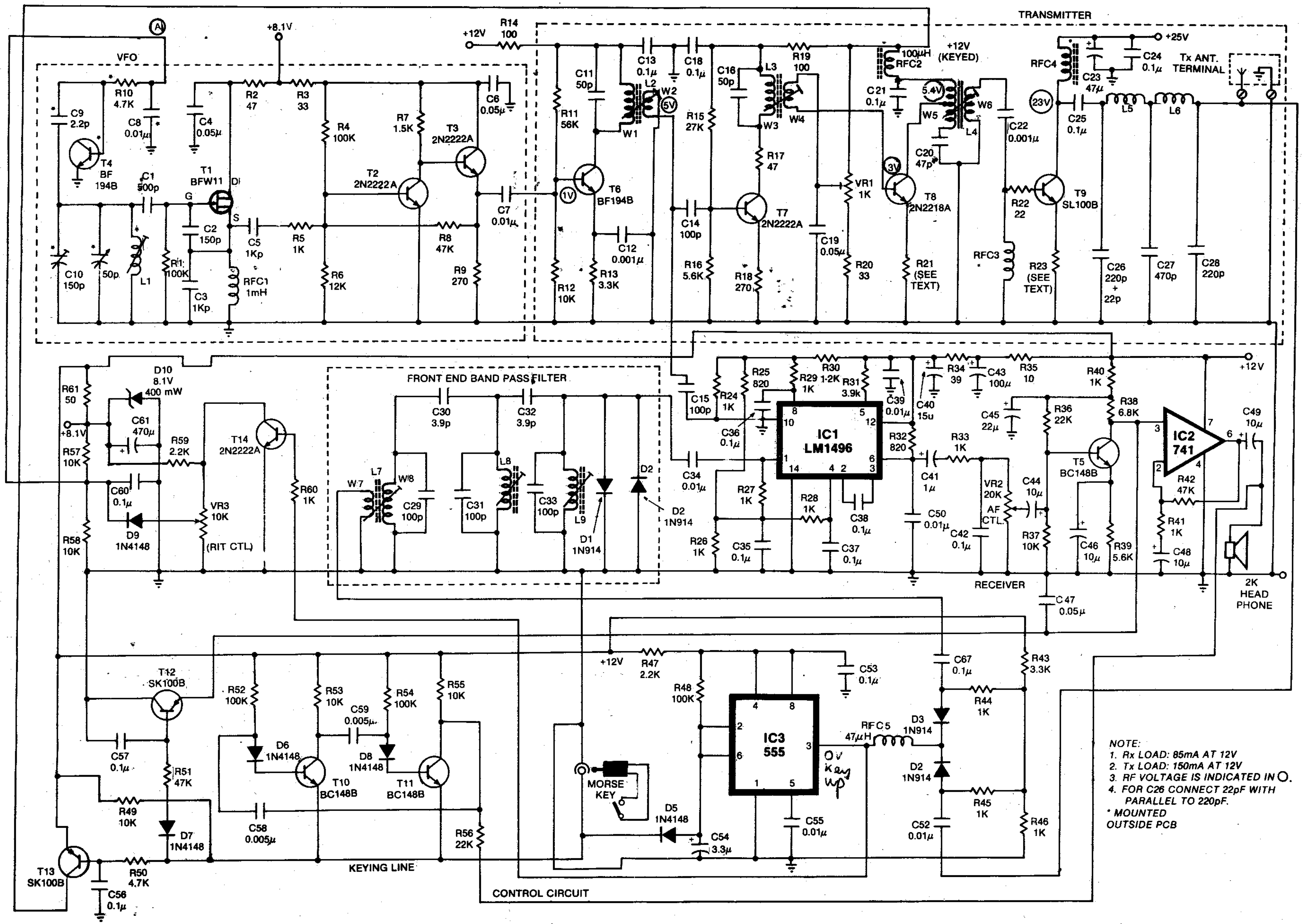

Fig. 2: Complete circuit diagram of the transceiver.

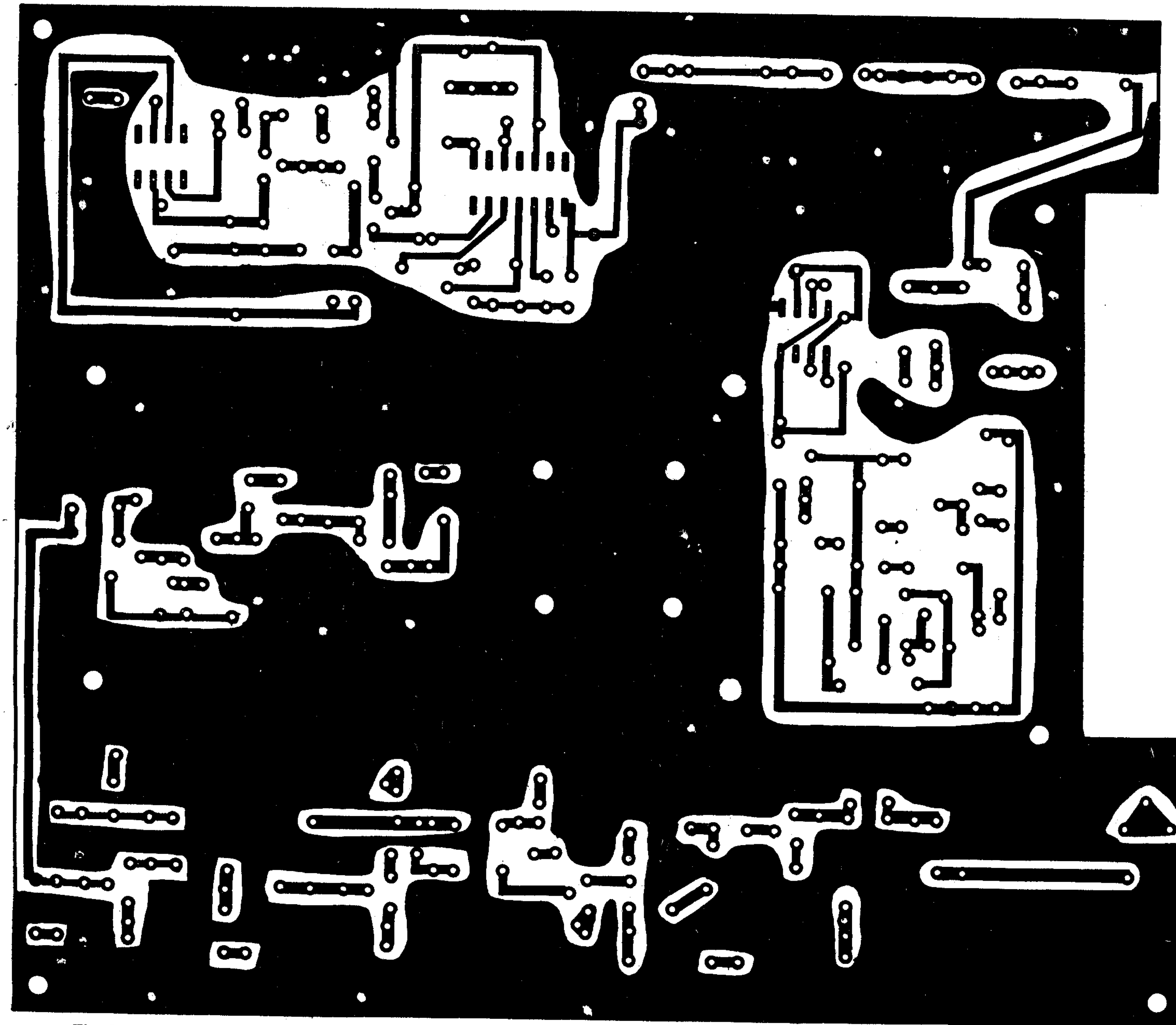

Fig. 3: Actual-size PCB layout of the transceiver. (excluding power supply and RIT section).

Construction

PCB layout for the complete transceiver circuit excluding power supply is shown in Fig. 3. Fig. 4 gives components layout for the same. In addition RIT circuit components are mounted on a small piece of a veroboard. Conventional slug-tuned coils have been used throughout because they are easily available as compared to toroidal ones. A TO-5 type heatsink is required only for the final transistor T9 in the transmitter chain. Sockets have been used for all the ICs. TV balun cores have been used for RFC3 and RFC4. The winding procedure is given in Fig. 7. Unfortunately winding the same number of turns on available balun cores of same dimensions and appearance may provide altogether different results in terms of inductance, Q and frequency response because balun cores being marketed for the same service may vary wildly in characteristics. Cores manufactured by CEL are good for this purpose. The PCB should be accommodated in a home-made aluminium box for proper shielding. However, provide an extra shielding in VFO section for better stability.

Testing and tuning

The following instruments are required for initial testing of the transceiver:

1. Multimeter with RF probe
2. GDO (Gate or grid dip oscillator)
3. Frequency counter
4. A calibrated communication receiver or oscilloscope

In case the constructor does not possess or have access to these instruments, this project should not be attempted at.

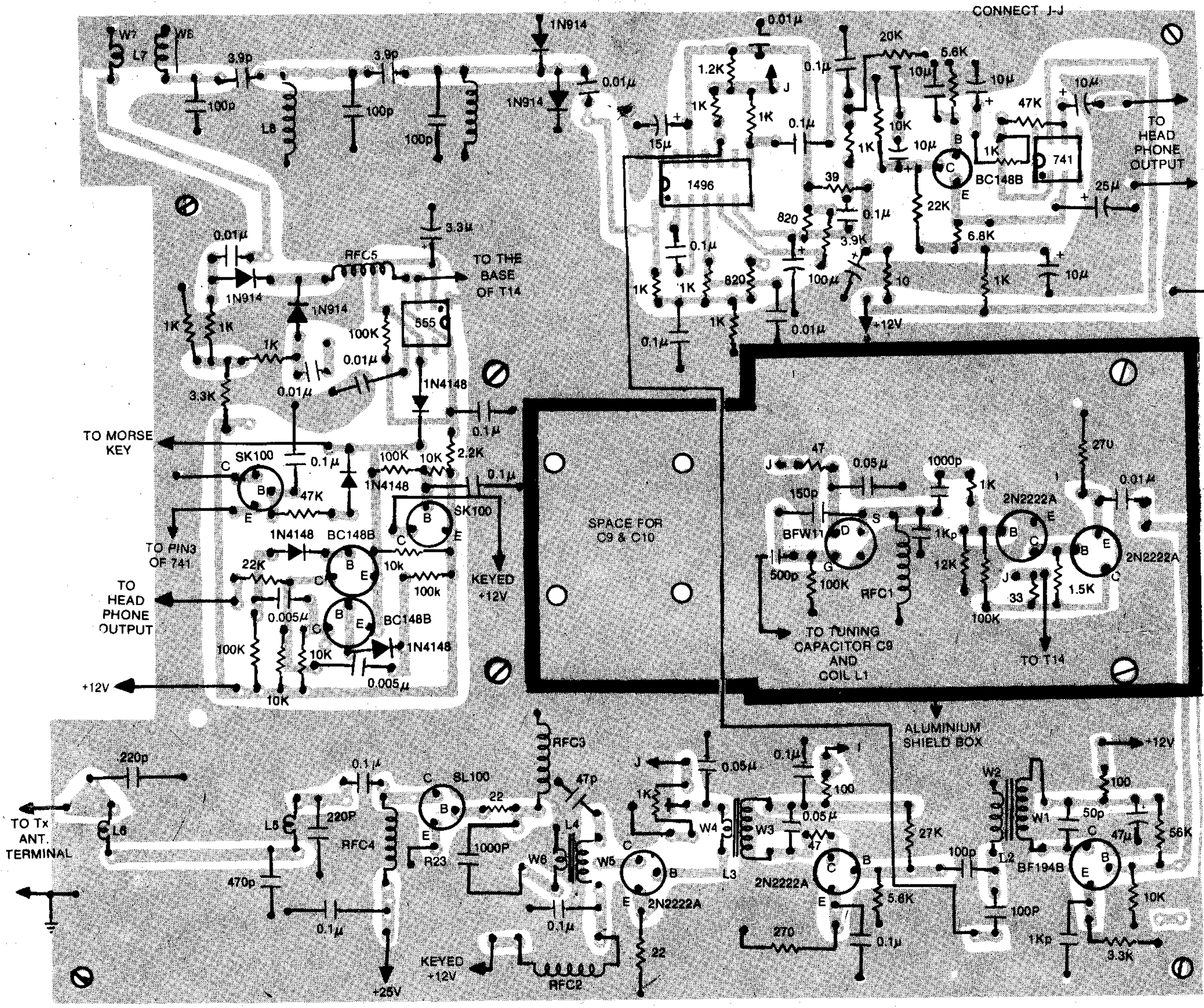

Fig. 4: Components layout for the PCB.

The various DC and RF voltages at different points and under specific conditions are shown in the circuit diagram (Fig. 2). For measuring RF voltage at different points a RF probe may be assembled as shown in Fig. 5 and used with a multimeter. The voltages measured give an idea of comparative RF levels at different stages and they are not accurate or absolute values.

Capacitor C10 and coil L1 are so adjusted that VFO covers a range of 3.50 to 3.55 MHz or so. During reception, the DC voltage at point A for RIT operation varies from 3.4V to 5.1V DC. This variable DC voltage allows a shift of VFO frequency by 600 Hz. The next step is peaking of coil L2 on the transmitter board. The coil is tuned at fourth harmonic of the VFO frequency, so that frequency at pin 10 of detector IC1 varies from 14.0 MHz to 14.20 MHz.

The signal is now peaked by adjusting slugs of coils L7, L8 and L9 of band pass filter. In case of broadcast interference, the slugs are readjusted at the cost of receiver sensitivity. Even with this compromise CW and SSB stations shall pour in under good condition.

To tune the transmitter, the RF input from VFO is disconnected by removing C7 from PCB. The collector current of T8 is adjusted to 30 mA by the preset VR1 under key-down condition. After connecting C7 (VFO output) back to the base of T6, RF voltage is measured across RFC3 under key-down condition. This RF voltage is peaked by adjusting slugs of coils L3 and L4. Apply 25V DC to T9 and connect a 6.3V, 0.3A lamp across antenna terminals as a dummy load. Under keydown condition, this lamp should glow brilliantly. Using a loop probe loosely around the coil L6, the frequency is measured with

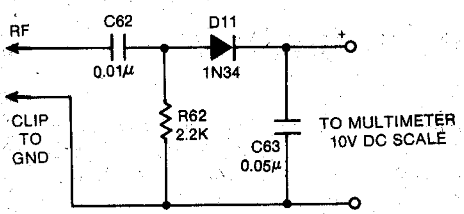

Fig. 5: Circuit diagram for constructing a RF probe.

a frequency counter. The side-tone output is available at the headphone and voltage at pin 3 of IC2 is at a very low level. For R21 and R23 in transmitter circuit author has used a small jumper of 22SWG wire in prototype.

The circuit diagram of the power supply is shown in Fig. 6 and is self-explanatory. A three-terminal 12V regulator IC has been used, current handling capacity of which is improved by the addition of transistor T15. A load current of 1A can easily be handled by this circuit. The 25V DC output can be brought out from the cathode junction of rectifier diodes D12 to D15. The entire circuit has been housed in a standard metal cabinet used for AC voltage stabilisers.

Ordinary dipole antenna fed with twinflex can be used and gives reasonably good results. Dimensions for such an antenna are available in any ARRL/RSGB handbook. However,

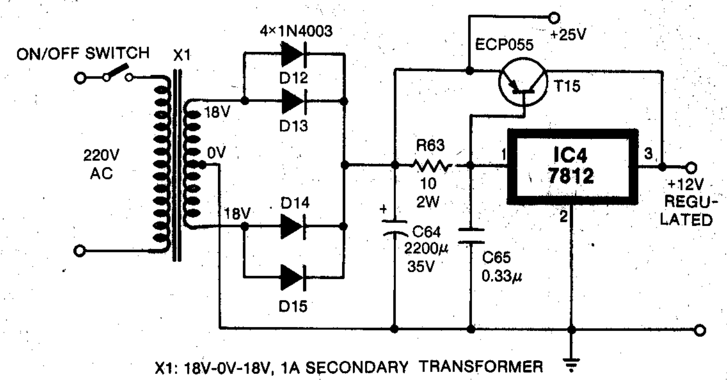

Fig. 6: Circuit diagram of regulated power supply.

TABLE I

DATE/ TIME I.S.T.	STATION WOR-KED	HIS RST	RST REC-VD	HIS NAME	HIS QTH	FREQ	MODE OF WOR-KING	TIME OF ENDG.	REMARKS
7.2.87 0933	UL7GDX	579	579	OLEG	ALMA ATA	14	2×CW	0942	
14.2.87 0918	UM9 NWA	599	589	ALIK	OSH	"	"	0929	
1521	VU2SRB	59	599	SUDHIR	NAGPUR	"	SSB/CW	1531	
21.2.87 1624	RZ4HZZ	599	599	SERGEY	KUIB-SHEIV	"	2×CW	1632	
7.3.87 0849	VU4 APR/RBI	569	559	BHARA-THI	ANDA-MAN IS	"	"	0855	Special operator from Andaman Island.
10.3.87 1950	SM4EMO	599	559	KEN	KUMLA	"	"	1957	
13.3.87 1947	LA2AB	589	559	OLAV	OSLO	"	"	1955	
16.3.87 0820	UI8AH	599	599	TOL	TASH-KENT	"	"	0828	
28.3.87 1750	RA9JM	599	599	OLEG	SAMOT-LOR	"	"	1756	
7.4.87 2048	OH2 BMM	549	539	PENTI	HELS-INKI	"	"	2101	
17.4.87 2116	SLØCB	599	579	HANS	STOCK-HOLM	"	"	2128	

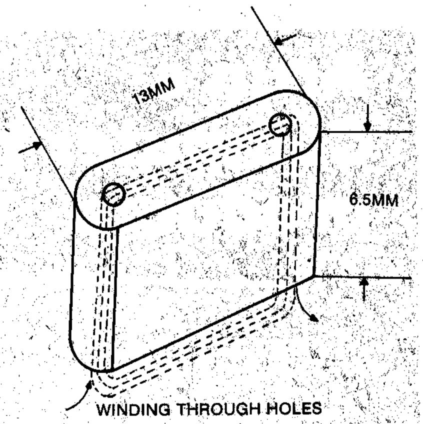

Fig. 7: Winding details on TV balun/core.

suggested details are given in Fig. 8. For QRP operation it is advisable not to call CQ, and it is better to answer someone who has just finished calling CQ. As a general practice the front panel RIT control should be set in such a way that the VFO frequency during reception is lowered by about 200 Hz from that during transmission.

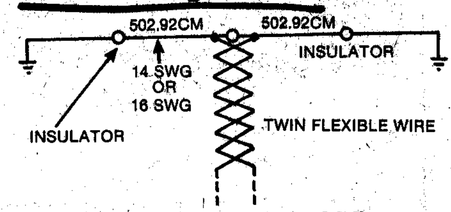

Fig. 8: Suggested antenna for QRP transceiver.

In other words transmission frequency is made to shift slightly on the higher side to zero-beat with the incoming signal. However, it requires some practice to get used to the technique of such transceiving operation.

The prototype has been used by VU2 ATN for more than six months. Its performance has been better than expected. With an output power of less than 2 watts, a number of DX stations have already been worked. The longest DX is LA2AB from Norway with a 559 report for VU2ATN. Russian stations are being worked with consistent good report. A copy of log sheet at VU2 ATN is shown in Table I which gives the reports received with this little wonder. The author is indebted to VU2ALP, VU2APU, VU2CZ, VU2ARQ, VU2RCH and many others who have inspired and helped him in constructing and testing this QRP equipment. □