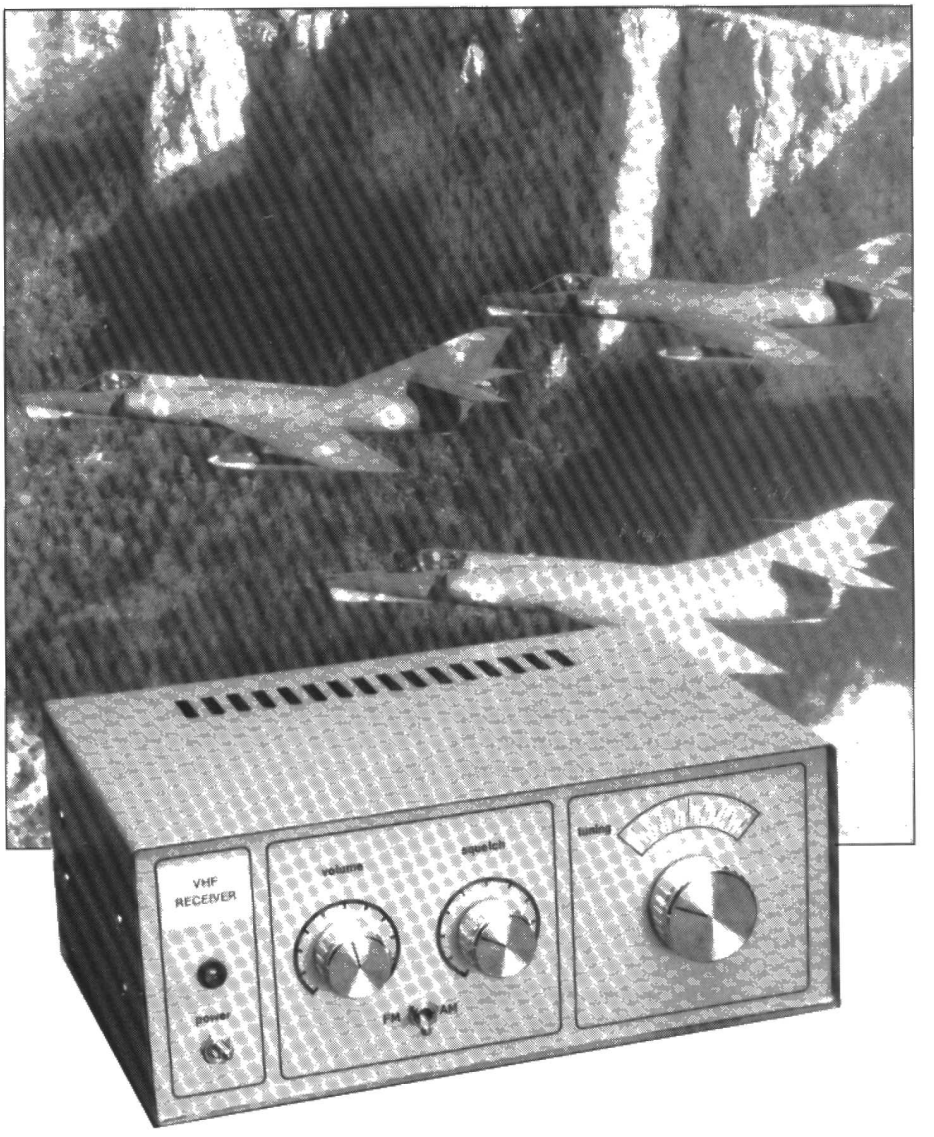
AM/FM VHF RECEIVER

This compact, sensitive, communications receiver has a tuning range of 80 to 135 MHz, covering part of the VHF-low band, the entire VHF broadcast band, and the VHF air band. The upper frequency limit of the receiver can be changed fairly easily to include the 2-metre amateur band.

by J. Bareford



The block diagram given in Fig. 1 shows that the present receiver is a single-conversion type with an intermediate frequency of 10.7 MHz. The RF section, comprising the RF input amplifier, the mixer and the local oscillator, is of conventional structure, and requires no further detailing here. An integrated circuit, to be discussed later, provides the necessary IF amplification, and at the same time comprises the AM and FM demodulators. A squelch (noise suppression) circuit, built from discrete components, works in AM as well as FM mode.

RF circuit

With reference to the circuit diagram of the RF section of the VHF receiver, given in Fig. 2, the aerial signal is raised

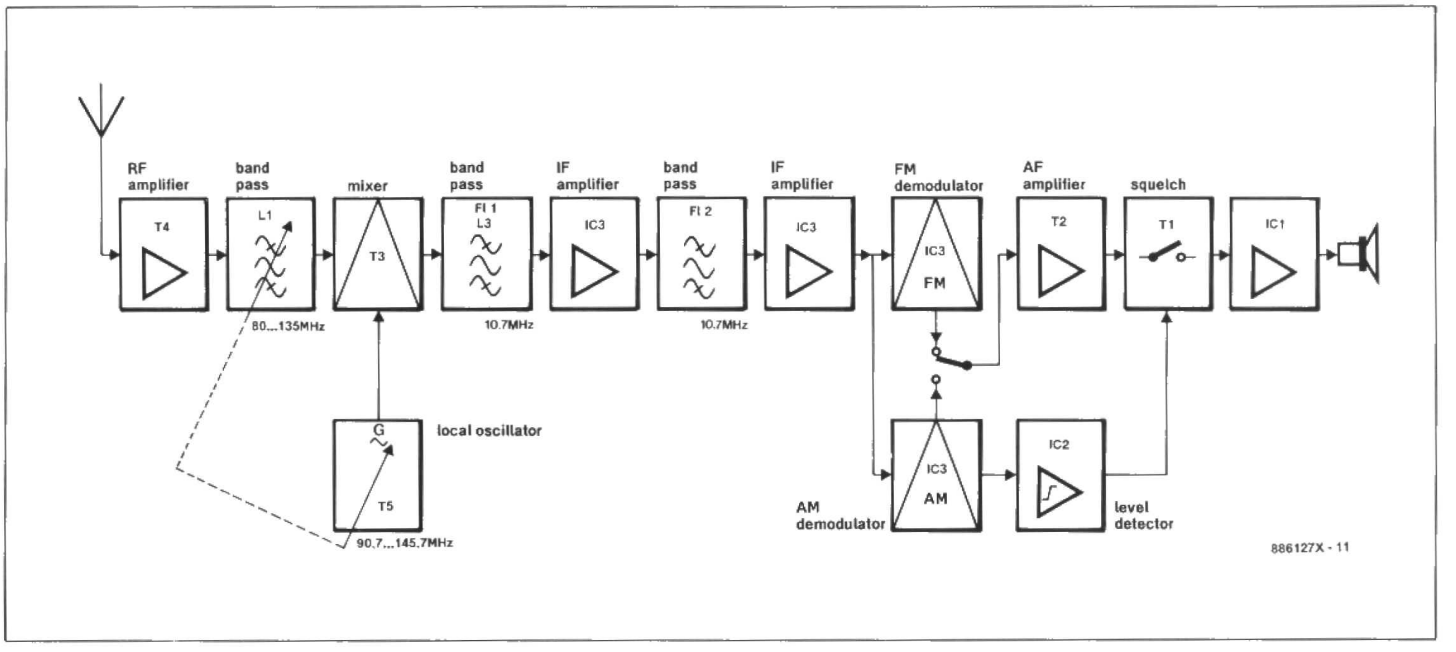


Fig. 1. Block diagram of the AM/FM VHF receiver.

in a wide-band input amplifier based around low-noise transistor Type BFG65. A 10.7 MHz high-pass filter, L_6-C_{20}, is fitted at the aerial input to prevent IF breakthrough. The amplified RF signal available at the collector of T_4 is coupled out to a tap on tuneable band-pass filter L_1-(C_{15}+C_{16}). A double-section tuning capacitor, C_{16}, tunes the band-pass filter together with L-C combination L_2-(C_{16}+C_{24}) in the local oscillator set up around dual-gate MOSFET T_5. The amplified RF signal is applied to gate-1, the LO signal to gate-2, of mixer T_3. The difference frequency, 10.7 MHz, is filtered out with the aid of tuned circuit L_3 in the drain line of the DG MOSFET.

IF circuit and demodulators

Details of the IF amplifier, demodulators, squelch and AF amplifier are given in the circuit diagram of Fig. 3. The signal at point A in the previously discussed RF section is applied to ceramic filter FL_1, which adds to the function of L_3 by reducing the overall bandwidth of the receiver.

Since the Type NE604N integrated circuit combines a number of functions in the receiver, yet may not be familiar to many readers, its internal structure and pinning are given in Fig. 4. The prefiltered IF signal applied to pin 16 is raised in an on-chip amplifier. From output pin 14, it is applied to a second ceramic filter, FL_2, and fed back to the second IF amplifier in the chip. This amplifier drives the internal FM demodulator, which is a so-called quadrature detector that works in conjunction with tuned circuit L_4. Since the on-chip mute-circuit is disabled, the demodulated AF signal is available at pin 6.

The output from the signal-strength detector internal to the NE604N is available at pin 5. Since RF power, and with it RF and IF signal strength, is a function of the amplitude of the modulation signal applied to an AM transmitter, pin 5 of IC_3 simply carries the demodulated AM signal when the receiver is tuned to an AM station (AM is the standard in VHF air-traffic communication).

Squelch and AF amplifier

The FM or AM input signal for buffer T_2 is selected with mode switch S_1. The FET ensures a low driving impedance for the LM386-based AF amplifier, and at the same time prevents the outputs of the NE604N being damaged by the virtual short-circuit to ground when the squelch transistor, T_1, conducts. T_1 is driven by opamp IC_2, which is configured as a comparator, comparing the direct voltage at pin 5 of the NE604N to a level set with potentiometer P_2. When the signal strength of the received trans-

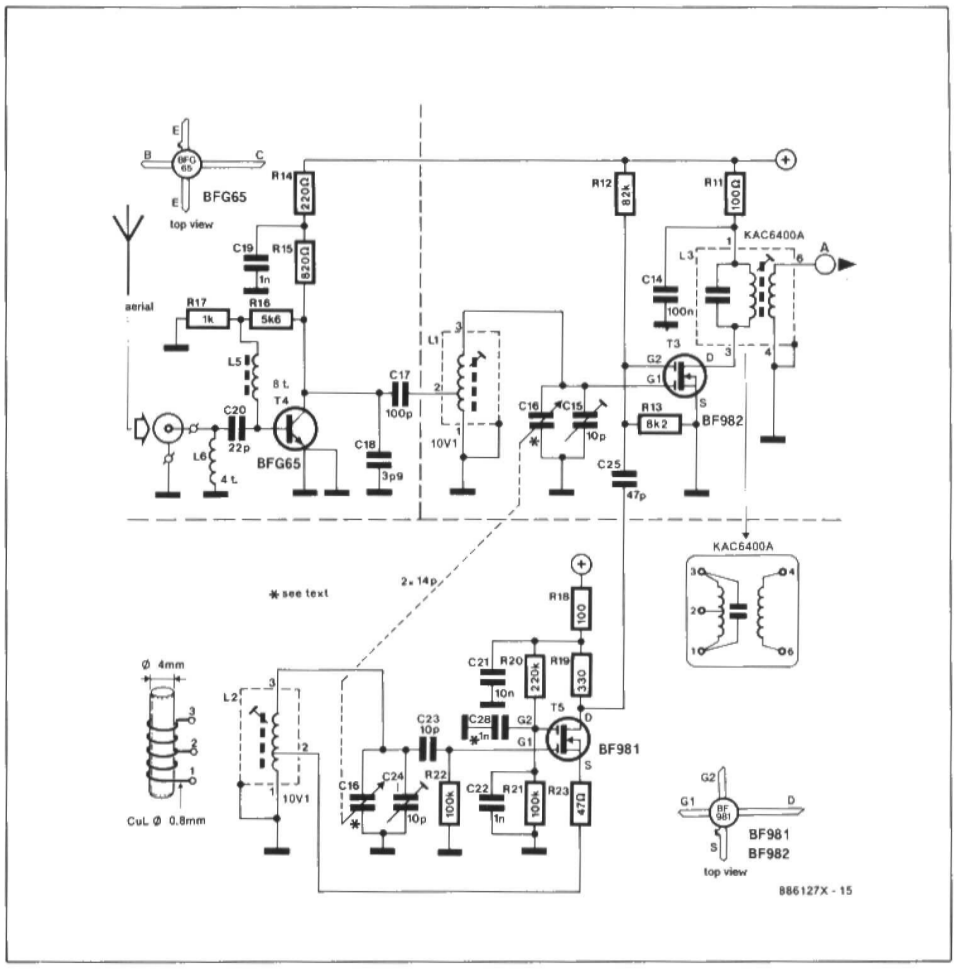


Fig. 2. Circuit diagram of the RF section of the VHF receiver. Note the use of a ganged tuning capacitor, C_{16}.

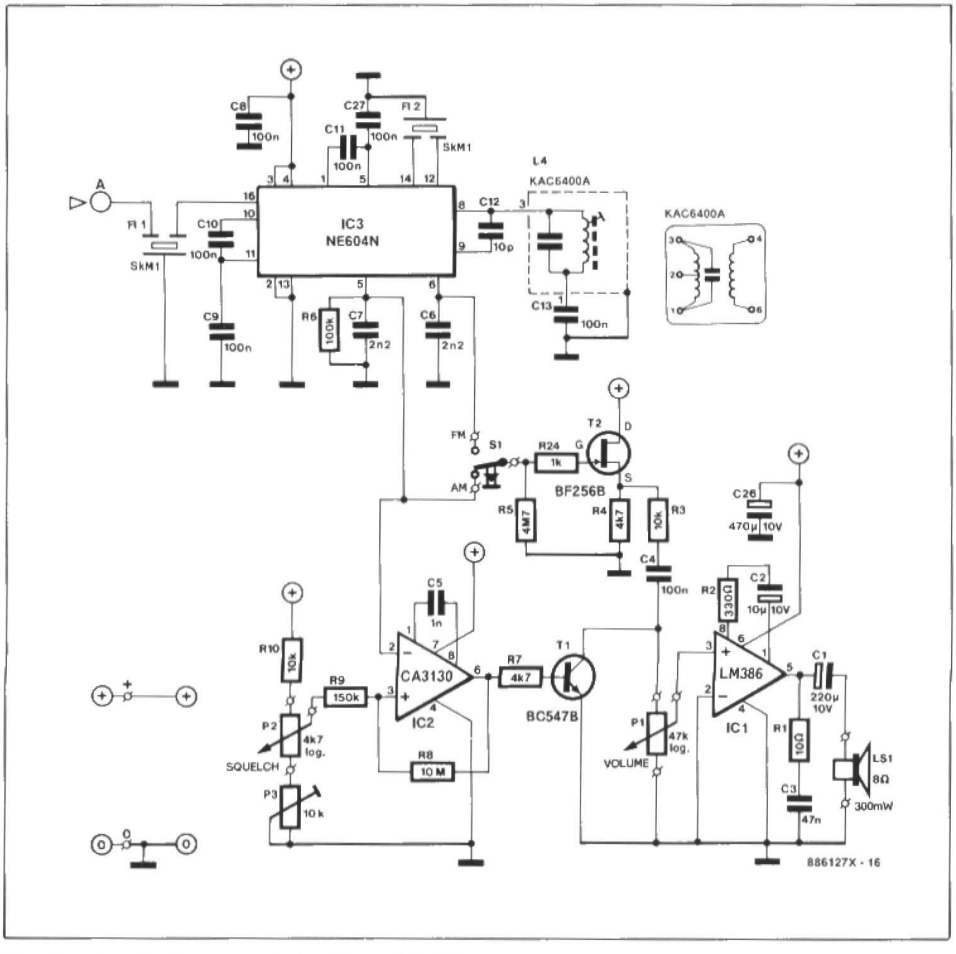


Fig. 3. Circuit diagram of the 10.7 MHz IF section, squelch and AF amplifier.

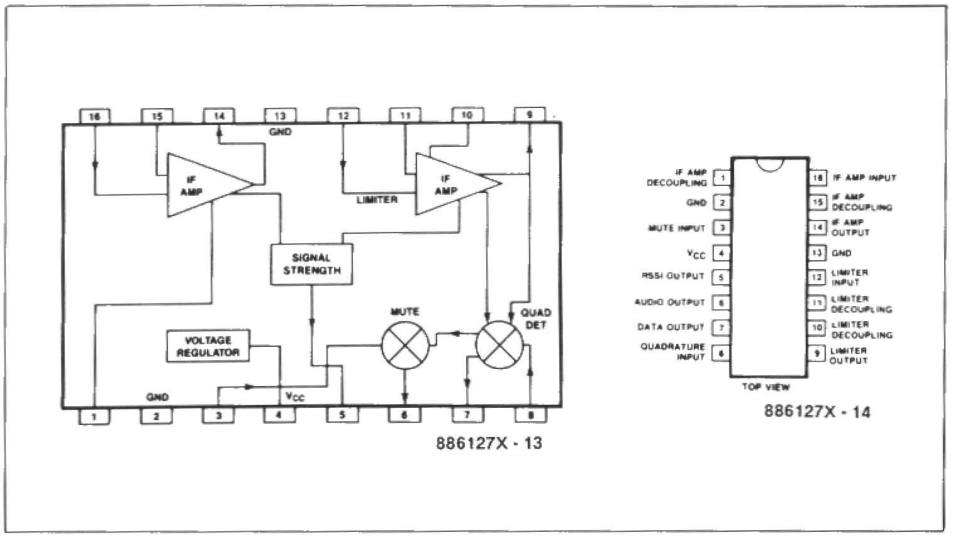


Fig. 4. Internal structure and pinning of the NE604N IF amplifier/FM demodulator from Philips Components.

mitter exceeds the squelch threshold set with P_2, the output of the comparator is virtually 0 V because the voltage at its − input is higher than that at its + input. T_1 is then switched off, so that the demodulated signal is no longer shorted to ground, and can reach AF amplifier IC_1. Resistors R_8 and R_9 provide some hysteresis in the comparator circuit to prevent this toggling as a result of small signal-strength fluctuations. Hysteresis is, of course, essential for AM reception, since without it oscillation would occur. Sometimes, oscillation may still occur, however, and in these cases, the resulting hum level may be reduced by setting P_2 to a slightly higher trip level. Should the comparator persist in oscillation, either increase the value of C_5, or reduce that of R_8.

The AF amplifier set up around the Type LM386 integrated circuit is a standard application, and requires no further detailing.

Building the receiver

Start the construction of the receiver by winding inductors L_1 and L_2. These are identical, and wound as shown in the circuit diagram on the white, ABS, former supplied with the Neosid Type 10V1 inductor assembly. Point 2 is a tap made at about 2 turns from the earthy end of the inductor. Great care should be taken not to overheat the base of the former as the wires are soldered to the three pins at one side of the base. Also make sure that the solder joint made on the three connected pins can not cause a short-circuit with the inside of the metal screening can to be fitted later. Check the completed inductors for correct continuity.

Proceed with making L_5 and L_6. The first consists of 8 close-wound turns of 0.2 mm dia. enamelled copper wire; the internal diameter is about 3 mm and no former is used. L_6 is a VHF choke consisting of 4 turns of 0.2 mm dia. enamelled copper wire, wound through a 3 mm long ferrite bead. Carefully remove the enamel coating at the wire ends of these inductors.

The printed-circuit board for the VHF receiver is a double-sided, but not through-plated, pretinned type. The component mounting plan is given in Fig. 5. The component side is left largely unetched to enable it to function as an earth plane. To effect through-contacting and short connections to earth, some component terminals are soldered at *both* PCB sides, i.e. direct to the earth plane at the component side, and to a solder island at the track side of the board. The two rotor connections of PTFE foil trimmers C_{24} and C_{15} are among the component terminals that require soldering at both PCB sides. Every possible care should be taken to solder these terminals as quickly as possible to the ground plane to prevent damaging the foil by overheating.

The rotor plates of the tuning capacitor, C_{16}, are internally connected to the base plate. This is soldered direct to the earth plane, opposite the stator terminals. Short wires are used to connect these to the relevant holes in the PCB. One connection goes to junction C_{23}-C_{24}, the other to junction C_{15}-3(L_1)-G2(T_3).

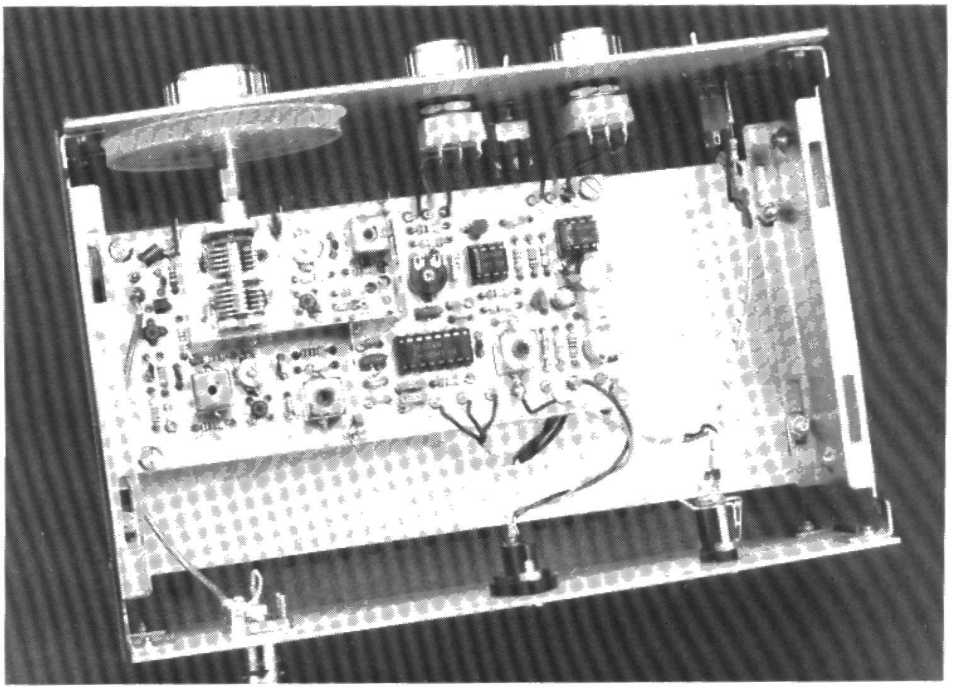
Surface-mount capacitor C_{28} is not shown on the component overlay of the board. This part, which is essential to ensure oscillator stability, is soldered direct between the G2 terminal of T_5 and the earth plane. Stray radiation from the oscillator and the RF preamplifier is prevented by soldering 20 mm high tinplate or brass screens on to the earth plane, as indicated by the dashed lines on the component overlay.

The IF amplifier/demodulator, IC_3, is soldered direct on to the board, i.e., without an IC socket. Solder pins 2 and 13 to ground as outlined above.

The input to the receiver should be made in thin coaxial wire connected between the two soldering pins and a BNC or SO-239 socket mounted on to the rear panel of the enclosure. The connections to the front-panel mounted squelch and volume potentiometers may be made in unshielded wires, but only if these are kept shorter than about 5 cm.

As shown in the photograph of Fig. 6, the connections to the external loudspeaker and the power supply may be made in a DIN loudspeaker socket and a small DC-input socket, respectively.

A standard 8 V supply, set up around a 7808 with decoupling capacitors at the input and output, may be built into the receiver enclosure. This has the advan-



A look inside the completed prototype.

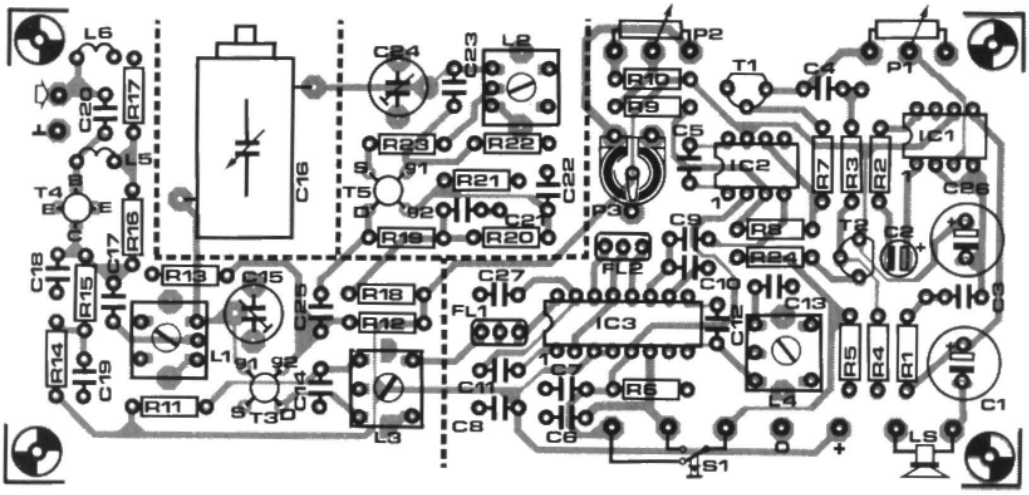


Fig. 5. Printed-circuit board for the VHF receiver.

Parts list

Resistors (±5%):
R1 = 10R
R2;R19 = 330R
R3;R10 = 10K
R4;R7 = 4K7
R5 = 4M7
R6;R21;R22 = 100K
R8 = 10M
R9 = 150K
R11;R18 = 100R
R12 = 82K
R13 = 8K2
R14 = 220R
R15 = 820R
R16 = 5K6
R17;R24 = 1K0
R20 = 220K
R23 = 47R
P1 = 47K logarithmic potentiometer
P2 = 5K or 4K7 linear potentiometer
P3 = 10K preset H

Capacitors:
C1 = 220µ; 10 V; radial
C2 = 10µ; 10 V; radial
C3 = 47n
C4;C8;C27 = 100n
C5;C19 = 1n0
C6;C7 = 2n2
C9;C10;C11;C13;C14 = 100n; ceramic
C12;C23 = 10p
C15;C24 = 10p foil trimmer (yellow)
C16 = 2×14p ganged tuning capacitor with gearing. Available from Meek-it Elektronika
C17 = 100p
C18 = 3p9
C20 = 22p
C21 = 10n ceramic
C22 = 1n0 ceramic
C25 = 47p
C26 = 470µ; 10 V; radial
C28 = 1n0 surface-mount capacitor

Semiconductors:
IC1 = LM386N
IC2 = CA3130E
IC3 = NE604N (Philips Components)
T1 = BC547B
T2 = BF256B
T3 = BF982 (C-I Electronics)
T4 = BFG65 (Universal Semiconductor Devices; C-I Electronics)
T5 = BF981

Inductors:
L1;L2 = Neosid assembly Type 10V1. Winding details are given in the text. (Neosid Limited • Icknield Way West • LETCHWORTH SG6 4AS. Telephone: (0462) 481000. Telex: 826405. Contact: Mr. E. Adcott. Neosid inductors are also available from C-I Electonics, P.O Box 22089 • 6360 AB Nuth • Holland).
L3;L4 = KAC6400A (Toko; UK distributor is Cirkit PLC; telephone 0992 441306)
L5 = see text.
L6 = see text.

Miscellaneous:
FL1;FL2 = SKM1 or similar 10.7 MHz; 50 kHz ceramic filter.
S1 = miniature toggle switch.
BNC or SO-239 (Amphenol) socket.
Loudspeaker; 8 Ω; min. 300 mW.
PCB Type 886127 (see Readers Services page).
Metal enclosure: approx. size 20×14×8 cm.

tage of allowing the use of an inexpensive mains adapter with 12-18VDC output.

The tuning vernier, of which the design is given in Fig. 7, is glued onto a 5 mm thick perspex disc, drilled in the centre for securing on to the spindle of the tuning capacitor.

It is imperative that the VHF receiver be mounted in a metal enclosure, for which a front-panel is made as suggested in Fig. 8.

Setting up

To begin with, the cores of the four inductor sets are screwed in halfway the formers with the aid of a nylon trimming tool. The two trimmer capacitors, C_{24} and C_{15}, and the squelch range preset, P_3, are set to the centre of their travel. Short-circuit the receiver input. Connect a loudspeaker (min. 8 Ω), and apply power.

First, check the presence of the supply voltage, 8 V, at a number of points on the board. Connect an AC-coupled frequency meter to gate-2 of T_3. Set the tuning capacitor to full capacitance, and adjust L_2 for 90.7 MHz. Adjust C_{24} if this frequency can not be obtained even with the core of L_2 fully screwed in. Set the tuning capacitor to minimum capacitance, and check that the oscillator frequency is about 145 MHz. Now re-adjust C_{24} and, if necessary, the core in L_2, until the desired tuning range is obtained.

Set S_1 to FM mode, and disable the squelch by turning the control fully anticlockwise. Peak L_4, L_3, and L_1 for highest, stable, AF noise output.

Remove the short-circuit at the receiver input, and connect a 50 to 75 Ω unbalanced aerial, e.g., a whip or a ground-plane type. Tune to a relatively strong FM transmission, and adjust the quadrature coil, L_4, until the

demodulated sound is undistorted. Tune to a relatively weak transmission, or attenuate the aerial signal, and re-adjust L_1 and L_3 for minimum noise. This adjustment may also be carried out by switching to AM mode and tuning to an air-band beacon (in many areas, these may be found between 110 and 120 MHz).
Finally, the span of the squelch control may be set to individual requirements by adjusting P_3.

Radio amateurs and other experienced RF constructors will have little difficulty modifying the receiver for a higher maximum frequency, so that the 2-m (144-146 MHz or 144-148 MHz) and weather satellite bands (135-137 MHz) are covered at the expense of shifting the lower tuning limit from 80 to about 90 MHz. Obviously, this requires less inductance for L_1 and L_2, so that some experimentation may be needed in reducing the number of turns and moving the taps accordingly. ⏮

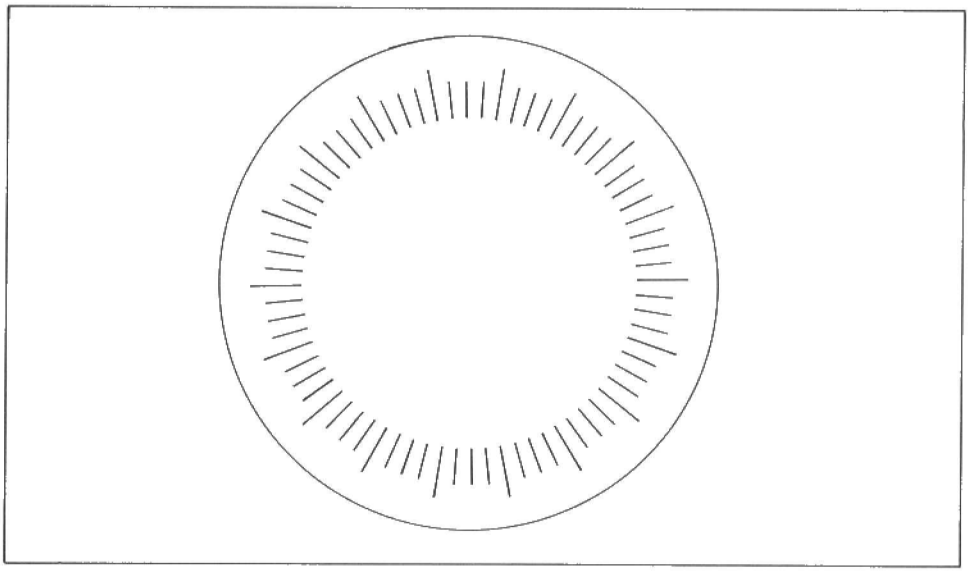


Fig. 7. Tuning vernier. This should be provided with a frequency scale after calibrating the receiver.

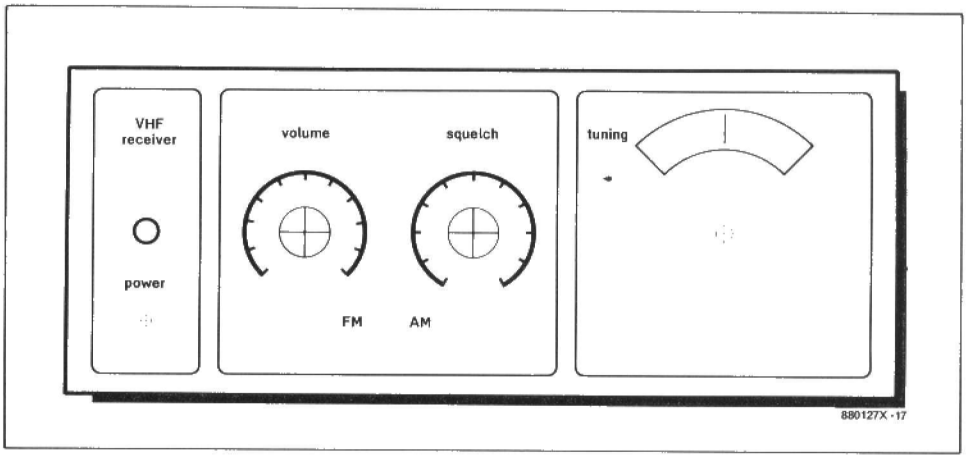


Fig. 8. Suggested front-panel layout.

NEWS

Top award for TV graphics and editing systems

Britain's top engineering prize, the 1988 MacRobert Award has gone to Quantel, creators of the Paintbox TV graphics system and the Harry video editing facility. The prestigious award is made annually by The Fellowship of Engineering, the UK's engineering academy, in conjunction with the MacRobert Trusts, to mark excellence of achievement in engineering innovation along with technical and commercial development.
Paintbox is a complete electronic graphic design system for programme production working directly in the TV medium. Using just a pressure-sensitive pen on a touch table, artists can effectively paint directly on to a video screen. Harry is a video recording and editing system developed as a logical extension of Paintbox, which allows designers to work with the moving image. It is said to be the only system that can display the clips of video being worked on, in a similar way to that in which film is traditionally edited.

Amplifier for fibre optic systems

Avantek has introduced a 0.1 MHz to 4,000 MHz amplifier that offers 19 dB gain, ±0.5 dB full-band gain flatness, low pulse overshoot (less than 15%) and less than 1.8:1 input and output VSWR (all typical).
Designated ACT-4032, the amplifier is particularly suitable for use in high data rate (>1 GHz) fibre optic systems, as well as in pulse amplification, and instrumentation applications. The unit is also extremely versatile as a 'workbench' amplifier for the R&D laboratory.

New name for Teleprinter Group

At the recent AGM of the British Amateur Radio Teleprinter Group, members voted in favour of the proposed change of name to British Amateur Radio Teledata Group.

Brown goods market 1988

The figures for the third quarter of 1988 published by the British Radio & Electronic Equipment Manufacturers' Association suggest that:

- the colour TV market will achieve record levels again and complete the eleventh year of continuous growth in this market;
- teletext offtake is likely to achieve a year on year growth of 25% and will exceed the 1 million level for the first time;
- the FST market has continued to accelerate and, from 50% penetration at the end of 1987, will comprise some 80% of large-screen offtake for 1988.
- in the video recorder market, consumer activity has been very lively throughout 1988 and final figures should show an offtake of close to 2.4 million, substantially surpassing the previous record year of 1983.
- the audio sector has also been notable for the continued buoyancy of demand for compact disc facilities, particularly in the CD separates market which is likely to enjoy in excess of 30% growth.