

PORTABLE SSB TRANSCEIVER FOR 144 - 146 MHz
WITH FM-ATTACHMENT

PART II: CONSTRUCTION AND ALIGNMENT

by G. Otto, DC 6 HL

The characteristics and circuits of this portable or fixed transceiver were described in Part I of this article. This is now to be followed by details of the components, construction and alignment. The FM-attachment will be described in Part III.

3. CONSTRUCTION

Since the layout of the transceiver is dependent on many preferences and requirements, this description is to be limited to the construction of the individual modules. However, the photograph in Part I could be of some assistance for the total layout. The construction and component details are given module for module.

3.1. THE MAIN BOARD DC 6 HL 001

Figure 9 which is given on the centre pages of this magazine, shows the printed circuit board DC 6 HL 001. The dimensions of this board are 245 mm x 65 mm. It accommodates the main part of the receiver and transmitter circuit shown in Figure 3 of Part I. A photograph of the completed module is given in Figure 10. A number of thin screening plates are provided to screen the various stages from another. The dimensions and positions of the screening panels are given on the component location plan in Figure 9. The height amounts to 18 mm. They are grounded and mounted with the aid of short pieces of wire that are placed through the board at the positions shown in Figure 9 where they are soldered to the ground surface. This arrangement represents a slight disadvantage for the receiver: The excellent ultimate selectivity of the crystal filter XF-9 B cannot be utilized to the full with a PC-board construction without use of considerable screening measures. Of course, this disadvantage is present with all equipment with an open PC-board construction. A certain improvement can be obtained with the screened 9 MHz coupling circuits in the IF-amplifier. However, this disadvantage can only be avoided by complete screening. It should be mentioned, that the selectivity of this transceiver is by no means inferior to any previously published equipment and it is considered that the improvement that can be obtained is not worth the extensive screening measures required.

The power output transistor T 118 and its collector circuit are mounted on a 1 mm thick copper cooling plate (heat sink) that is flatly mounted onto the PC-board. The longest sides are bent up to a height of 18 mm. The shape of the heat sink is given in the component location plan and room is provided on the PC-board for this. Trimmer capacitor C 193 is mounted in a cut-out in the heat sink since both connections are at RF voltage. The thermistor R 192 is mounted on the heat sink in the vicinity of the output transistor. Since this thermistor is grounded at one end, it is not necessary for it to be insulated. It is important that the connection leads of the driver transistor T 117 are kept as short as possible. This, as well as a sufficiently high local oscillator voltage at the ring mixer (and an optimum alignment), are decisive for the output power value.

3.1.1. SPECIAL COMPONENTS FOR DC 6 HL 001

The smallest available components should be used for construction.

T 101... T 103: 40673, 40820, 3N187 (protected gate, dual-gate MOSFET (RCA))
T 104 - T 106: 40602, 40604 (RCA) or gate-protected types
T 107 - T 108: BF 245 A (Texas Instruments Germany, Siliconix),
W 245 A (Siliconix)
T 109 - T 111: BC 167 - BC 169, BC 107 - BC 109, 2 N 2926
T 112 - T 113: BSX 39 (Fairchild), BSX 20 (Philips),
BF 224 (Texas Instruments Germany), 2 N 3304
T 114 - T 115: BFY 90 (Philips), BF 224 (Texas Instruments Germany)
T 116 : 40673 (RCA)
T 117 : 2 N 4427 (RCA, Motorola) with cooling fins
T 118 : 2 N 5641 (Motorola)

D 101 - D 102: OA 90 (Philips), 1 N 914, 1 N 4148 or similar
D 103 - D 107: BAY 83 (Fairchild), 1 N 914, 1 N 4148
D 108 : ZF 6, 2 (ITT-Intermetall), BZY 85/C6V2, 1 N 753
D 109 - D 119: BAY 83, 1 N 914, 1 N 4148 or similar
D 120 - D 123: 1 N 4148

L 101 - L 104: 6 turns of 0.8 mm diameter (20 AWG) silver-plated copper wire wound on a 5 mm former, self-supporting.
L 101: coil tap 2 turns from the cold end.
L 102 - L 104: without coil tap.
L 105 : 6 turns as L 101 except coil tap 4.5 turns from the cold end
L 106 : 7 turns of 0.35 mm diameter (27 AWG) enamelled copper wire wound on a 5 mm coilformer with core (red), coil tap 4 turns from the cold end.
L 107 - L 110: 10.7 MHz IF-filters for transistor receivers (Type FM-FB) with built-in capacitors and approx. 22 pF external capacitance
L 111 : 15 turns of 0.35 mm diameter (27 AWG) enamelled copper wire wound on a 5 mm coilformer with core (red).
L 112 : 4 turns of 0.35 mm diameter (27 AWG) enamelled copper wire wound onto L 111.
L 113 : 30 turns of 0.2 mm diameter (32 AWG) enamelled copper wire wound on a 5 mm diameter coilformer with core (red), honeycomb wound.
L 114 : 5 turns of 0.2 mm diameter (32 AWG) enamelled copper wire wound onto L 113, with centre tap
L 115 : 5 turns of 0.8 mm diameter (20 AWG) silver-plated copper wire wound on a 5 mm coilformer with core (red), centre tap
L 116 : As L 115 but without tap
L 117 : As L 116 but self-supporting
L 119 : 3.5 turns of 0.8 mm diameter (20 AWG) silver-plated copper wire wound on a 5 mm former, self-supporting
L 120 : 4 turns of 1.5 mm diameter (15 AWG) silver-plated copper wire wound on a 9 mm former, self-supporting
L 121, L 122 : 7 turns of 0.3 mm diameter (29 AWG) enamelled copper wire wound on a 5 mm coilformer with core (red).

- Ch 101 : 10 turns of 0.3 mm diameter (29 AWG) enamelled copper wire wound on a ferrite core (Philips 4312 020 30161) or on a core for the IF frequency
- Ch 102 - Ch104: Ferrite bead with three turns of 0.3 mm diameter (29 AWG) enamelled copper wire, pulled through the bead.
- C 101, C 103, C 106, C 109, C 111, C 182, C 194: 3.5 - 13 pF ceramic disc trimmers of 7 mm dia.
- C 120, C 192, C 193: 2 - 22 pF foil trimmer capacitors of 7 mm diameter.
- C 121 : 10 - 40 pF ceramic disc trimmer, 10 mm diameter.
- 17 ceramic capacitors for bypassing of VHF frequencies (approx. 1 nF)
- 22 ceramic capacitors for bypassing lower frequencies (4.7 nF to 22 nF)
- 1 Tantalium electrolytic capacitor (drop type) 1 μ F/16 V
- 6 Tantalium electrolytic capacitors (drop type) 2.2 μ F/16 V
- 1 Tantalium electrolytic capacitor (drop type) 10 μ F/16 V
- 3 Tantalium electrolytic capacitors (drop type) 22 μ F/16 V
- 3 Tantalium or aluminium electrolytic capacitors 47 μ F/16 V
- R 192: 100 Ω Thermistor

3.2. CARRIER OSCILLATOR DC 6 HL 002

This module is accommodated on printed circuit board DC 6 HL 002 which is shown in Figure 11. The dimensions of this double-coated PC-board are 55 mm x 30 mm. A photograph of the completed module is given in Figure 12. The printed circuit board is not drilled; the components are soldered directly to the conductor lanes. After mounting the components and checking the operation of this module, the printed circuit board DC 6 HL 002 should be provided with side panels of 18 mm in height. These side panels can be manufactured from metal plate or PC-board material. Figure 13 shows the construction in the form a drawing. The cover can be screw-fitted if a nut is soldered to each corner. The operating voltage and the switching voltage for the diodes are fed in via feedthrough capacitors (C 202, C 204, C 213) that have been soldered in the side panels.

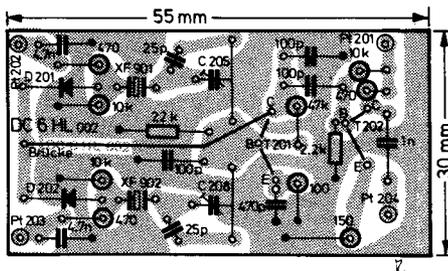


Fig. 11: PC-board DC 6 HL 002

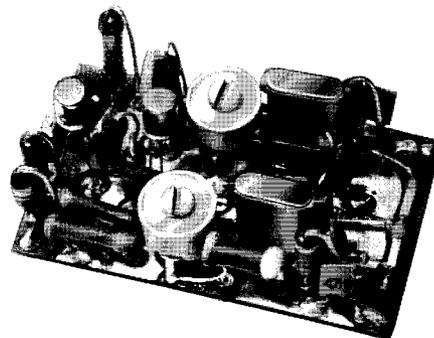


Fig. 12: Photograph of module DC 6 HL 002

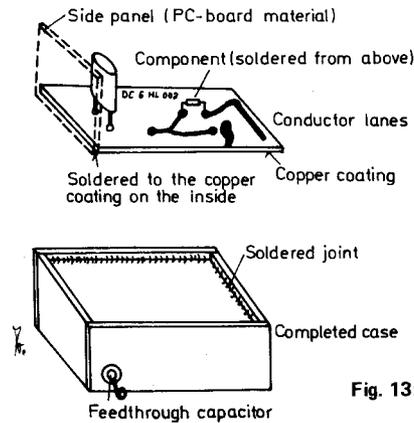


Fig. 13: Construction principle for modules DC 6 HL 002 + 003

3.3. LOCAL OSCILLATOR MODULE DC 6 HL 003

This printed circuit board contains the circuit shown in Figure 6 of Part I. It is accommodated on a double-coated PC-board in a similar manner to that of module DC 6 HL 002. Figure 14 gives the component locations on the 115 mm by 40 mm PC-board DC 6 HL 003. The components are mounted on the printed side of the board in the same manner as for module 002 and the components directly soldered to the conductor lanes. This means that the PC-board should not be drilled. It is only the large circles marked with a cross, that are drilled with a 5 mm diameter drill for mounting the coilformers. With the exception of this, the copper surface on the lower side of the PC-board remains as screening surface.

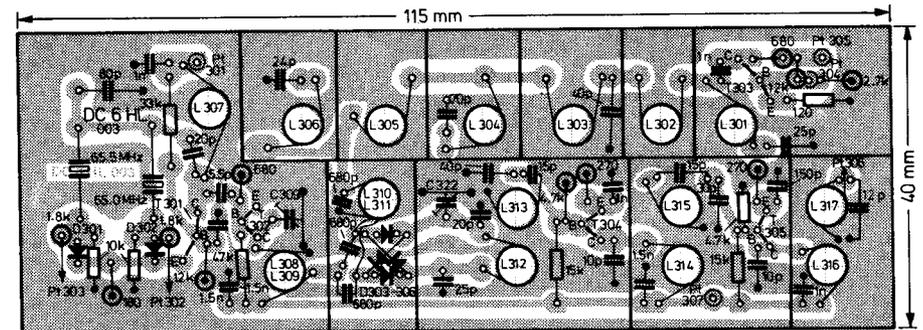


Fig. 14: PC-board DC 6 HL 003

This module is also provided with a number of thin, 18 mm high brass screening panels. The shape and size of these panels can be taken from the component location plan. The panels are provided with small cut-outs with the aid of a round file where no ground surface is present. At other positions, it can be directly soldered to the ground surface. The module is also provided with screening panels which are soldered to the edges of the printed circuit board as shown in Figure 13. The feedthrough capacitors C 301, C 307, C 308, C 311 and C 334 are soldered to the required position. Figure 15 shows a photograph of the completed module. The construction should be carried out in the following order:

- a) It is advisable for the resonant frequency of the inductances to be checked before installation (dipmeter). Firstly mount the crystal oscillator and doubler. The crystal connections should not be shortened so that room is available for smaller components underneath the crystals.
- b) Solder the centre screening panel into place and mount the first lowpass filter chamber.
- c) Solder the screening panel to the next lowpass filter chamber and so on until all lowpass filters have been mounted.
- d) The chambers for the ring modulator and selective amplifier are now mounted in a similar manner.
- e) Align according to the instruction.
- f) Place the feedthroughs and feedthrough capacitors into the side panels.
- g) Correct the alignment.

Note: If the crystal oscillator oscillates wildly, it will be necessary for the value of C 304 to be increased (up to 150 pF).

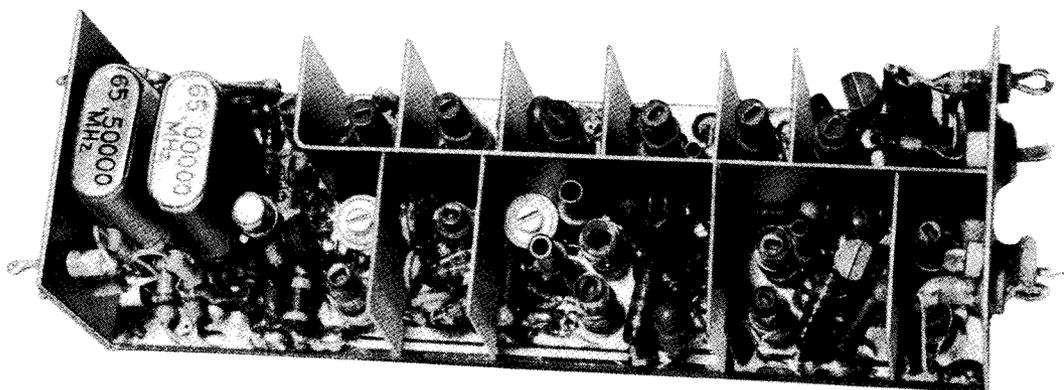


Fig. 15: Photograph of the completed module DC 6 HL 003

3.3.1. SPECIAL COMPONENTS FOR DC 6 HL 003

The smallest components available should be used.

T 301: BC 169, BC 109 (low noise), 2 N 708 or similar

T 302, T 303: BF 224, BF 173, BF 167, BF 115

T 304, T 305: BF 167 (C_{12e} = 0.15 pF !)

D 301, D 302: BAY 83, 1 N 914, 1 N 4148 or similar

D 303 - D 306: 1 N 4148, 1 N 914 (should be selected for the same forward resistance)

Inductances L 310 and L 311 are wound at random, e.g. honeycomb-wound.

L 301, L 306: 13.5 μ H, 55 turns of 0.15 mm dia. (35 AWG) enamelled copper wire close wound on a 5 mm coilformer with core (red).

L 302: 20.3 μ H, 70 turns, otherwise as L 301

L 303: 23.7 μ H, 75 turns, otherwise as L 301

L 304: 1.85 μ H, 21 turns, otherwise as L 301

L 305: 18.6 μ H, 66 turns, otherwise as L 301
 L 307: 6 turns of 0.45 mm diameter (25 AWG) enamelled copper wire wound on a 4 mm coilformer with core (red)

L 308: 3.5 turns, otherwise as L 307

L 309: 2 turns on L 308

L 310: 17 turns of 0.15 mm diameter (35 AWG) enamelled copper wire wound at random on a 4 mm coilformer with core (red). Wound onto a small piece of adhesive tape (sticky side towards the wire) to form a movable roll on the top of the coilformer.

L 311: 33 turns wound on the lower end of the coilformer of L 310

L 312: 4 turns of 0.45 mm dia. (25 AWG) enamelled copper wire wound on a 4 mm coilformer with core (red).

L 313 - L 317: As L 312

L 317: Coil tap at 2 turns from the cold end.

1 crystal of 65.0 MHz and 65.5 MHz directly soldered without holder.

C 317 - C 319: 680 pF miniature styroflex capacitors.

C 309, C 322: 3.5 - 13 pF ceramic disc capacitor of 7 mm dia.

7 ceramic bypass capacitors of approx. 1 nF

1 ceramic bypass capacitor of approx. 10 nF

5 ceramic feedthrough capacitors of approx. 2.2 nF.

3.4. CONVENTIONAL AF AMPLIFIER DC 6 HL 004

This PC-board contains the circuit given in Figure 7 of Part I. The dimensions of printed circuit board DC 6 HL 004, which is shown in Figure 16, are 93 mm x 40 mm. The complimentary transistor pair is provided with an aluminium heat sink as shown in Figure 17. Diode D 401 must be glued with a two-component adhesive (UHU-Plus, Araldite) to the heat sink. Further details can be taken from the photograph given in Figure 18. This module is very uncritical.

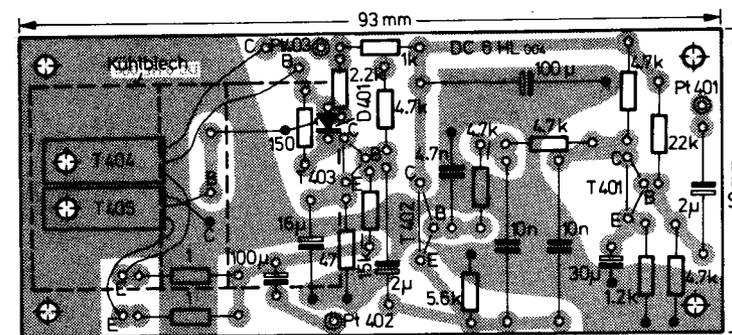


Fig. 16: PC-board DC 6 HL 004

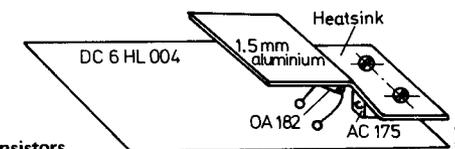


Fig. 17: Drawing of the heatsink for the output transistors

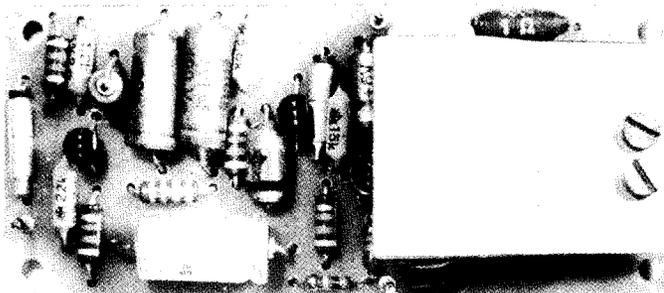


Fig. 18: Photograph of module DC 6 HL 004

3.4.1. SPECIAL COMPONENTS FOR DC 6 HL 004

- T 401 - T 403: BC 167 - BC 169, BC 107 - BC 109, 2 N 2926 or similar
 T 404 : AC 175, AC 187 K
 T 405 : AC 117, AC 188 K
 D 401 : OA 182 (AEG-Telefunken), AA 144 (ITT-Intermetali), 1 N 277
 R 411 : 150 Ω trimmer potentiometer for PC-board mounting
 (spacing 12.5/10 mm).

3.5. INTEGRATED AF AMPLIFIER DC 6 HL 005

Due to the non-availability of the original round IC-type, the circuit shown in Figure 8 of Part I was modified for a split-Dip case. Please note the new connections on the circuit diagram shown in Figure 19. The printed circuit board DC 6 HL 005 and component locations are shown in Figure 20, and a photograph of the module is given in Figure 21.

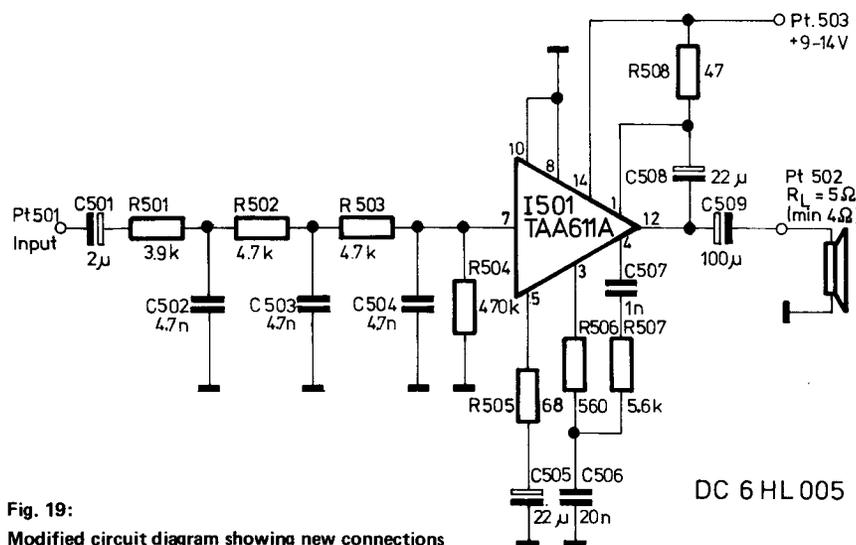


Fig. 19:
Modified circuit diagram showing new connections

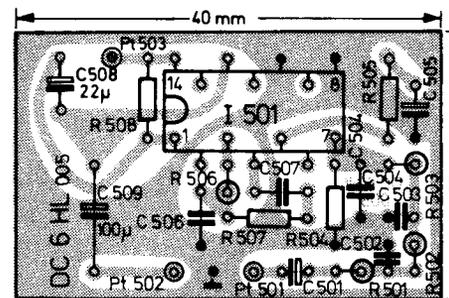


Fig. 20: PC-board DC 6 HL 005



Fig. 21: Photograph of module DC 6 HL 005

3.5.1. SPECIAL COMPONENTS FOR DC 6 HL 005

- I 501: TAA 611 A 12 (12 V type, split-DIP, Fairchild Germany)
 C 501, C 505, C 508 and C 509: Tantalum electrolytic capacitors
 C 502 - C 504: Ceramic disc capacitors, spacing 5 mm

3.6. REFLECTOMETER DC 6 HL 006

The reflectometer is accommodated on printed circuit board DC 6 HL 006 which possesses the dimensions 70 mm x 40 mm (Figure 22). This PC-board is double-coated and the small number of components are soldered to the printed side of the board as shown in the photograph given in Figure 23. Only 4 holes must be drilled, through which one end of the terminating resistors and the bypass capacitors are connected to the ground surface. The coaxial cables are directly soldered to the centre conductor and the ground surface.

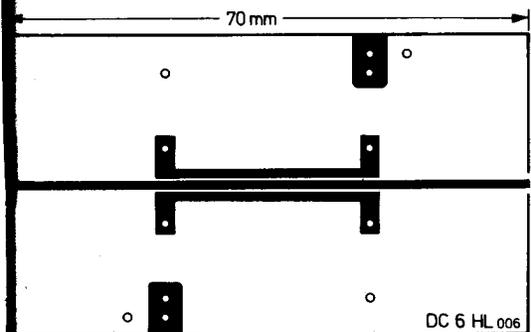


Fig. 22: PC-board DC 6 HL 006

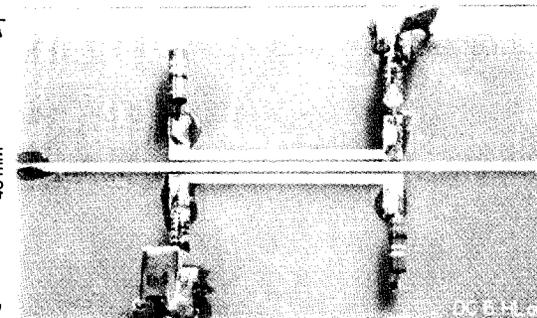


Fig. 23: Photograph of the reflectometer module

3.6.1. COMPONENTS FOR DC 6 HL 006

- D 601, D 602: AA 112, 1 N 87 A or similar germanium demodulator diodes
 2 resistors 60 Ω (56 Ω or 62 Ω) carbon resistors
 2 ceramic bypass capacitors of 1 nF, spacing: 5 mm

not provide more than 100 mV_{rms} output at Pt 304 so that no harmonics are present at Pt 306. It should be mentioned that it is possible to deviate slightly from the frequency concept used in this transceiver without having to alter the circuits. For instance, the author uses crystals of 64.9 and 65.4 MHz in module DC 6 HL 003 and a VFO frequency range of 5.2 to 6.2 MHz.

4.4. LOCAL OSCILLATOR MODULE DC 6 HL 003

The alignment of this extensive module is carried out in steps:

4.4.1. LOW-PASS FILTER

- a) Insert the cores of L 301 to L 306 by approximately half.
- b) Solder a 1 nF coupling capacitor to the input connection Pt 304 and inject a signal (e.g. from a dipmeter).
- c) Disconnect the output of the filter (L 306) from the bandpass filter (C 317) and terminate with a 560 Ω resistor.
- d) Connect the RF-probe of a VTVM or the arrangement shown in Figure 26 and feed the operating voltage to Pt 305.
- e) Align L 302, L 303 and L 305 so that the output signal falls as much as possible above 6.5 MHz.
- f) Align the signal generator (dipmeter) to 11 MHz (harmonic of the VFO centre frequency) and increase the drive to the filter until the meter indicates a clear reading.
Align L 301 and L 306 for minimum reading.
- g) Tune the signal generator from 7 MHz towards higher frequencies. The output signal should firstly fall and then increase at frequencies over about 12 MHz. Inductance L 304 should be aligned for minimum reading at the frequency of maximum signal.
- h) A low, constant insertion loss between 5 MHz and 6 MHz is obtained by carefully correcting L 302, L 303 and L 305. If the attenuation commences lower than 6 MHz, it will be necessary to correct the alignment of L 301 and L 306.
- i) Remove the terminating resistor and reconnect L 306 to C 317/L 310.

4.4.2. CRYSTAL OSCILLATOR AND DOUBLER

- a) Provide connections Pt 301 and Pt 302 (or Pt 303) with a stabilized operating voltage.
- b) Align the core of inductance L 307 until the coupled dipmeter indicates RF-energy.
- c) Correct alignment of L 307 so that the oscillator commences oscillation and offers the same output with each of the crystals.
- d) Align L 308 and C 309 for maximum output voltage at twice the oscillator frequency. Check for equal output at both frequencies, using the circuit shown in Figure 26.

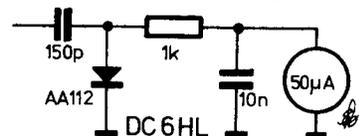


Fig. 26: Alignment aid if no VTVM available

4.4.3. RING MODULATOR

- a) Adjust the connected VFO to 5.5 MHz and place trimmer capacitor C 322 to its centre position.
- b) Align L 310 and L 311 for max. reading at the output of the ring modulator.
- c) Disconnect L 306 from C 317/L 310 and measure the RF-voltage on L 306.
- d) Reconnect the filter and remeasure the output voltage. It should have been reduced by half (power matching). If this is not the case, the spacing between L 310 and L 311 must be changed, after which the measurement should be repeated.
- e) Switch the crystal oscillator to the lower frequency and adjust the VFO to 6 MHz. A frequency of 136 MHz should be present at L 312 (measure with dipmeter). Align L 312 and L 313 for maximum reading.

4.4.4. SELECTIVE AMPLIFIER

- a) Align L 314, L 315, L 316 and L 317 for maximum output at 136 MHz. If the output voltages differ greatly from that at 135 MHz or 137 MHz, L 314 and L 315 should be corrected.
- b) If a measuring receiver is available, it is possible for trimmer capacitor C 322 of the ring modulator to be aligned for minimum output of the fixed frequency (connect the receiver input to the base of T 304).

4.5. MAIN BOARD DC 6 HL 001

4.5.1. TRANSMITTER

Connect the carrier oscillator and VFO/mixer module to PC-board DC 6 Hl 001 and terminate the output of the transmitter.

- a) The quiescent current of output transistor T 118 is adjusted to 20 - 30 mA with the aid of the base trimmer potentiometer R 191. After this, R 190 and R 191 can be replaced by a fixed resistor of the same value.
- b) Feed an AF signal to input Pt 110 from a microphone or audio generator. A signal of 4 V_{pp} should be present at the emitter of the second AF transistor T 111 (at low distortion).
- c) Place trimmer potentiometer R 159 of the ring modulator to one of the stops. The carrier signal should be present at L 111/L 112. The core of these inductances should be aligned for maximum carrier output.
- d) The core of L 113/L 114 should also be aligned for maximum.
- e) The signal should now be received on a two metre receiver. Adjust the carrier to 145 MHz by tuning the VFO.
- f) Align L 115, L 116 and trimmer capacitor C 182 for maximum carrier output.
- g) Screw out the core of L 121 until the signal at L 119 begins to fall.
- h) It is now possible for the driver and PA to be aligned for maximum power gain. L 115, L 116 and C 182 should be aligned to the correct frequency from a higher frequency so that they are not incorrectly aligned to 137 MHz.
- i) It is necessary to spread the resonance points of the circuits in the linear amplifier slightly so that there is no fall of at the band limits.
- j) Align trimmer potentiometer of the ring modulator for minimum carrier output (max. carrier suppression).

k) The transmitter should now be driven at low level by the AF generator. Now align trimmers C 120 and C 121 of the crystal filter for minimum ripple in the pass band.

l) Align the frequency of the XF 901 crystal so that the output power of the transmitter is 3 dB lower at 3 kHz than in the voice frequency range.

4.5.2. RECEIVER

- Connect earphones or an AF-amplifier to the SSB-output Pt 107.
- Connect the S-meter circuit to the control voltage line. The meter should be adjusted with R 2 so that a very slight reading results.
- Connect a signal generator via a 10 pF capacitor to the "hot end" of L 110. A heterodyne should be heard when the signal generator is tuned to 9 MHz. L 110 should now be aligned for maximum.
- This procedure should be repeated for L 109, L 108 and L 107.
- Inject a 145 MHz signal to L 105 and align C 111 for maximum.
- Inject the signal to L 103 and align trimmers C 106, C 109 and C 111 for maximum reading.
- Inject the signal to the antenna input and align L 101, L 102 and L 103 for maximum.
- Align L 106 for the highest conversion gain.
- Align L 122 for best image rejection.

5. NOTES AND IMPROVEMENTS

5.1. INTERMODULATION MEASUREMENT ON THE TRANSMITTER

The author carried out intermodulation measurements on the transmitter of his SSB-transceiver.

Measuring equipment: two AF-generators SBF (Rohde u. Schwarz) and attenuator, Spectrum Analyzer 8554 L with probe (HP), terminating resistor 50 Ω .

Measurement: Two-tone modulation 350 Hz and 2350 Hz.
RF-output (two-tone): 0.5 W

Result: Greatest intermodulation product: -33 dB.

5.2. AUTOMATIC GAIN CONTROL FOR SSB RECEPTION

The SSB control voltage output Pt 108 remains connected to the control line during the alignment of the receiver. If the gain of the IF-amplifier is too great (tendency to self-oscillation), the value of the 4.7 nF source capacitors should be reduced or one of them or more should be removed. During normal operation, the control voltage will vary between approximately + 2.2 V without input signal and approximately + 0.5 V with local signals. If strong signals appear distorted, this will indicate that too little control voltage is being generated. This can be avoided by increasing the values of R 138 and R 139 from 680 Ω to 1.2 k Ω .

Since the AGC is distributed over two RF and three IF stages, it is possible for the first mixer to be overdriven in spite of full gain control. This will be observed as intermodulation and cross modulation in conjunction with strong signals. In order to avoid this, the last IF stage should remain uncontrolled and operate at full gain. The total control range is practically not affected by this. However, since only four stages are influenced by the AGC, the control range of each of these stages is higher, and thus the attenuation of the signal before the first mixer will be better. The modification is carried out easily by disconnecting resistor R 125 (390 Ω) from the control line and connect it to the basic bias voltage of 2.2 V (cathode of diodes D 101, D 103, D 108).

If the SSB-demodulator is not able to handle higher IF-voltages (distortion), it will be necessary to increase the oscillator voltage at connection Pt 106. This can be made using the intermediate transformation circuit shown in Figure 27.

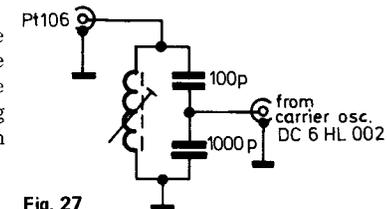
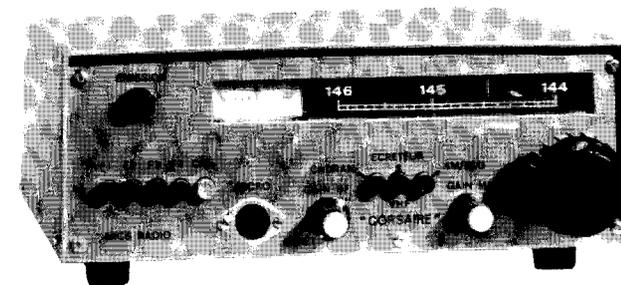


Fig. 27

6. REFERENCES

- G. Otto: Portable SSB Transceiver for 144-146 MHz with FM-Attachment Part I: Circuit Description and Specification VHF COMMUNICATIONS 4 (1972), Edition 1, Pages 2-15.



A mobile station easy on the battery

"CORSAIRE" Solid-state VHF Transceiver

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High efficiency
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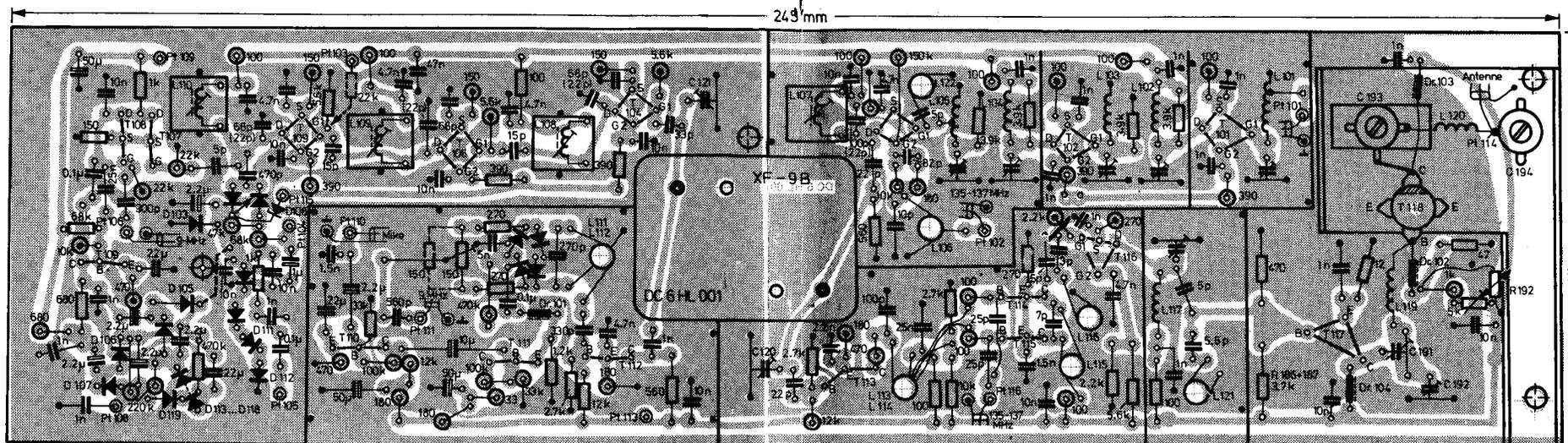
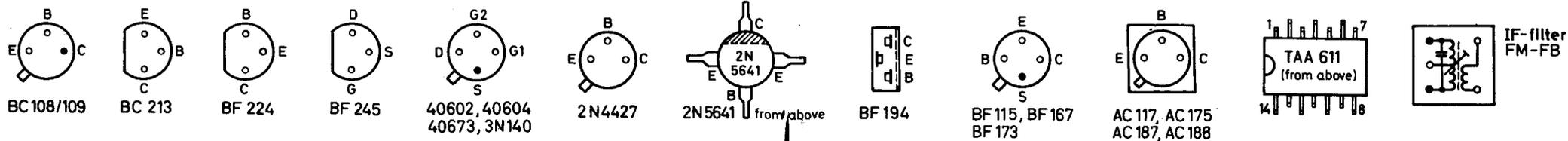


Fig. 9: Component location plan and PC-board DC 6 HL 001

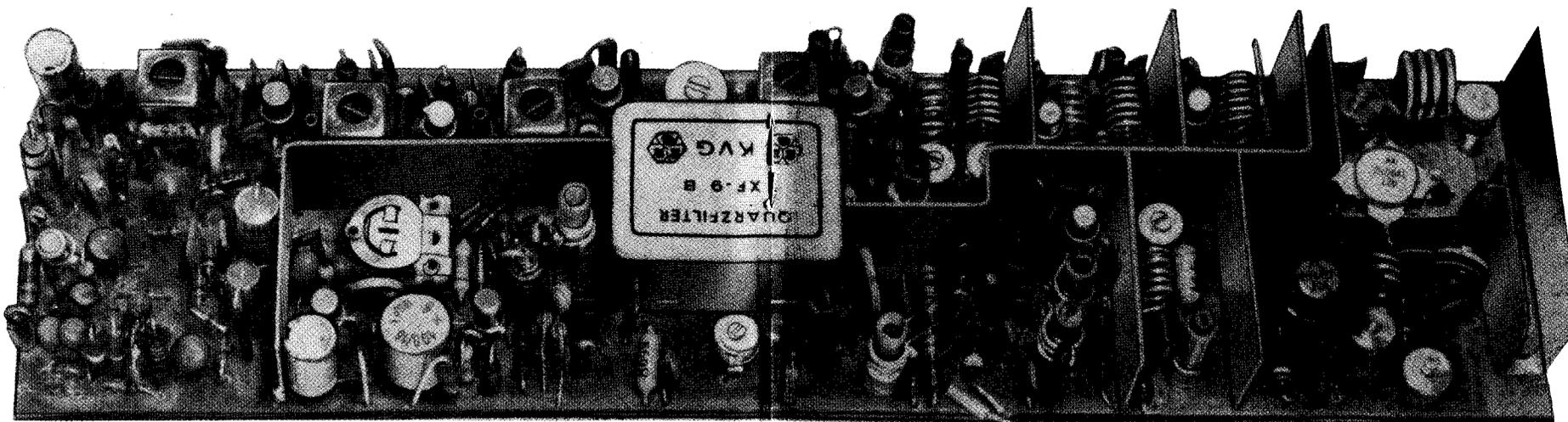


Fig. 10: Photograph of module DC 6 HL 001