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VHF COMMUNICATIONS

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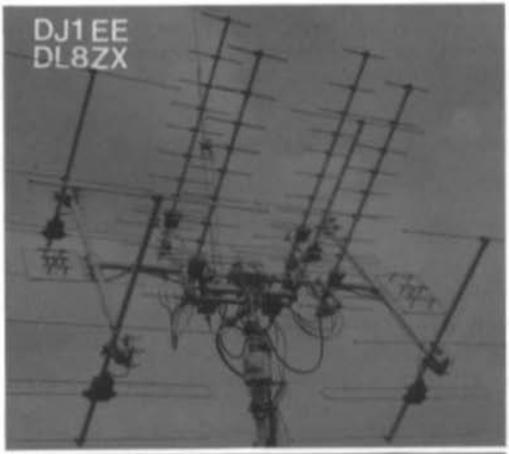

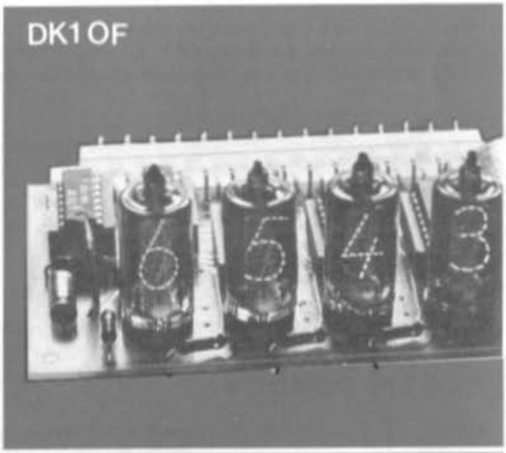

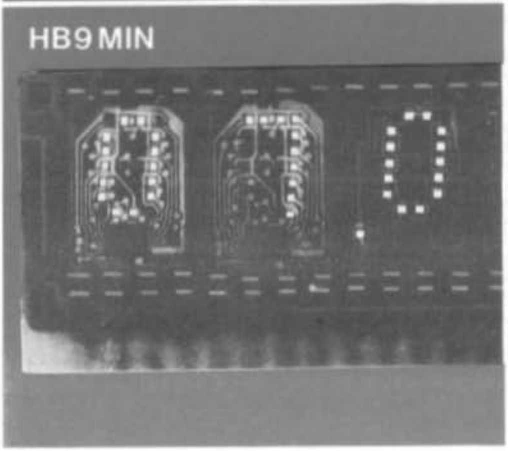

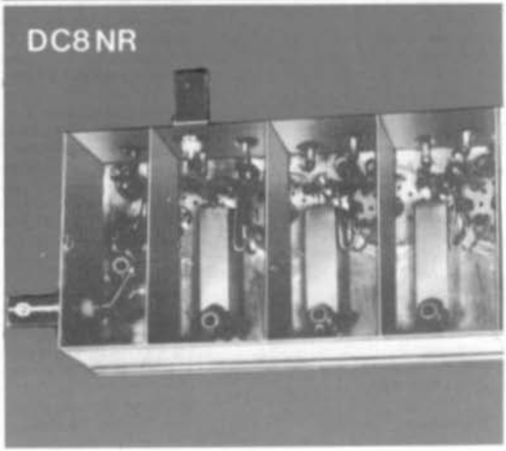

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Editors:
Terry D. Bittan, G3JVQ DJ0BQ, responsible for the text and layout
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Our title photograph shows the range of our descriptions and the frequency range from DC to 2304 MHz. One photograph shows the 12 cm and 23 cm antennas of DL 8 ZX which were described by DJ 1 EE. The 23 cm transverter designed by DC 8 NR is described in this edition, as is the DK 1 OF digital multimeter. The HB 9 MIN frequency counter has already been described.

A RELATIVELY SIMPLE LINEAR TRANSMIT-CONVERTER FROM 144 MHz TO 1296 MHz

by W. Rahe, DC 8 NR

A large number of receive converters for the 23 cm band (1296 to 1298 MHz) have been described (ref.1-4). However, very few linear transmit converters have been described. For this reason, the following article is to describe a relatively simple linear transmit converter together with a matching local oscillator chain. Both modules operate according to a similar principle to the modules described in (5) by J. Dahms, DC 0 DA, and G. Auth, DJ 2 HF. The circuit, which was not published, has been further developed to improve the reproducebility and make it more favorable for practical operation. Also, the described system uses an SSB exciter signal on the 2 m band, whereas the transmit converter described by DC 0 DA and DJ 2 HF used an exciter on the 10 m band.

The local oscillator chain is accommodated on the PC-board and is equipped with semiconductors. A second output is provided for a receive converter to ensure transceive operation. In addition to this, the circuit can be changed to obtain an output frequency of 2160 MHz which is suitable for use as local oscillator signal for 13 cm / 2 m converters. In contrast to the local oscillator chain, the transmit mixer, and linear amplifier are equipped with tubes. This is to be described in detail in the next section.

1. CONSIDERATIONS WITH RESPECT TO THE TRANSMIT CONVERTER

The mixer and linear amplifier module is equipped with four tubes type 8255. These tubes have a pico-9-socket and possess a somewhat shorter envelope than the well-known types EC 8010 or PC 88. The tube type 8255 is a further development by Telefunken of tube type E 88 C and special attention has been paid to reducing the dimensions of the electrodes. The reduced reactance values of the electrodes have especially improved the characteristics of the tube with respect to the upper frequency limit. The power gain of this type of tube at a wavelength of 23 cm is still approximately 8 dB.

The anodes of the tubes work into λ/2 lines which are easy to manufacture. Due to the considerable shortening due to the tube capacitances, it is not possible to use λ/4 lines in this frequency range. This means that several problems encountered with λ/4 circuits and cavity resonators (2 C 39) are not encountered: The bypass capacitors required must usually be homemade due to the high operating frequency and high plate voltages (linear operation). Such mechanical work usually discourages a lot of amateurs who are interested in getting on the 23 cm band. When comparing the described construction with that described in (6), it will be seen that this type of construction is far less extensive.

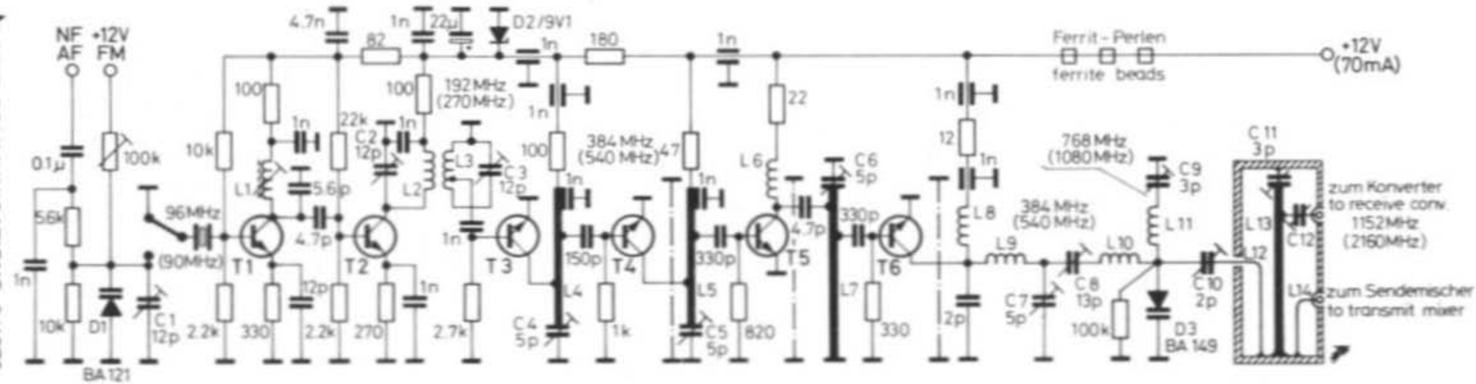

Fig. 1: Circuit of the local oscillator module (DC 8 NR 006) for 1152 (1296) MHz or 2160 (2304) MHz

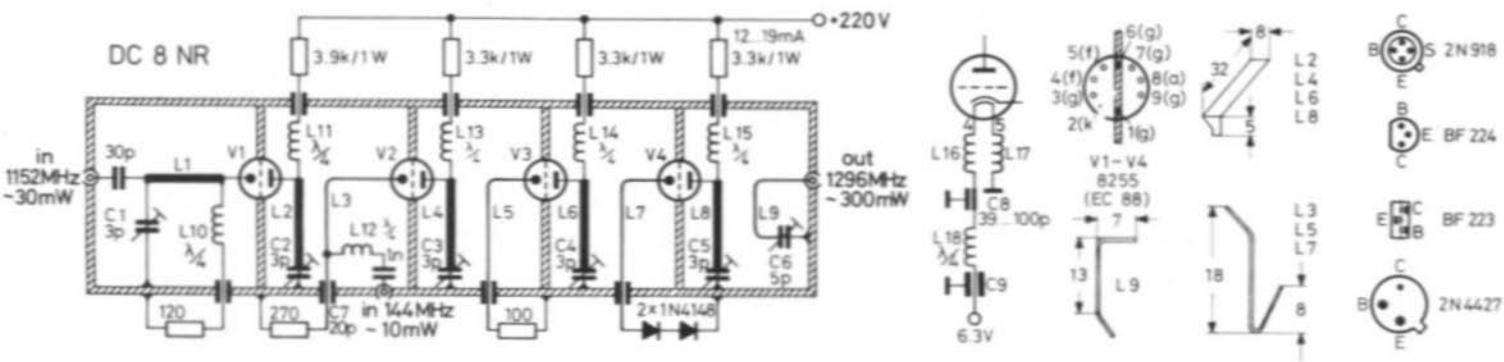

Fig. 2: Circuit diagram of the mixer and linear amplifier module for 1296 MHz equipped with the tube 8255

2. CIRCUIT DETAILS

2.1. Local Oscillator Chain

The circuit of the local oscillator chain is shown in **Figure 1**. The oscillator transistor T 1 operates with a 96 MHz crystal. The subsequent stages equipped with transistors T 2 and T 3 double this frequency to 192 MHz and 384 MHz respectively. The following straight amplifier equipped with transistors T 4 to T 6 provides enough gain to ensure an output power of 150 mW at 384 MHz. This amplifier is followed by a frequency tripler using the varactor diode D 3 which feeds a $\lambda/4$ circuit tune to the final output frequency of 1152 MHz. An output power of 40 mW is available here for the transmit mixer, and a second, capacitively coupled output provides 5 mW for a receive mixer.

The best efficiency of the cheaper varactor diodes was offered by the BA 149, which is no longer manufactured. The varactor diode BB 105 does not provide such good results in this circuit, but is still usable. Only recent deliveries of the transistor type 2 N 4427 should be used in this circuit, because the first manufacturing lots possessed only a transit frequency of 500 MHz, whereas the later series exhibited 700 MHz.

The selectivity at the required frequencies, and the suppression of unwanted harmonics is made in a bandpass filter using concentrated circuits at 192 MHz and airspaced lines at 384 MHz and 1152 MHz.

The type of construction in chambers plays an important part in the suppression of unwanted harmonics. Such difficulties that are sometimes observed such as too low a sensitivity of the diode mixers, or too low an output power of transmit converters due to insufficient local oscillator level should not be observed when using this local oscillator chain. The output power is sufficient for driving passive ring mixers.

2.1.1. Different Applications

When replacing the crystal with one in the order of 108.000 to 108.166 MHz, it is possible to use the described module as beacon transmitter, portable transmitter, or exciter. Both CW and NBFM are possible. The circuit diagram shows a simple accessory circuit, which is not provided on the PC-board. This is also not present on the described prototype. The AF input should be connected to some type of limiter, such as the AF clipper DJ 4 BG 006.

It is also possible to modify the local oscillator circuit to obtain an output frequency in the order of 2160 MHz, so that the module can be used as local oscillator chain in conjunction with mixers from 2304 MHz to an IF of 144 MHz, and vice versa. In this mode, a 90.000 MHz crystal is used which is tripled with the aid of transistor T 2 to 270 MHz, subsequently doubled to 540 MHz and amplified. The varactor diode D 3 is now used as quadrupler from 540 MHz to 2160 MHz. The idler circuit with inductance L 11 is tuned to 1080 MHz. When using a Schottky diode, this idler circuit will not be necessary, but the efficiency will only be in the order of 3 to 5 %. The efficiency when using special varactor diodes such as the BXY 14, BXY 19, or MA 4060 D provide efficiency values in the order of 40 %. However, they are not cf great interest in this power range due to their high prices.

The above frequencies are given in brackets in the circuit diagram. Any component details (inductances, trimmers, and semiconductors) are given in section 3.1. Of course, the output power at 2160 MHz is far lower. When using a crystal with a frequency of between 96.000 and 96.0833 MHz it is possible to make a beacon or miniature transmitter for 13 cm (2304 to 2306 MHz).

2.2. Mixer and Linear Amplifier

As can be seen in the circuit diagram given in **Figure 2**, all four tubes of this module operate in a grounded grid circuit. The first tube (V 1) amplifies the local oscillator frequency of 1152 MHz to a sufficient level for the mixer tube V 2. The input circuit for the 1152 MHz signal represents a pi-filter together with the input capacitance of the tube. Inductance L 10 represents a $\lambda/4$ choke for this frequency and connects the cathode of the tube via the required resistor to ground to provide the automatic grid bias.

The anode of the tube works into a shortened $\lambda/2$ line which is in the form of a relatively low impedance airspaced stripline and tuned to resonance with the aid of a ceramic tubular trimmer at the other end of the line from the tube.

The mixer tube V 2 is provided with the local oscillator signal via the coupling link L 3. The 144 MHz is fed to the cold end of this coupling link. The feedthrough capacitor C 7 for the cathode resistor possesses a very low value so that the 144 MHz voltage is not bypassed. The capacitance value is, however, not critical, but must be large enough so that the coupling link is bypassed for 1152 MHz, but not attenuate the exciter voltage. Inductance L 12 represents a $\lambda/4$ choke for 1152 MHz, which ensures that the local oscillator voltage is not fed to the 144 MHz input.

The $\lambda/2$ circuit of the mixer tube filters out the sum frequency of 1296 MHz. The two, subsequent stages are identical and amplify the required signal to an output power of approximately 300 to 400 mW. This power level is sufficient to drive a two-stage amplifier equipped with tubes of the 2 C 39 family to approximately 30 W.

The anode voltage of all four tubes is fed via $\lambda/4$ chokes. The chokes in the heater circuit are made according to details given in (7) and are also given in Figure 2. They provide the most favorable characteristics with respect to gain and noise figure since they ensure that no UHF power is lost via the cathode-heater capacitance and grounded via the heater circuit. The disc capacitor C 8 which is soldered directly to the chassis, provides a UHF bypass for choke L 16. The subsequent $\lambda/4$ choke L 18 ensures that the loss of the feedthrough capacitor C 9 is not transformed to C 8 where it would increase the loss of the heater circuit. This is necessary since an exact grounding is not possible with the aid of capacitor C 8. Capacitor C 8 possesses a sufficient value for 1200 MHz when it is in the order of 39 to 100 pF.

2.2.1. Tube Data

The socket connections of the AEG-Telefunken tube type 8255 and the position of the screening plate are given in Figure 2. The specifications of this tube and the absolute limits are as follows:

Nominal values:

Anode voltage:	160 V
Cath. resist.:	100 Ω
Anode curr.:	12.5 mA
S :	13.5 mA/V
μ :	65
Noise equ.resist.:	240 Ω
Add. noise factor:	9

Capacitances :
(outer screening to g)

$C_{g+m/c+f}$:	3.8 pF
$C_{a/g+m}$:	1.7 pF
$C_{a/c+f}$:	0.055 pF

Absolute limits:

Max.anode voltage(warm-up):	400 V
Max.anode voltage(operation):	200 V
Anode dissipation:	2.6 W
Cath. current:	16.5 mA
Grid bias:	- 50 V
Grid resistor:	0.5 MΩ
Heater/cath.voltage:	± 100 V
Heater/cath.resistance:	20 kΩ

Heater:

U_f :	6.3 V ± 5 %
I_f :	approx. 160 mA

The guaranteed life of 10.000 hours is only valid when the heater voltage remains within the limits of ± 5 %.

3. CONSTRUCTION

3.1. Local Oscillator Module

The double-coated PC-board designed for accommodating this module has been designated DC 8 NR 006. The dimensions are 145 mm x 60 mm and this board is shown in **Figure 3**. The ground surface on the upper side of the board (component side) remains intact except for the connection holes and a small area around them where the copper surface is removed using a 3 mm diameter drill in order to ensure that no shorts occur between the component leads and ground. The conductor side of the board is also provided with a large ground surface. For this reason, holes are also drilled for the ground connections of the components so that these are also grounded to the lower side.

The photographs given in **Figures 4 and 5** show that the PC-board is accommodated in a 40 mm high framework made from thin brass or tin plate. This is made after drilling the board, but before mounting the components. Three intermediate panels are provided on the upper side of the board, whereas a 42 mm x 15 mm large chamber is provided on the lower side of the board for the output circuit and varactor tripler. It is now possible for the complete module to be silver-plated. However, this is only really necessary for the wires of the inductances and line circuits, as well as for the tubing of the output circuit. The installation of the PC-board in a sealed case virtually represents a »cold« thermostat. This means that rapid temperature variations do not have such a great affect on the output frequency (multiplication: x 12 or x 24), as would be the case with an open, PC-board construction.

The feedthrough capacitors at the end of lines L 4 and L 5 are soldered on the component side of the PC-board where they support the line circuits. The crystal is directly soldered, without socket, and the case should be grounded. Transistor T 6 is provided with small cooling fins of only 12 mm diameter. The following components are located on the conductor side of the board: the zener diode D 2, the lead from its feedthrough capacitor, the collector resistors of transistors T 3, T 4, T 5 (100Ω, 47 Ω, 22 Ω), chokes L 6 and L 8, as well as the varactor tripler. The connection point at the hot end of diode D 3 is supported by the small trimmer capacitor C 10 which in its turn is soldered to the spindle side of a teflon, or ceramic feedthrough for the coupling link L 12. The tubular trimmer C 9 is mounted on the PC-board and supports inductance L 11. Inductance L 10 is soldered directly to the conductor lane to the trimmer C 8 at one end. At this point, the author provided a small test point for 384, or 540 MHz in his prototype (use a low capacitance feedthrough and short connection to C 8 / L 10).

The coaxial circuit L 13 is soldered to a central position in the small chamber. The tube should be cut approximately 1 to 2 mm longer than given, placed through a 6 mm hole in the panel and soldered around the edge on the outside. This is not possible on the inside of the panel due to a lack of space. The other end is placed on to the tubular trimmer C 11, after removing the coating, before soldering into place. The inner conductor then represents a part of the capacitor, and the trimmer is then screwed into place on the outer panel. The output BNC connector to the transmit mixer is connected 10 mm from the cold end of L 13, and the socket for the receive mixer 28 mm. The latter is provided with a thin metal plate of approximately 3 mm x 5 mm which is soldered to the inner conductor and represents the inner conductor of capacitor C 12. It should be noted that the PC-board of the author's prototype differs somewhat from that give in Figure 3.

3.1.1. Special Components for the local Oscillator Module

T 1:	2 N 918
T 2, T 3:	BF 224 (TI), BF 199 (Siemens)
T 4:	BF 223 (AEG-Tfk), BF 199 (Siemens)
T 5, T 6:	2 N 4427 (RCA and others)
D 1:	BA 121 (AEG-Tfk), BA 110 (ITT), BB 105 (Siemens)
D 2:	9.1 V zener diode
D 3:	BA 149 (see text), BB 105 (Siemens)
L 1:	6 turns of 1 mm dia. (18 AWG) silver-plated copper wire wound on a 5 mm coil former with core (red)
L 2, L 3:	4 turns each in the same direction, wire and coil former as for L 1, cold ends facing PC-board, tap on L 3: 2.5 turns from cold end, without cores
L 4, L 5, L 7:	silver-plated copper wire of 2 mm dia., straight length 37 mm, bent approx. 5 mm from the hot end, spaced 5 to 6 mm above the ground surface, tapings: L 4: 10 mm, L 5, L 7: 13 to 14 mm from the cold end
L 6, L 8:	8 turns of approx. 0.3 mm dia. (29 AWG) enamelled copper wire wound on a former of 3 mm dia., self-supporting
L 9:	1.75 turns of silver-plated copper wire wound on a 5 mm dia. former pulled out to fit holes on the PC-board, self-supporting
L 10:	2 turns, otherwise as L 9
L 11:	1 turn on 6 mm former
L 12:	silver-plated copper wire of 1 mm dia. (18 AWG), 14 mm long, spaced 1 to 1.5 mm in parallel to L 13

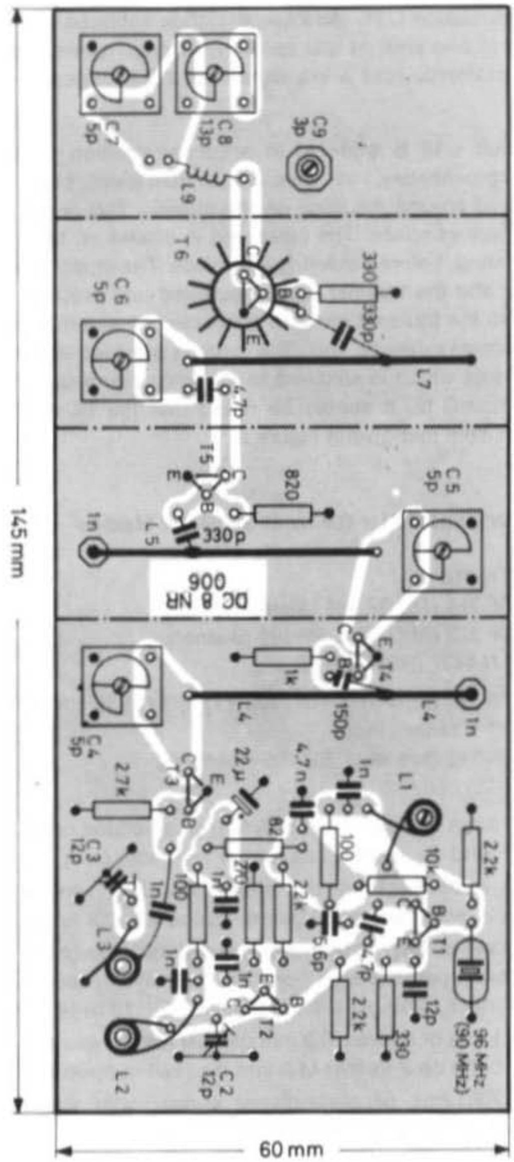

Fig. 3: PC-board DC 8 NR 006 and component locations of the oscillator module

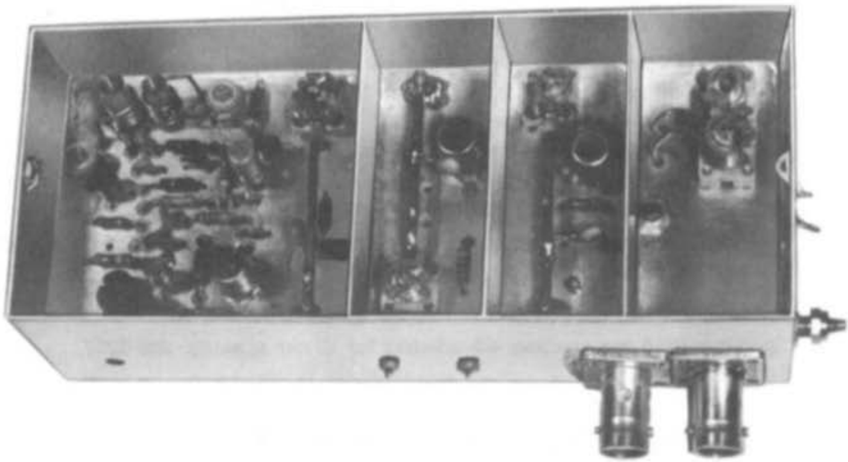

Fig. 4: Photograph of the author's prototype from above

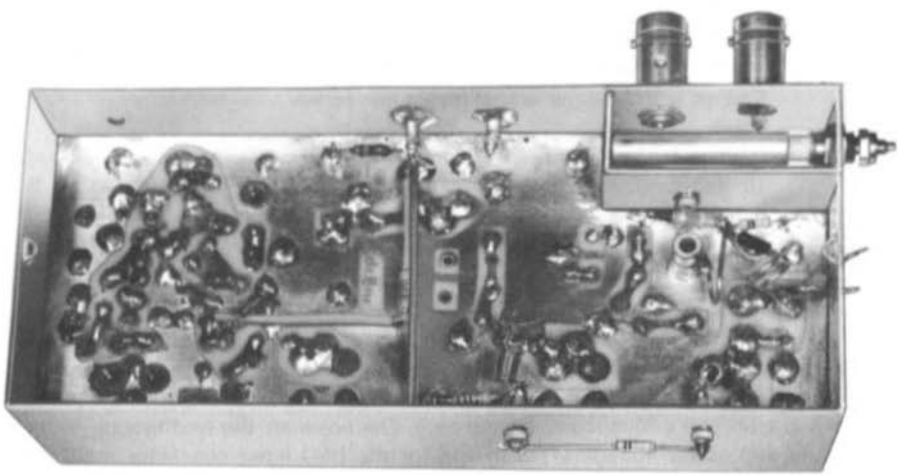

Fig. 5: Photograph of the author's prototype from below
showing the varactor tripler

L 13:	silver-plated brass tube of 6 mm dia., 0.5 mm tubing, 34 mm long, mounted centrally in the metal chamber 15 mm x 15 mm x 42 mm
L 14:	silver-plated copper wire of 1 mm dia., 10 mm long, spaced 1 mm in parallel with L 13
C 1 ... C 3:	13 pF ceramic or plastic foil trimmer of 7 mm dia.
C 4 ... C 7:	5 pF airspaced trimmer with two or four pins for PC-board mounting
C 8:	13 pF airspaced trimmer as C 4
C 9:	3 pF ceramic tubular trimmer Philips 2222 801 20001 or 802 20001
C 10:	3 pF ceramic miniature tubular trimmer, 4 mm dia., approx. 10 mm long for single hole solder mounting, Philips 2222 801 20051
C 11:	3 pF ceramic tubular trimmer, Philips 2222 802 20001, remove stator coating
C 12:	home-made from metal plate, see text

6 pieces feedthrough capacitors of between 100 pF and 1 NF.
All fixed capacitors for 5 mm spacing; all resistors for 10 mm spacing, size 0207,
crystal: HC-25/U.

3.1.2. Different Components required when constructing for 2160 MHz

T 3:	BFY 90, BFX 47 (Philips), or BFX 89 (Philips, Siemens, AEG-Tfk)
T 4:	BFX 47, BFX 89, or BFW 30 (Philips)
T 5:	BFW 16 A, BFW 17 A (Philips, Siemens)
T 6:	BFR 65, BLX 65/66 (Philips)
D 3:	BA 149 or Schottky diode such as HP 2800 or similar
L 2, L 3:	2 turns, tap on L 3: 0.75 turns from cold end
L 4:	length 27 mm, space max. 5 mm over the board, coil tap approx. 8 to 10 mm from the cold end
L 5, L 7:	30 mm long, space max. 5 mm over the board, coil tap approx. 8 to 10 mm from the cold end
L 6, L 8:	6 turns; L 9: 1.5 turns wound on a 4 mm former
L 10:	1 turn
L 11:	U-shaped, 15 mm long; L 12: 6 mm long
L 13:	16 mm long, slide into the ceramic part of C 11 by approximately 5 mm
L 14:	6 mm long
C 2, C 3:	6 pF; 2 pF capacitor at the collector of T 6 deleted.

3.2. Transmit Converter

Photographs of the author's prototype of the mixer and linear amplifier module are given in **Figures 6 and 7**. The chassis of this module is made from thin brass or tin plate. The dimensions are 145 mm x 60 mm and 30 mm high. The holes for the feedthrough capacitors of the anode and heater voltage (4 each) and for the BNC input connector are drilled as shown in **Figure 8**. The small short panels are provided with a BNC connector for the local oscillator and signal frequency. Four holes are drilled in the upper panel for the tube sockets, four for the cathode feedthrough capacitors and six for the trimmer capacitors. After the frame and cover have been drilled and joined together, the screening collars of the tube sockets should be soldered into place.

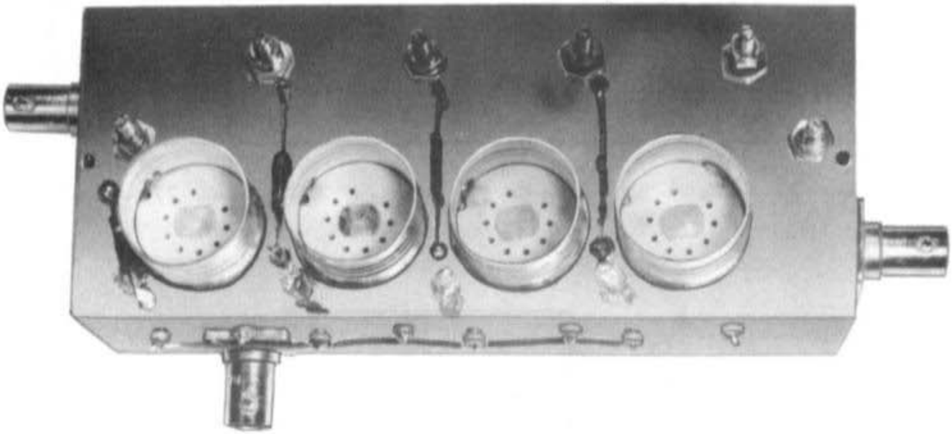

Fig. 6: Photograph of the author's mixer/linear amplifier module

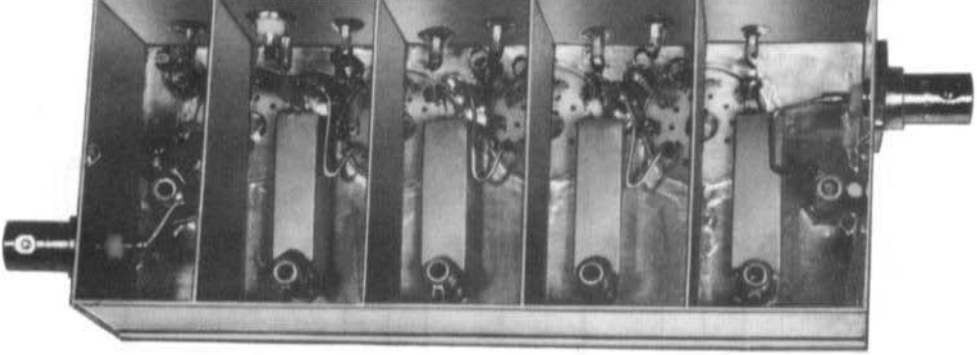

Fig. 7: Internal view showing the anode striplines

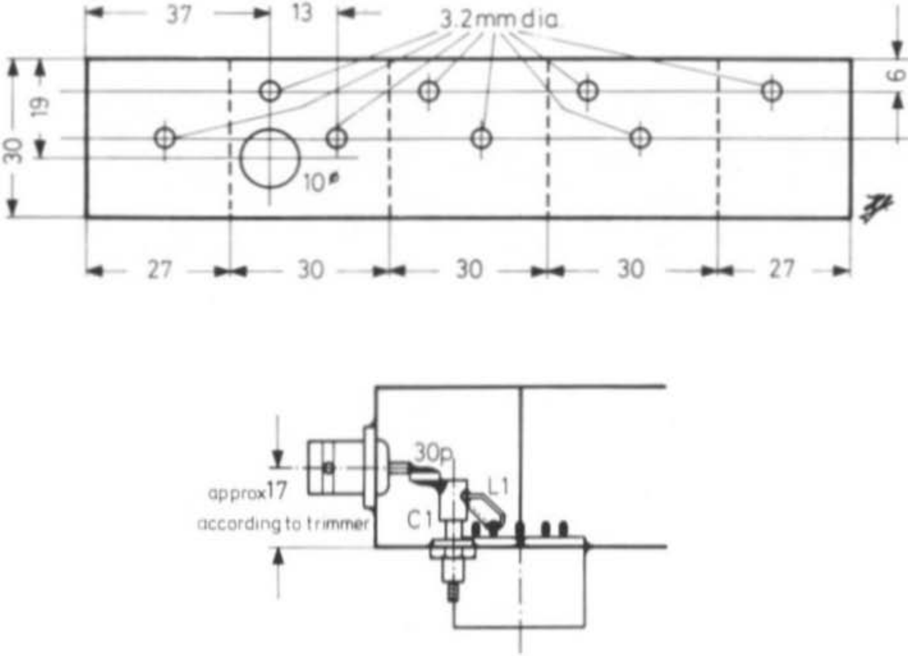

Fig. 8: Required holes on the side panel of the mixer/linear amplifier module

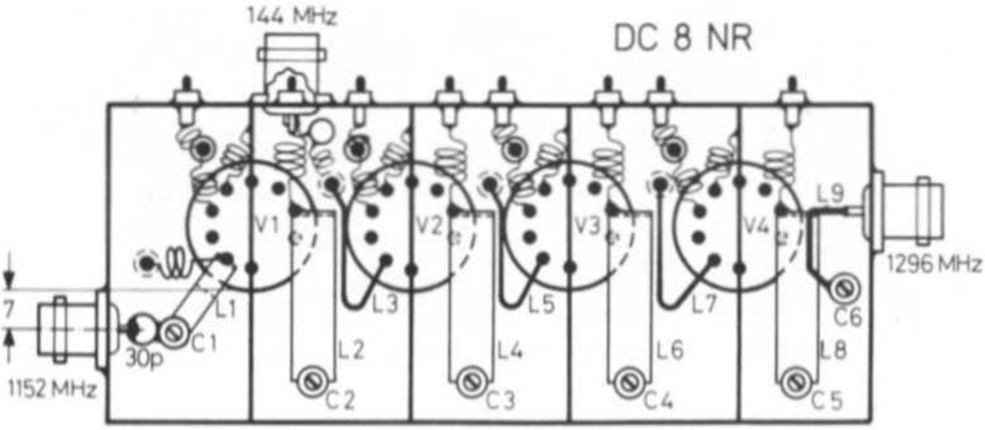

Fig. 9: Construction of the mixer/linear amplifier module

After this, the four intermediate panels that are placed across the tube sockets are filed and soldered into place. It is now possible for the complete module to be silver-plated. The stripline circuits and wire for the coupling links should most certainly be silver-plated.

The tube sockets are placed into the screening collars from above and connections 1 and 6 soldered to the intermediate panels as is shown in Figure 2. The tube sockets are held into place by two solder blobs on the screening collar as can be seen in **Figure 6**. The grid connections 3, 7 and 9 are bent back and soldered to the collar.

It is now possible to solder the rest of the components into place. Further details regarding this are given in **Figure 9**. The shape of the wide anode striplines is also given in Figure 2. The bent, diagonally cut end is soldered to the anode pin 8. The straight end is soldered to the tubular trimmer. The spacing of the stripline from the cover plate amounts to approximately 5 mm. Inductance L 1 is 18 mm in length and 5 mm wide. It is placed from trimmer capacitor C 1 in a curve to pin 2 of tube V 1. The 30 pF chip capacitor is soldered into place between the pin of the BNC connector and the solder tag of C 1. The four disc capacitors C 8 are soldered between the tube sockets beside the feedthrough capacitors for the cathodes. The four small chokes per chamber made from enamelled copper wire are arranged so that they are virtually vertical to another.

3.2.1. Components for the Transmit Mixer

V 1 - V 4:	8255 (AEG-Tfk), or E 88 C
L 1:	silver-plated brass plate, 0.7 mm thick, 18 mm long, 5 mm wide
L 2, L 4, L 6, L 8:	plate as for L 1, dimensions according to the diagram
L 3, L 5, L 7, L 9:	silver-plated copper wire of 1 mm dia. (AWG 18) dimensions and form according to the diagrams beside Figure 2. spacing from the line circuits 1.5 to 2 mm
L 10, L 11, L 12 and L 18 for V 1:	$\lambda/4$ chokes for 1150 MHz (approx. 65 mm enamelled copper wire) wound on a 4 mm former, self-supporting
L 13, L 14, L 15 and L 18 for V 2 ... V 4:	$\lambda/4$ chokes for 1300 MHz (approx. 58 mm enamelled copper wire of approx. 0.4 mm dia.)
L 16, L 17:	8 chokes, 3 turns of approx. 0.3 mm dia. (29 AWG) enamelled copper wire, wound on a former of 4 mm, self-supporting
C 1 - C 6:	3 pF ceramic tubular trimmer (Philips 2222 801 20001 or 802 20001 With C 6 connect a fixed capacitor of 3 pF in parallel
C 8:	4 pieces of disc capacitors without connection wires, value: 39 - 100 pF

11 pieces of feedthrough capacitors for soldering, value: 100 pF - 1 nF
2 pieces of silicon diodes 1 N 4148 or similar
1 piece of feedthrough capacitor for soldering approx. 2 pF

The value of the four anode resistors depends on the voltage of the power supply. The maximum voltage that can be fed to the tubes amounts to 200 V.

4. ALIGNMENT

The alignment of both modules should not cause any difficulties to experienced radio amateurs, since the circuits are not critical, and relatively high levels are available. However, required are an absorption wavemeter (8) for frequencies above approximately 700 MHz, as well as a frequency counter for frequencies of up to 540 MHz (9) or at least an absorption wavemeter. In addition to this, a simple power meter is required to indicate the output power.

4.1. Oscillator Module

The oscillation of the crystal at the fifth overtone must be checked with the aid of a VHF broadcast receiver if a frequency counter is not available.

This is because the oscillator can also oscillate at the third overtone of approximately 57.6 MHz if the core is completely inserted.

The transistor stages T 3 to T 6 are now aligned for maximum collector current of the subsequent stage during which the frequencies should be checked. This is followed by connecting a power meter to the previously mentioned testpoint. After disconnecting inductance L 10 and connecting 15 pF in parallel with trimmer capacitor C 8, it is possible to align the transistor stages for maximum power reading at 384 MHz (540 MHz). After this, the original circuit should be connected again.

The absorption wavemeter is now connected to the output socket of the transmit mixer, and the coaxial circuit comprising L 13 / C 11 is tuned. A small reading should appear at resonance, after which the other components can be aligned alternately for maximum reading. Attention should be paid that the coaxial circuit can also resonate at the fourth harmonic of 1536MHz when the trimmer capacitor is virtually at minimum capacitance.

After connecting a receive converter, the value of trimmer capacitor C 12 should be increased from its maximum spacing until no further increase in sensitivity is noticed.

Using a sensitive absorption wavemeter it was only possible to find the second harmonic (768 MHz) with a level of less than 0.5 mW as only spurious signal. This frequency will be greatly suppressed in the subsequent amplifier stage equipped with V 1, and the linear amplifier.

4.2. Mixer and Linear Amplifier Module

This is commenced by aligning the local oscillator amplifier by connecting a power meter or absorption wavemeter to the 144 MHz input and aligning trimmer C 1 and C 2 to maximum reading. The local oscillator voltage at this point is sufficiently high for a reading to be obtained. After this, the power meter is connected to the 1296 MHz output socket, and a 144 MHz signal of approximately 10 mW is connected to the signal input. A short piece of wire is now connected to the input of the absorption wavemeter and placed in the vicinity of the anode striplines. This allows these lines to be coarsely aligned until a power reading is obtained at the output. The final alignment is made with the base plate in place. It is also possible for all stages to be firstly aligned to 1152 MHz, and for trimmer capacitors C 3, C 4 and

C 5 to be decreased in value from this position until a reading is observed. The values of the quiescent current and full drive current of V 4 are given in the circuit diagram.

The output power will only increase up to an oscillator level of approximately 25 mW. In excess of this, the conversion gain will no longer increase. The input stage comprising C 1 becomes very wideband in excess of 20 mW, which means that the alignment should be made at a lower level.

No tendency to self-oscillation was observed even when removing the screening cans, which shows that simple epoxy glassfiber sockets without screening can be used (glue into place). When trying a tube EC 8010 instead of the 8255 in the output, it was found that the output circuit comprising L 8 / C 5 could no longer be brought to resonance due to the higher value of the anode to grid capacitance (C_a/g).

Spurious frequencies, including the oscillator frequency could not be observed in the spectrum of the output frequency with the measuring equipment available to the author. The output power was measured to be 350 mW. G. Auth, DJ 2 HF, gives the following values for a similar construction with an intermediate frequency of 28 MHz:

Output power:	400 mW
1 dB bandwidth:	4.5 MHz
Suppression of the local oscillator signal:	20 dB

Due to the far greater spacing of the local oscillator signal from the required frequency, the suppression of the local oscillator frequency in the case of the described module should be at least 40 dB.

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RECEIVE CONVERTER
WITH SCHOTTKY DIODE MIXER FOR 24 cm

by B. Lübbe, DJ 5 XA

If the activity on the 24 cm amateur band is to be increased, it is necessary for a number of kits to be available in addition to the ready-to-operate converters. This receive converter uses printed striplines, a printed hybrid ring and Schottky diode mixer. The demands placed on the radio amateur with respect to measuring instruments and measure work are therefore very low.

A local oscillator chain and a IF preamplifier are accommodated on the PC-board. Two versions are described, one for communications (1296 MHz - 1298 MHz / 28 - 30 MHz) or ATV-operation (1252.5 MHz - 48.25 MHz). In order to keep the PC-board as small as possible, no preamplifier and selectivity is provided for the input frequency. This also eases construction since it is easier to manufacture the complete station from smaller modules. Section 5 gives details regarding a suitable preamplifier and filtering. A photograph of the author's prototype is given in **Figure 1**.

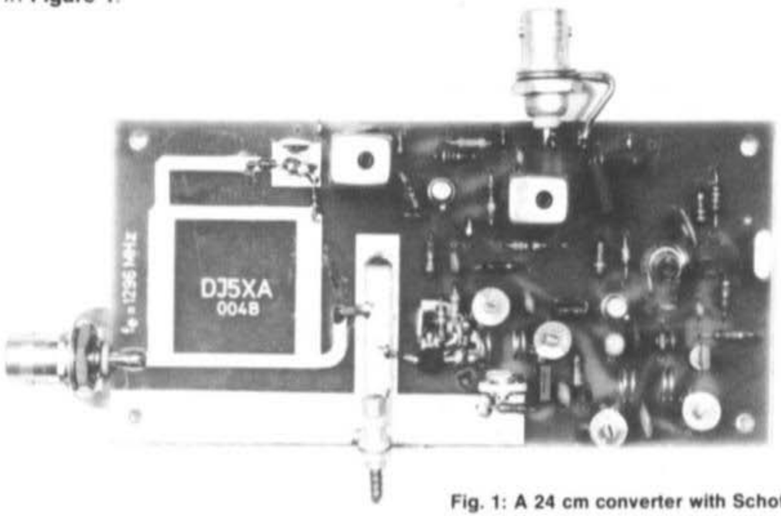

Fig. 1: A 24 cm converter with Schottky mixer

1. CHARACTERISTICS

Operating voltage:	12 V (- 1 / + 2 V)
Current drain:	approx. 30 mA
Overall gain:	approx. 20 dB
UHF-bandwidth:	1250 - 1300 MHz
IF-bandwidth at 30 MHz:	approx. 3 MHz
IF-bandwidth at 50 MHz:	approx. 7 MHz
Noise figure (with image):	approx. 7 dB
Dimensions:	135 mm x 65 mm

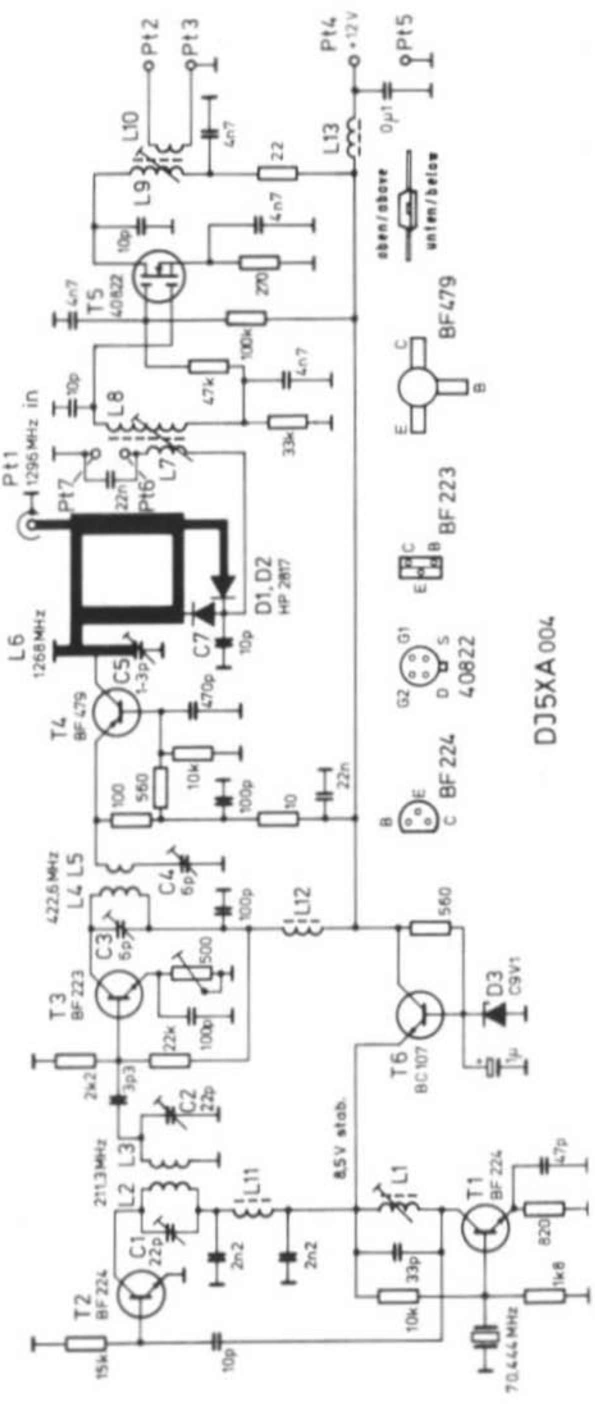

Fig. 2: Circuit diagram of the 24 cm converter with stripline hybrid ring

2. CIRCUIT DESCRIPTION

The circuit diagram of the converter is given in **Figure 2**. The main feature of the converter is the stripline hybrid ring working in conjunction with the Schottky-diode mixer. This hybrid ring is used as a 3 dB coupler. The mixer diodes are connected in antiphase and are switched in the forward direction at the same time, whereas the oscillator voltage at the interconnection point of the two diodes is cancelled out.

The noise of the oscillator is also cancelled out together with the required signal and is therefore not fed to the IF-amplifier. This results in a noticible improvement of the sensitivity. The hybrid ring circuit is discussed in more detail in section 6. Measurements have shown that the use of UHF-Schottky-diodes such as hp 5082-2817 can bring an improvement in the noise figure of 1.5 to 2 dB over when using universal Schottky diodes such as hp 5082-2800.

The type of mixer circuit used does not allow the diode current to be measured during operation. However, this is not necessary. If the alignment is to be checked, one of the diodes can be disconnected and the current of the second diode can be measured between connection point Pt 6 and Pt 7. During normal operation, these two points are bridged with the aid of a capacitor. A DC-bridge is not necessary and would interfere with the diode currents.

A dual-gate MOSFET has been used as intermediate frequency preamplifier, which possesses a resonant circuit at input and output. Coupling links are used for matching to the mixer diodes and to the 50 Ω coaxial cable to the shortwave receiver. This stage has a considerable influence on the noise figure of the converter (1); for this reason, a noise matching and not power matching is selected.

A further important part of the circuit with respect to the noise figure of the mixer is the last resonant circuit of the oscillator chain. If the Q of the stripline circuit L 6 / C 5 is too low, this will cause an increase of the noise figure. For this reason, L 6 is made in the form of an air-spaced stripline. If a printed stripline was used on the epoxy material, the Q would be too low, a PTFE (Teflon) PC-board would be too expensive.

The crystal oscillator comprising transistor T 1 operates in conjunction with a series-resonant crystal (fifth overtone) at a frequency in the order of 70 MHz. The collector circuit is tuned to the crystal frequency. The subsequent stage equipped with transistor T 2 triples the frequency to approximately 210 MHz; a bandpass filter comprising L 2 / L 3 suppresses any unwanted frequencies.

The first two stages are fed with a stabilized voltage of approximately 8.5 V in order to avoid any frequency variations due to fluctuations of the supply voltage. The third stage comprising T 3 doubles the frequency to approximately 420 MHz. A bandpass filter is also used here. A trimmer potentiometer in the emitter circuit allows the most favorable oscillator amplitude to be adjusted as was the case with the 70 cm converter DJ 5 XA 003 (2). The fourth stage of the oscillator chain finally triples to the required frequency.

A low-noise silicon PNP high-current transistor is used for transistor T 4. The PNP-configuration allows the collector circuit to be directly grounded (negative). The transistor type BF 479 in a plastic T-case is designed for VHF and UHF TV tuners with PIN diode control. In this case, the gain of the transistor is not controlled, and it operates with a relatively high collector current of 10 to 20 mA. This allows the high output voltage of for instance 200 mV to be provided at a large intermodulation ratio of for instance - 40 dB. Germanium transistors such as Siemens AF 379 are also used for such tuners. However, no experiments were made to see how suitable they would be for this application.

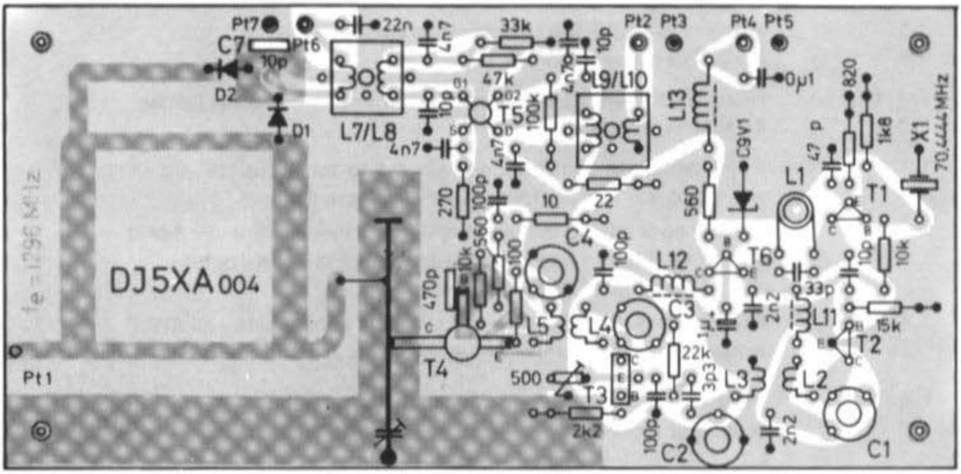

Fig. 3: PC-board DJ 5 XA 004

3. CONSTRUCTION

The PC-board DJ 5 XA 004 was developed for accommodation of the converter. The dimensions of this double-coated board without through-contacts are 135 mm x 65 mm. The PC-board and the component locations are shown in **Figure 3**. The components are mounted on the side of the board with the hybrid ring. Transistor T 4 should be soldered directly on to the conductor lanes on top of the PC-board. The collector connection is bent up towards the air-spaced stripline L 6 and soldered into place. The two Schottky diodes are also directly soldered to the conductor lanes. It should be noted that they should be mounted as shown in antiphase, that only one diode is installed during the alignment, and that the connection »island« should be connected using a wire bridge to the conductor on the lower side of the board.

The base of transistor T 4 and the IF-connection of the two mixer diodes are bypassed using ceramic chip capacitors. Suitable slots should be sawn into the PC-board for these capacitors, whose values are not critical.

The coaxial cable from the antenna is directly soldered with the inner conductor to the short connection line of the hybrid ring, and the shield to the lower side of the board. If the PC-board is to be mounted in a case, it is very favorable for the coaxial socket to be directly soldered into position as shown in Figure 1.

The converter can be installed in an aluminium Teko box, size 4 A. However, a matching case made from brass plate or PC-board material would be more favorable. The ground surfaces of the PC-board should then be directly soldered to the case. This makes the converter insensitive to adjacent effects. It is only necessary for the case to be 30 mm, or even 25 mm, high.

3.1. Components

T 1, T 2:	BF 224 (TI) or BF 199 (Siemens)
T 3:	BF 223 (AEG-Tfk)
T 4:	BF 479 (SGS-ATES)
T 5:	40841 or 40822 (RCA) or other dual gate MOSFET
T 6:	BC 107 or other silicon AF-transistor
D 1, D 2:	HP 5082-2817 (Hewlett-Packard) or other UHF Schottky diodes
D 3:	9.1 V zener diode
L 1:	4.75 turns silver-plated copper wire 0.8 to 1 mm dia. (18 - 20 AWG) wound on a 5 mm coilformer with VHF core (brown)
L 2, L 3:	2 turns silver-plated copper wire 0.8 to 1 mm dia. (18 - 20 AWG) wound on a 5 mm former, self-supporting, direction of turns and spacing given by the PC-board
L 4, L 5:	2 turns silver-plated copper wire 0.8 to 1 mm dia. (18 - 20 AWG) wound on a 4 mm former, self-supporting, spacing to PC-board: 3 mm
L 6:	silver-plated brass strip of 5 mm width, 40 mm long; cold end of 5 mm bent down and soldered to the ground surface of the PC-board in the vicinity of L 7 / L 8. The free end of the strip is soldered to trimmer capacitor C 5, whose cold end is soldered to ground at the edge of the PC-board. A small piece of silver wire should be soldered from the connection strip to the hybrid ring in a vertical direction and soldered to L 6.
L 7, L 8:	6 turns / 16 turns copper enamelled wire approx. 3 mm dia. in coilkit D 41-2165
L 9, L 10:	16 turns / 4 turns wire and coilkit as for L 7 / L 8
L 11, L 12:	Ferrite bead with 3.5 turns of copper enamelled wire approx. 0.2 mm
L 13:	6 hole core Ferroxcube choke
C 1, C 2:	20 pF ceramic or plastic foil trimmer 7 mm dia.
C 3, C 4:	6 pF, other details like C 1, C 2
C 5:	6 pF or less ceramic spindle trimmer
C 6:	100 - 1000 pF chip capacitor
C 7:	10 pF chip capacitor

All remaining capacitors: ceramic disk types with 5 mm spacing.

A spacing of at least 10 mm is available for all resistances.

Crystal: HC-25/U

1296 - 1298 / 28 - 30 MHz: 70.4444 MHz
1252.5 MHz / 48.25 MHz: 66.90278 MHz

Trimmer potentiometer: 500 Ω or 1 kΩ miniature, standing, spacing 5 mm / 2.5 mm.

4. ALIGNMENT

A frequency counter or absorption wavemeter is required for alignment of the oscillator chain to ensure that the correct harmonic is selected. The resonant circuit comprising L 1 should be aligned so that the oscillator commences operation reliably on switching the operating voltage. The two bandpass filters for 210 MHz and 420 MHz are aligned for maximum collector current of the subsequent stage (chokes L 11, L 12 or the 10 Ω resistor should be disconnected at one side). The alignment is simplified when a simple power indicator is provided.

The last oscillator circuit comprising L 6 / C 5 can be coarsely aligned when one of the Schottky diodes is disconnected and the current between connection point Pt 6 and Pt 7 is indicated. All previous adjustments can be optimized during this. The final alignment of trimmer C 5 is made in conjunction with a receive signal.

The IF preamplifier must now be aligned. Preliminary, it is sufficient for an alignment for maximum noise or signal to be made at the centre of the band. It is possible that the IF amplifier will oscillate when not correctly terminated to the subsequent receiver. If the receiver is not to be modified, a 3 dB attenuator should be connected between the IF output of the converter and the subsequent receiver.

The following alignment steps should be made in the following order: Adjust trimmer C 5 in conjunction with a weak signal at the center of the band for maximum signal.

The trimmer resistor in the emitter lead of T 3 is reduced from its maximum value in conjunction with a very strong signal until no increase of signal takes place. At the same time, the noise will be reduced to a minimum.

Optimize the alignment of C 5 and the other oscillator stages.

Finally, align inductance L 8 in conjunction with a weak signal, or if possible together with a noise generator for best noise matching (best signal-to-noise ratio).

5. POSSIBLE EXTENSIONS

As was shown in the examples given in (1), the highest possible sensitivity of a receive system for 24 cm cannot be achieved when only using a mixer. At least one, and better two preamplifier stages should be used before the overall noise figure is mainly determined by the first transistor. This was underlined in a lecture given by Dieter Vollhardt, DL 3 NQ, at the Weinheim VHF convention in 1975. DL 3 NQ recommended the transistor type BFR 34 A in a preamplifier such as PTFE PC-board described by DJ 1 EE (3). It is just as important to limit the noise component of the image frequency with the aid of a filter for the required frequency. This allows a sensitivity increase of a maximum of 3 dB to be obtained assuming that insersion loss of the filter is zero. Coaxial and interdigital filters can be used for this application. The interdigital filter described in (4) possesses a bandwidth of 50 to more than 100 MHz according to adjustment. This means that it is not suitable for suppressing the image frequency of 1324 MHz at an intermediate frequency of 28 MHz. At least the filter should be aligned so that the receive frequency range is at the upper end of the passband. Of course, an intermediate frequency in the order of 70 MHz or 100 MHz is far more favorable.

5.1. ATV Operation

In the ATV mode on the 24 cm band, the video carrier of 1252.5 MHz is converted to an intermediate frequency of 48.25 MHz (CCIR channel 2). This requires a local oscillator frequency of 1204.25 MHz; when multiplying by 18, a crystal frequency of 66.902777 MHz is required.

No modifications are required to the oscillator chain of the converter. It is only necessary to modify the resonant circuits of the IF preamplifier:

L 7 / L 8: 4/10 turns. Wire and coil data as in section 3.1.
L 8 / L 10: 10/4 turns. Wire and coil data as in section 3.1.

5.2. Higher IF

If the intermediate frequency is to be in the order of 70 MHz, 100 MHz or 144 MHz, only minor modifications need be made to the oscillator chain with the exception of the crystal frequencies. The IF coils are then wound on 5 mm coilformers in screened cans. The turns-ratio between the coupling winding and the resonant circuit should be maintained approximately.

It may be necessary to reduce the value of capacitor C 7.

5.3. Transmit Mixer

Module DJ 5 XA 004 can also be used as transmit mixer. In this case, the IF preamplifier is deleted and the transmit signal is fed at low impedance to the interconnection point of the mixer diode. The required signal and the image appear at the original antenna input. Of course, the mixer should be followed by a filter.

The oscillator level should be in the order of 7 dBm (5 mW) and the transmit signal 0 dBm (1 mW). This results in an output power of approximately 0.1 mW (- 10 dBm). If higher power diodes are used, higher drive levels and higher output powers can be achieved. The experiments made by the author only used diodes type hp 5082-2800.

6. APPENDIX

6.1. Further Details on the Mixer Circuit

The noise of a Schottky diode mixer comprises shot effect noise (1) of the Schottky junction, and thermal noise (1) of the diode path resistance both in the frequency range of interest and at IF level. Noise components of the diode path resistance at the image frequency are also converted to the IF level if this is not filtered out. This can be made using coupled resonators for the image frequency (5).

In addition to the given noise components of the Schottky diode, the noise of the local oscillator can deteriorate the sensitivity of the mixer. No oscillator is completely free of spontaneous fluctuations of the frequency and amplitude, which means that a spectrum of frequencies is generated instead of one discrete frequency. According to the Q of the oscillator, the envelope of this spectrum decreases on increasing the spacing from the center frequency.

Noise components that are spaced at the same value as the intermediate frequency from the center frequency (in other words those that are within the receive frequency or image frequency range) are also converted to IF level in the same way as the image frequency in the mixer. They are superimposed on to the required signal in the form of noise interference.

This noise component can be very high, especially at low intermediate frequencies since the noise spectrum of the local oscillator is not suppressed sufficiently at such a small spacing from the center frequency.

In order to suppress this noise interference from the local oscillator, it is possible for this spectrum to be decreased using narrowband filters. However, this requires resonators having a very high Q, which means that line or cavity resonators must be used. This can be avoided by use of suitable mixer circuits that use two or four paired diodes in a balanced or antiphase circuit. Such a circuit suppresses (cancels out) the noise of the local oscillator (5).

The simplest circuit to achieve this aim would be a push-pull mixer. In order to obtain the sumat one side and the difference of the signal and local oscillator at the other side a 3 dB directional coupler is often used at higher frequencies. **Figure 4** shows such a 3 dB directional coupler; its form makes it relatively uncritical in its dimensions, and makes it suitable for use up to very high frequencies.

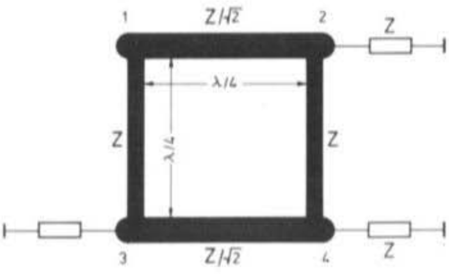

Fig. 4: 3 dB directional coupler

The operation of this hybrid ring is as follows:
A signal that it passed on the upper line from 1 to 2 firstly couples via the line 1-3 to line 3-4 and causes a forward and reflected wave. The signal from 1 to 2 also couples via 2-4 to line 3-4 and causes a second forward and reflected wave at 4. The two forward waves are in phase at position 4 since they have equally long paths on all lines. The two reflected waves are, however, in antiphase at position 3 since the signal component passing via line 2-4 possesses a delay of λ/2 with respect to the signal component driving directly from 1 to 3. When connections 2 and 4 are correctly loaded, these components will be cancelled so that the directivity is guaranteed and point 3 is decoupled from point 1. The impedances and

connections for the circuit given in Figure 4 had been selected so that not only is 3 de-coupled from 1, but also that a signal connected to position 1 will be divided equally between point 2 and 4, as is required from an ideal 3 dB coupler.

The matching of the mixer diodes is never ideal in practice. This means that a portion of the power from the local oscillator will always be reflected at point 2 and 4 and fed to the antenna via point 1. In order to avoid this, a 90° phase shifter in the form of a $\lambda/4$ line should be inserted between the hybrid ring and one of the two diodes. If the mismatch of the diodes is equal, the oscillator frequency will be cancelled out at point 1. This type of circuit is used for the mixer on PC-board DJ 5 XA 004.

6.2. Design of the Stripline Hybrid Ring

The principle of calculating the hybrid ring is now to be briefly described with the aid of **Figure 5**. Further details regarding the calculation of the striplines are given in (6).

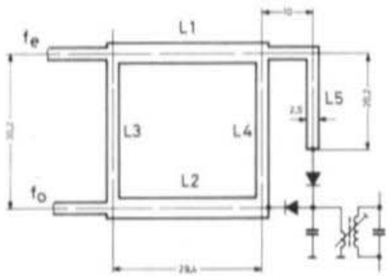

Fig. 5: The hybrid ring used in the converter

The first problem is that of matching the two mixer diodes to the antenna. The diodes are assumed to have 50 Ω each. If one assumes a short-circuit at the local oscillator input, lines L 2 and L 3 will represent shorted $\lambda/4$ lines and need not be considered. Since the antiphase diodes conduct simultaneously, they represent a load of 25 Ω and L 1 must match the input impedance f_{in} of 50 Ω to 25 Ω. The impedance of L 1 should therefore amount to:

$$Z_{L\,1} = \sqrt{50 \times 25} \approx 35\ \Omega$$

The oscillator input will also see a load of 25 Ω when the input for the signal frequency is shorted (the impedance of one diode is connected in parallel with the other diode via 2 x $\lambda/4$ = $\lambda/2$). In this case, L 2 should also have an impedance of 35 Ω. Lines L 3, L 4 and L 5 should be 50 Ω lines so that matching takes place.

In order to determine the dimensions of the hybrid rings it is assumed that the operating wavelength is 235 mm corresponding to 1276.6 MHz (center frequency).

The following is then varied: $\lambda_0/4$ = 235 mm / 4 = 58.75 mm with λ_0 = wavelength in free space. λ_S = wavelength of the stripline e.g. $\lambda_S = \lambda_0 \times VF$

In the case of epoxy glassfiber boards with a thickness of 1.5 mm:
VF = 0.515 in the case of 50 Ω lines and
VF = 0.50 in the case of 35 Ω lines

This means that the 50 Ω lines will be 2.5 mm wide and 30.2 mm long, and the 35 Ω lines 4.5 mm wide and 29.4 mm long.

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A T V INFORMATION

by J. Grimm, DJ 6 PI

1. COMBINING THE VIDEO AND SOUND SIGNALS

1.1. Various Possibilities

a) Separate video and sound transmitters fed to separate antennas. This method is very inefficient, but avoids problems of combining these two signals.

b) Separate video and tone transmitters that are connected to a common atenna via a diplexer. Such a diplexer is usually quite expensive.

c) Separate video and tone processing at IF-level, combining before the mixer. This allows the use of a common 70 cm-mixer and subsequent linear amplifier (as used by DJ 4 LB).

1.2. Realization of the Method given in 1.1.c.

G, Sattler, DJ 4 LB, developed and improved a method of combining the video and sound signal which was not published. This second circuit offers several advantages to that given in (1). The circuit diagram of this combining network is given in **Figure 1.**

The input impedance of each input amounts to approx. 60 Ω. Each input is decoupled with the aid of the 330 Ω resistors. The trimmer potentiometer is provided to allow a gain adjustment of the combined video and sound signal.

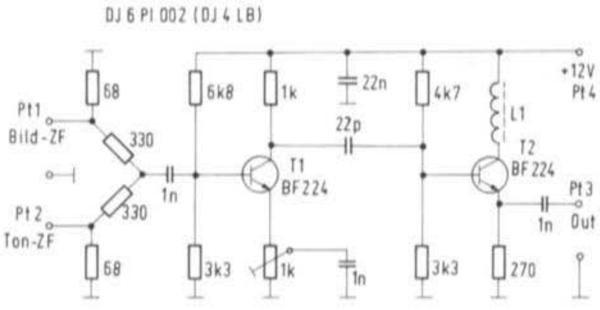


Fig. 1: Circuit diagram of the video/tone combining stage

1.3. Construction of a Video/Sound Coupling Network

PC-board DJ 6 PI 002 and the component locations are shown in **Figure 2**. The dimensions of this PC-board are 60 mm x 50 mm. No problems are to be expected if this PC-board is used for construction. The board width of 50 mm was selected so that it matches the size of the DJ 4 LB boards. Inductance L 1 is a 6-hole ferrite choke.

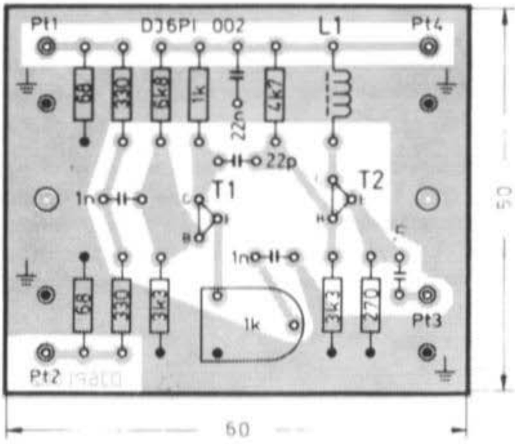


Fig. 2: PC-board DJ 6 PI 002

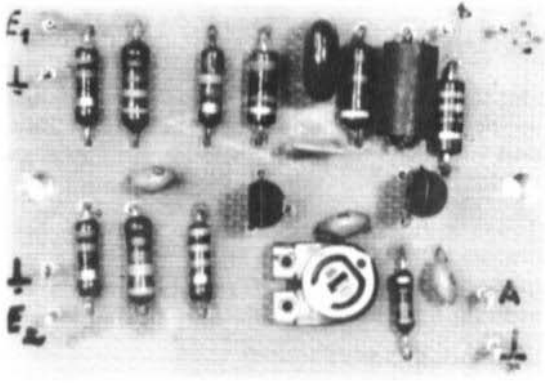


Fig. 3: Prototype of the combining circuit

2. MAINTAINING THE VIDEO/SOUND CARRIER SPACING AT 5.5 MHz

The self-excited sound carrier oscillator of module DJ 4 LB 002 is relatively instable. It is often necessary for its frequency to be adjusted to the nominal frequency of 33.4 MHz if the best sound and video quality are to be maintained. A temperature compensation of this circuit, or frequency modulation of a crystal oscillator would mean a redesign of the sound carrier oscillator. However, it is possible to stabilize the original oscillator circuit DJ 4 LB 002 relatively easily if a control loop is provided. A circuit diagram as well as a PC-board layout are to be described for this.

2.1. Principle of the AFC Circuit

An automatic frequency control circuit is to be used. This is firstly achieved by using the demodulator board DJ 4 LB 005 which is loosely coupled to the output of the transmitter via a small capacitor of 0.5 - 1 pF.

The difference frequency between sound and video carriers will be present at output Pt 502. This signal is fed to the circuit DJ 6 PI 003 (see **Figure 4**). An integrated circuit type CA 3089 (RCA) compares this difference frequency with the internal reference frequency of 5.5 MHz (resonant circuit with L 3). The integrated circuit provides a DC-voltage at connection 7, which is proportional to the difference between these two frequencies (2).

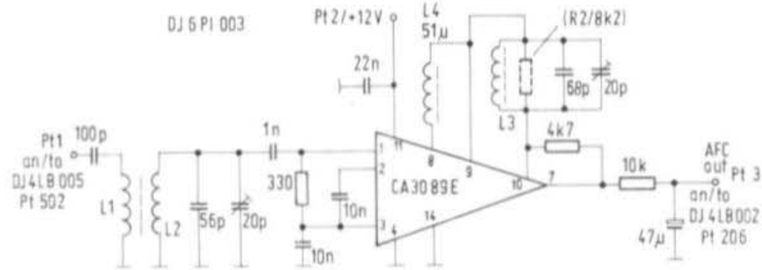


Fig. 4: Circuit diagram of an AFC-Circuit

The control voltage is fed to the varactor diode of the sound carrier oscillator DJ 4 LB 002 via connection Pt 206. After removing the interconnection between Pt 206 to ground, a control loop results which keeps the sound carrier at a frequency 5.5 MHz below the crystal-controlled video carrier.

The control voltage should, of course, only compensate for the temperature and aging dependent frequency variations and not control the frequency modulation. For this reason, the integration link (low-pass) at the output (10 kΩ / 47 µF), which is provided to filter any residual AF-voltages from the control voltage, possesses a cut of frequency of several Hertz.

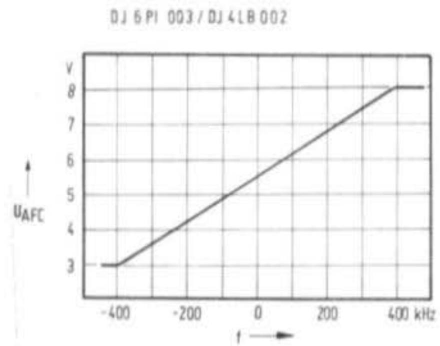


Fig. 5: AFC-voltage as function of the frequency error of the sound carrier oscillator

Figure 5 gives the control voltage U_{AFC} generated in the circuit (Figure 4) as a function of the frequency difference. The AFC-voltage slope given in **Figure 11** of (1) is steeper. The varactor diode (D 203 in DJ 4 LB 002) will also operate from the given control voltage.

2.1.1. Hold Range and Residual Control Deviation

The Q of the reference resonant circuit (L 3) determines both the hold range and the residual control deviation: a high Q represents a small hold range and small control deviation, and vice versa. It is necessary to make a compromise between the targets of the lowest possible control deviation and the widest hold range. The Q can be reduced (large hold range) by providing the damping resistor shown in dashed lines. This resistor will linearize the AFC characteristics and will allow frequency deviations of maximum ± 1 MHz to be controlled if the resistance value is in the order of 8.2 kΩ. Since the sound carrier oscillator will most certainly not be more than 1 MHz from its nominal frequency even at extreme temperature variations, this resistor is usually not required and should be left out for control accuracy reasons. The following measured values resulted on the author's prototype:

Control range: ± 500 kHz

Commencement frequency deviation	Residual deviation	Control factor
500 kHz	10 kHz	50
200 kHz	3 kHz	66
100 kHz	1 kHz	100

It will be seen in the differing control factor that the AFC characteristic is not linear. However, this is of no importance.

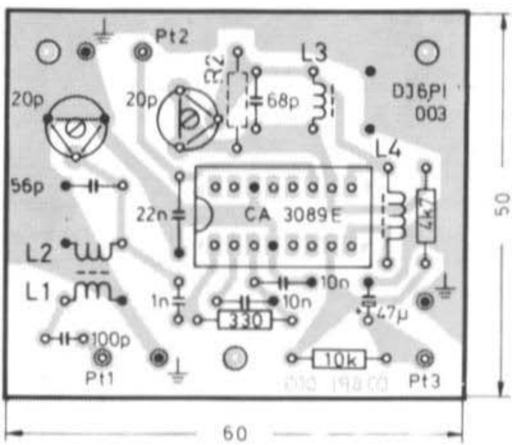


Fig. 6: PC-board DJ 6 PI 003

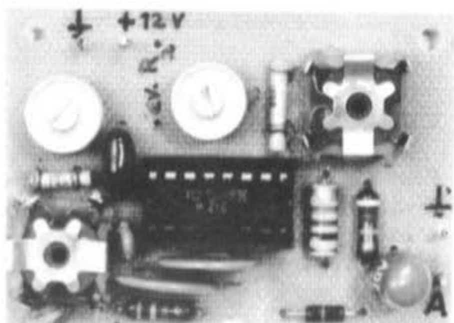


Fig. 7: Author's prototype of the AFC-circuit

2.2. Construction of the AFC-Circuit

The PC-board DJ 6 PI 003 has been designed for accommodation of the AFC control circuit as given in **Figure 4**. The dimensions of this board are also 60 mm x 50 mm. The component locations are given in **Figure 6** and photograph of the author's prototype in **Figure 7**. It will be seen that the two potted cores are used without alignment screws, since the alignment range is found to be too small. Instead of this, trimmer capacitors are used.

Inductance L 4 is a miniature Ferrite wideband choke of approx. 50 μH. Since the inductivity of this choke has an effect on the AFC characteristic, a home-wound version should only be used when an inductivity meter is available.

2.2.1 Component Details

I 1: CA 3089 E (RCA) with or without socket

2 pieces potted core kit 11 mm dia. x 7 mm
Siemens B 65 531 or Philips P 11 AL 40 406

Core: B 65 531 - K 0040 - A 001 (material: K 1, AL-40)
B 65 531 - L 0016 - A 012 (material: K 12, AL -16)
(see number of turns given in brackets)

Coil former: B 65 532 - A 0000 - H 001 or - R 002

Holder: B 65 535 - A 001 - X 000

Windings:
L 1: 3 turns (5 turns)
L 2, L 3: 16 turns (26 turns)
0.2 mm dia. enamelled copper wire (silk covered)

L 4: 50 - 70 μH Ferrite chokes (Amphenol-Delevan)

2 pieces trimmer capacitors of approx. 20 pF, 7 mm dia.,
ceramic or plastic foil types

2.3. Alignment

Required equipment: Dipmeter, a frequency counter is also of advantage. The 330 Ω resistor is disconnected at one end and the input circuit is aligned to 5.5 MHz. This is done by placing the coil of the dipmeter near to the top of the metal clamp of the potted core. The dip is not very deep due to the weak coupling (low stray field of the potted core) but can be seen. After this, replace the resistor.

After this, the reference circuit including inductance L 3 is also aligned to 5.5 MHz. It is necessary for the operating voltage to be switched off during this alignment. Since this resonant circuit determines the spacing between video and sound carrier, it is advisable for the dipmeter to be calibrated with the aid of a frequency counter where possible.

The input Pt 1 is connected to Pt 502 of module DJ 4 LB 005. The operating voltage of 12 V should now be connected and the AFC-input Pt 206 (module DJ 4 LB 002) provided with 6 V with the aid of a voltage divider. Connect the frequency counter to Pt 202 and align the sound carrier oscillator by adjusting the core of L 201 to 33.4 MHz. The AFC voltage at the output (Pt 3, DJ 6 PI 003) should now amount to approx. 6 V.

The DC-voltage source is disconnected from Pt 206 and this point is now connected to Pt 3 of DJ 6 PI 003 instead. The frequency counter must again indicate 33.4 MHz. A variation of the core of L 201 by ± 1 to 2 turns from the previously selected position should only cause a deviation of a few kHz on the counter. If the deviation is greater, this would indicate that the alignment of the 5.5 MHz reference circuit is incorrect. This circuit should then be adjusted in small steps until the described detuning test only causes slight deviations in the order of a few kHz.

Finally, everything should be switched off and switched on after a short period. After approximately a second (due to the time required to charge the 47 μF capacitor), the frequency should once again amount to 33.4 MHz.

The alignment requires some patience, especially when no frequency counter is available. The heating of the reference circuit and sound carrier oscillator with the aid of hairdrier caused only a deviation of several kHz, whereas the frequency of the sound carrier oscillator varied by more than 100 kHz if no AFC was prcvided.

3. REFERENCES

(1) G. Sattler: Module ATV transmitter
VHF COMMUNICATIONS 5, Edition 1/1973, pages 2 - 15
VHF COMMUNICATIONS 5, Edition 2/1973, pages 66 - 80

(2) RCA Solid State: Data sheet and technical data of integrated linear circuits and MOSFETs, 1973

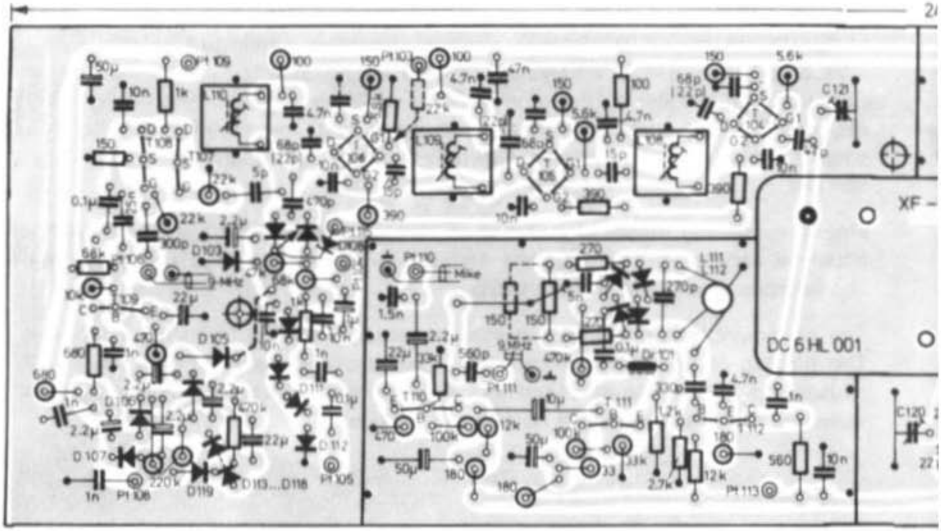
TEN METER VERSION OF THE DC 6 HL TRANSCEIVER

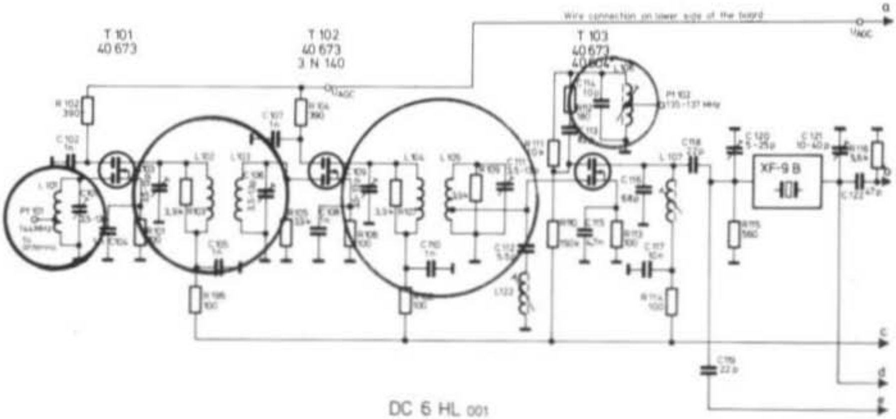
by K. Ochs, DJ 6 BU

The main PC-board of the wellknown SSB/FM transceiver DC 6 HL (1) can easily be modified to form an SSB transceiver for the 28 MHz band. This forms then an ideal exciter for 70 cm and 23 cm transverters, or for direct operation on the 10 m band in conjunction with a suitable linear amplifier.

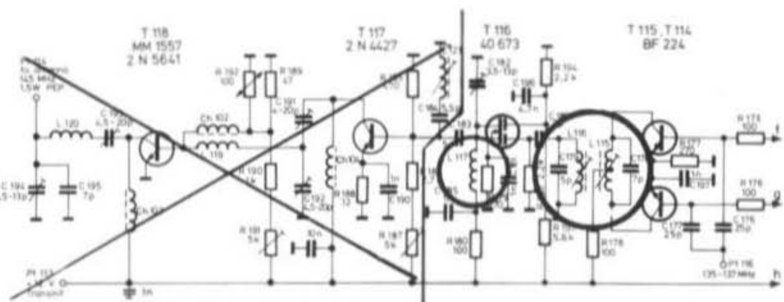
1. CIRCUIT DESCRIPTION

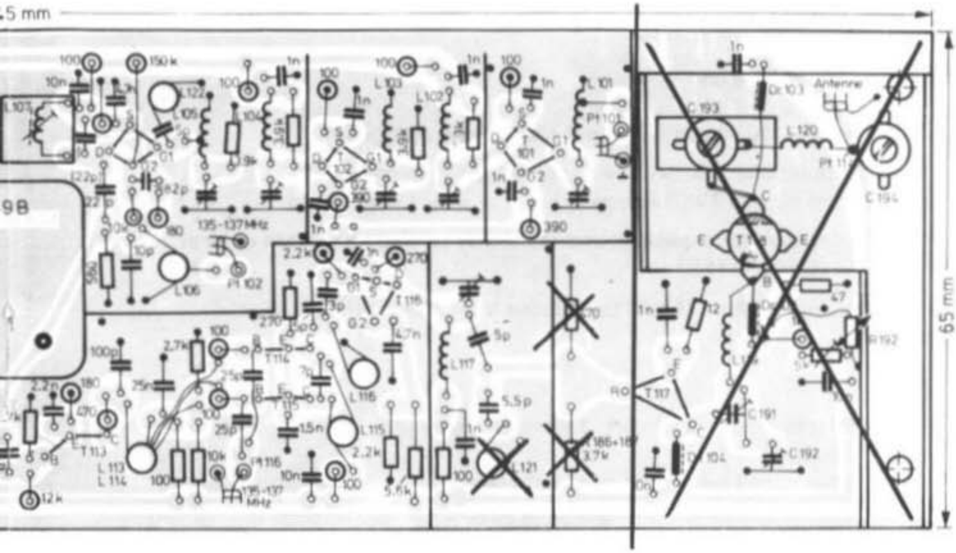
Figure 1 gives the circuit diagram of the DC 6 HL transceiver without oscillator and AF modules. The parts to be modified are ringed, and the parts to be deleted are crossed out. The driver and the final output transistor of the transmitter are deleted. An output power of approximately 10 mW can be taken from L 117, which is usually suffient for conversion in a transverter. A VFO variable in the range of 19 to 21 MHz or from 37 to 39 MHz should be connected to Pt 116 or Pt 102. The VFO described in (2) is suitable for this application. Finally it is necessary to change the 145 MHz resonant circuits to 29 MHz, which is described below.

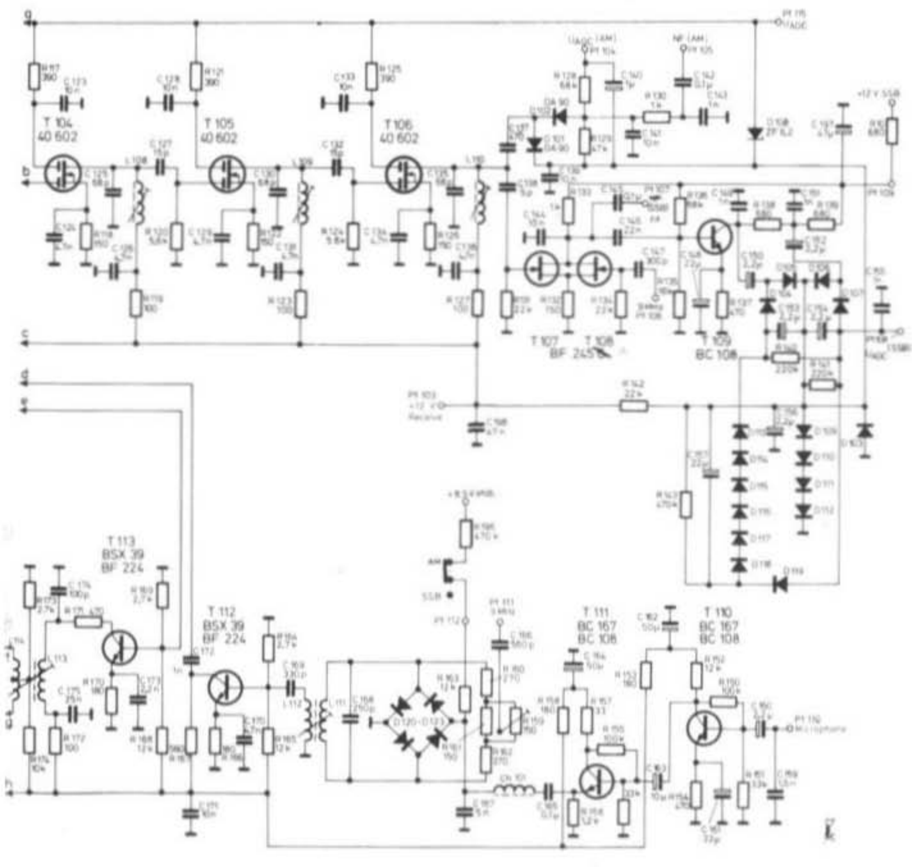

XF -
DC 6 HL 001


T 101
40 673
T 102
40 673
3 N 140
T 103
40 673
40 604
Wire connection on lower side of the board
XF-9 B

DC 6 HL 001


T 118
MM 1557
2 N 5641
T 117
2 N 4427
T 116
40 673
T 115, T 114
BF 224


65 mm
Antenne
135-137 MHz
L 101
L 102
L 103
C 193
C 194
L 120
C 191
C 192
R 192


T 104
40 602
T 105
40 602
T 106
40 602
T 107
T 108
BF 245
T 109
BC 108
T 113
BSX 39
BF 224
T 112
BSX 39
BF 224
T 111
BC 167
BC 108
T 110
BC 167
BC 108

2. RESONANT CIRCUIT DATA FOR 28 - 30 MHz

2.1. Input Circuit of the Receiver

The resonant circuits of transistors T 101 to T 103 must be changed.

Coilformers: 5 mm outer diameter, with red or possibly brown core.
Wire: Approx. 0.5 mm dia. (26 AWG) enamelled copper wire, close wound.

Remove the following trimmer capacitors and replace by ceramic disc types of 30 pF:
C 101, C 103, C 106, C 109, C 111.

The following damping resistors should be reduced from 3.9 kΩ to 2.2 kΩ:
R 103, R 105, R 107, R 109.

Coils:

L 101:	10 turns, coupling winding 3 turns on cold end.
L 102 - 104:	10 turns.
L 105:	10 turns, coil tap 4 turns from hot end.
L106:	10 turns, coupling winding 3 turns at cold end.

Parallel capacitor C 114:	VFO 37 - 39 MHz: 10 pF
	VFO 19 - 21 MHz: 40 pF

L 122: deleted

The input circuit possesses a very high sensitivity and gain. It exhibits a tendency to self-oscillation, even after the damping resistors have been reduced in value. The resonant circuits should therefore be aligned for several different frequencies over the 10 m band. The receive converter DC 0 DA described in (3) is very suitable for use with the transceiver.

2.2. Transmit Mixer and Linear Amplifier

PC board DC 6 HL 001 is sawn off at the last screening panel of the receiver input circuit (see **Figure 2**) because the driver and output amplifier are not required. Coilformers and coil wire as for the receiver.

L 115:	10 turns with center tap, C 178: 30 pF
L 116:	10 turns with parallel capacitor C 179: 30 pF
L 117:	10 turns, coupling winding 3 turns at cold end. C 182: 30 pF

All components after C 183 are deleted. Module DJ 4 LB 004 (4) is very suitable for use as transmit converter for 70 cm.

3. GENERAL MODIFICATIONS

The product detector (T 107 / T 108) should always be equipped with the transistor BF 245 A. When using the transistor BF 245 C, so much current flows via resistor R 133 (1 kΩ) that the drain-source voltage drops to a few volts. This causes a large distortion of the AF signal. A product detector equipped with a DG-MOSFET would be better.

4. REFERENCES

(1) G. Otto: A Portable SSB Transceiver for 144 - 146 MHz
VHF COMMUNICATIONS 4, Editions 1 - 4/1972

(2) D.E. Schmitzer: A Variable Frequency Oscillator Module for the Modular Receiver System
VHF COMMUNICATIONS 5, Edition 4/1973, pages 241 - 249

(3) J. Dahms: A Receive Converter 432/28 MHz matching the Transmit Converter DJ 6 ZZ 002
VHF COMMUNICATIONS 5, Edition 3/1973, pages 165 - 166

(4) G. Sattler: A Modular ATV Transmitter
VHF COMMUNICATIONS 5, Edition 1/1973, pages 2 - 15

AN FM-HANDHELD TRANSCEIVER FOR THE 2 m BAND

by R. Tellert, DC 3 NT

Part 2: Construction and Alignment

The order of construction and alignment is firstly to be given for information:

Complete PC-board DC 3 NT 001.
Make a functional test of module DC 3 NT 001.
Complete PC-board DC 3 NT 002.
Make a functional test of module DC 3 NT 002.
Prepare the case, mounting plates and other mechanical pieces.
Mount the square and hextagonal bolts to the mounting plate.
Mount the rear panel (3 sockets and the AF output transistor).
Mount both PC-boards to the mounting plate.
Complete the front panel and solder the wires into place.
Screw both the front and the rear panels to the mounting plate.
Complete the wiring of the unit.
Carry out the final alignment.

5. CONSTRUCTION DETAILS FOR PC-BOARD DC 3 NT 001 (RECEIVER)

5.1. Complement

5.1.1.

The PC-board of 135 mm x 90 mm should be drilled with the following holes according to **Figure 4:**

Trimmer capacitors and resistors: 1.3 mm dia., ceramic filter and screening cans:1.5 mm dia., coil formers 4.2 mm dia. (file out slightly so that the coil formers fit tightly). Holes of 3.5 mm dia. should be provided for the three mounting holes and for the antenna cable; all other holes should be 1 mm in diameter.

5.1.2.

The components should now be mounted as shown in the component location plan:

All resistors and diodes are mounted vertically, as are C 20 and C 71. Important: C 16 and C 79 must be ceramic disc capacitors of 5 mm in diameter; if not, a tendency to oscillation may be noticed.

It is also important that the connection leads to these capacitors should be as short as possible. Of course, this is valid for all components of the VHF-stages. The lower surface of the transistors type BF 324 should never be more than 3 mm from the surface of the PC-board. The ceramic capacitors with values up to an including 2.2 nF should be disc types of 5 mm in diameter for a spacing of 5 mm. Spacings of 5 mm and 7.5 mm are used for the 10 nF capacitors. A spacing of 5 mm is also available for capacitors C 42, C 43, C 52 and

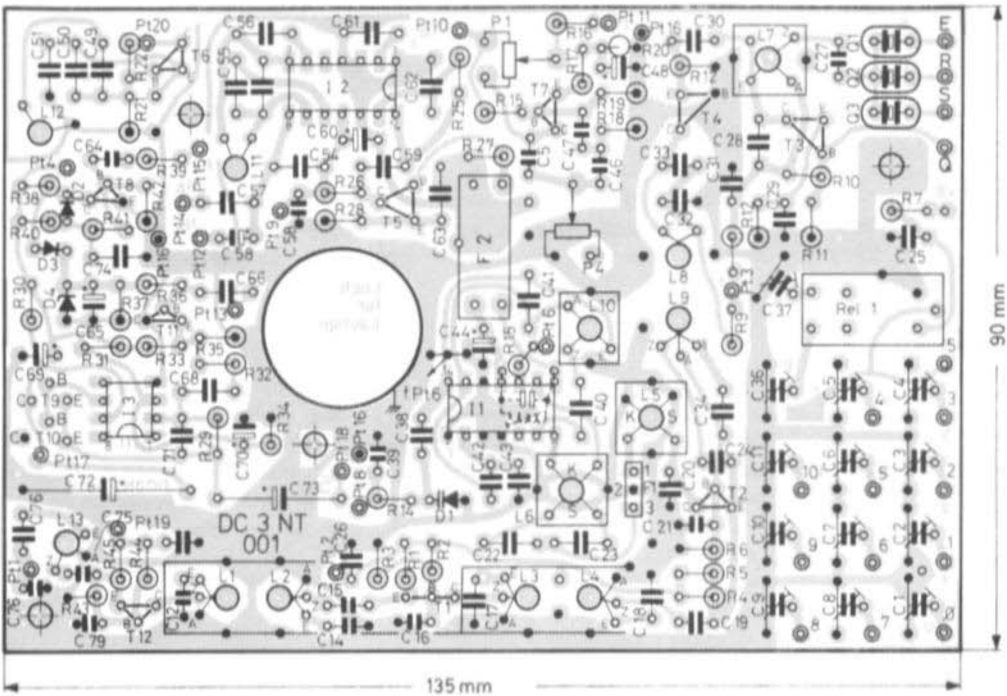


Fig. 4: PC-board DC 3 NT 001 (receiver)

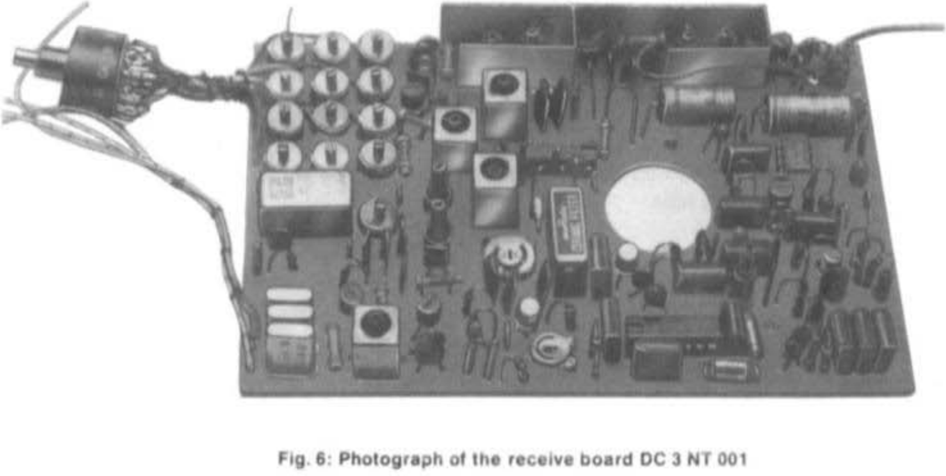


Fig. 6: Photograph of the receive board DC 3 NT 001

C 64; either ceramic or plastic foil capacitors can be used here. The 10 nF capacitors with a spacing of 7.5 mm should always be plastic foil types since the tolerances may not be so large. Capacitors C 46, C 47 and C 54 should also be plastic foil types.

5.1.3.

Wind all coils and solder them into place.

The following should be observed during this: electrically speaking, the direction of turns of all inductances is not of importance. However, in order to ensure that one obtain 4.25 and not 3.75 turns it is important with respect to the VHF inductances that the given direction is maintained.

5.1.4.

The inductances L 5, L 6, L 11 and L 12 are wound directly onto their coilformers and glued into place with a small amount of dual-component glue. L 7 and L 10 should also be glued. All other coils are wound on a former of 4.3 mm diameter, after which the ends are bent straight and solder coated. The coil taps on the coils using 0.8 mm dia. enamelled copper wire are made by connecting a thin wire before winding and then winding the coils on both sides commencing with the tap. The connection of the inductances should be soldered quickly so as not do damage the coilformers.

5.1.5.

A 55 mm long piece of thin coaxial cable (RG-174) is now prepared by removing the insulation from 10 mm at one end and 8 mm from the other end after which the shielding is pushed back. The inner conductor of the 10 mm side is connected to the conductor lane between C 38 and pin 14 of I 1. The screening of this end is soldered to the ground surface below I 1. The inner conductor of the other end is soldered to the surface »a« (near C 36).

This conductor lane leads to relay Rel 1 and to »S« (wiper of the channel switch). The shield is soldered to the ground connection of trimmer capacitor C 36.

5.1.6.

A further cable is required as above that is 30 to 35 cm long. The insulation is removed for 12 mm at both ends of the cable and the inner conductor is connected to Pt 1. The cable is fed via the 3.5 mm hole provided for the antenna cable and the screening is soldered to the ground surface around the hole.

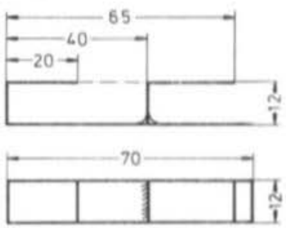


Fig. 5: Screening panels of the input stages of the receiver

5.1.7.

Prepare the screening plate as shown in **Figure 5** and solder into place according to the component location plan. Solder the screening cans of the IF coils into place.

Approximately 70 mm length of stranded wire is soldered into the connection points for the range switch (E-R-S-Q). The channel switch is also connected with the aid of stranded wire. The spacing between the edge of the board and the solder tags should amount to approx. 15 mm. The connections from channel 0, 7, and 8 should not be fed around the edge of the board since this could cause a large detuning effect due to the ground capacitance.

Approximately 15 mm length of wire should be soldered to all three connection points Pt ... and provided with a length of approximately 8 mm of insulating tubing. Only four connection points are required for the AF output transistors (+ U_b, ground, E, B) as long as the emitter and base connections are directly connected to another.

5.1.8.

Two connecting supports are now prepared for the additional resonant circuit comprising L 14 so that it is possible to mount it above I 1. The required values for this resonant circuit are: C = 4.7 nF / L = 30-40 turns of 0.1 mm diameter (38 AWG) wound on a Japanese 455 kHz resonant circuit. Align to 455 kHz before mounting into place.

5.1.9.

Connect a 25 mm length of silver-plated copper wire of approx. 0.8 mm in dia. (20 AWG) to the ground surface between C 1 and C 2. This wire must be soldered to a tag mounted under the hextagonal bolts on the channel selector switch on installing the PC-board into the case. If this ground connection is not made, the transmitter will affect the VFO, which causes a differing frequency spacing from channel to channel, which is so great that it cannot be compensated for with the aid of trimmer capacitor C 37.

5.2. Functional Test of Module DC 3 NT 001

The completed receive board (see **Figure 6**) is now checked and preliminary aligned.

5.2.1.

Connect Pt 19 to Pt 2 and place a Ferrit bead on to the connection wire. Also connect Pt 19 to Pt 4. Connect Pt 4 to Pt 3.

Temporarily connect the AF output transistors. Connect the squelch potentiometer to Pt 14, Pt 15, Pt 16, and the volume potentiometer to Pt 12, Pt 13 and Pt 16.

Connect Q to S (crystal oscillator), Pt 9 to Pt 17 and connect the loudspeaker.

5.2.2.

Feed a stabilized voltage of 12 V to Pt 17. Align L 11 for maximum noise. The squelch circuit should now operate.

Connect a frequency counter via a capacitor of approx. 1 nF to Pt 6 and ground. Adjust C 13 for maximum capacitance and align the resonant circuit comprising L 10 to 10.250 MHz.

5.2.3.

Measure the voltage drop across R 9 (1 V range) and adjust L 7 until an indication is seen. Adjust for maximum and then rotate a further half turn in a clockwise direction. The oscillator should now be checked whether it commences oscillation reliably on switching on the operating voltage. If required, insert the core of L 7 still further into the coil. If this oscillator does not commence oscillation, reduce the value of the emitter resistor R 12. The minimum value is in the order of 3.9 kΩ, however, the value should be as high as possible so that no unwanted harmonics are generated.

Couple a dipmeter or absorption wavemeter to L 8 and adjust this coil for maximum indication. This should be repeated for L 9.

5.2.4.

Connect a signal generator to the antenna input and align to approximately 145.450 MHz. Adjust the signal generator for maximum, select a narrow frequency modulation and align until a signal is received in the receiver. It is possible that no signal will be audible because of the incorrect alignment of the circuit. In this case, a 10.7 MHz signal is firstly fed via a capacitor of 10 pF to the emitter of T 2, and L 5 and L 6 aligned for maximum. After this, it should be possible to hear the 145.450 MHz signal at the input.

Inductances L 5 and L 6 should be aligned for minimum noise, and the output of the signal generator reduced further during the following alignment steps to ensure that the signal is always slightly noisy. Align inductances L 13, L 1, L 2, L 3, L 4, L 8 and L 9 for minimum noise. The order of alignment is not critical since the circuits hardly influence another. The resonant circuits comprising L 3 and L 4 possess a very sharp resonance. If self-oscillation should occur due to a high gain of transistor T 12, a 5.6 kΩ resistor should be soldered to the lower side of the board between the collector of T 12 and ground.

5.2.5.

The BFO (Pt 20) should also be connected to + 12 V in addition to the other receiver stages. The frequency counter should be connected via a series connection of 1 nF and 10 kΩ to the emitter of T 6 and inductance L 12 aligned to 455 kHz. The frequency counter is now disconnected. Feed an unmodulated signal from the signal generator to the antenna input and tune the receiver for zero beat. After this remove the operating voltage from Pt 20 (BFO switched off). Finally, modulate the signal generator with a frequency deviation of 5 kHz and align the inductance L 11 for maximum volume.

5.2.6.

Measure the noise voltage at the loudspeaker and increase the level of the unmodulated signal generator from zero until the measured noise drops to a tenth of the original value (20 dB AF signal-to-noise ratio without modulation). This value should amount to 0.3 to 0.4 µV.

5.2.7.

Now check the operation of the calling tone oscillator and align to 1750 Hz. This is done by connecting Pt 20 to + 12 V and connecting Pt 11 to an oscilloscope. Potentiometer P 1 is now aligned for maximum, undistorted amplitude and the frequency adjusted to 1750 Hz at Pt 4. If this oscillator does not commence oscillation, the value of R 17 should be reduced as described in 2.2.

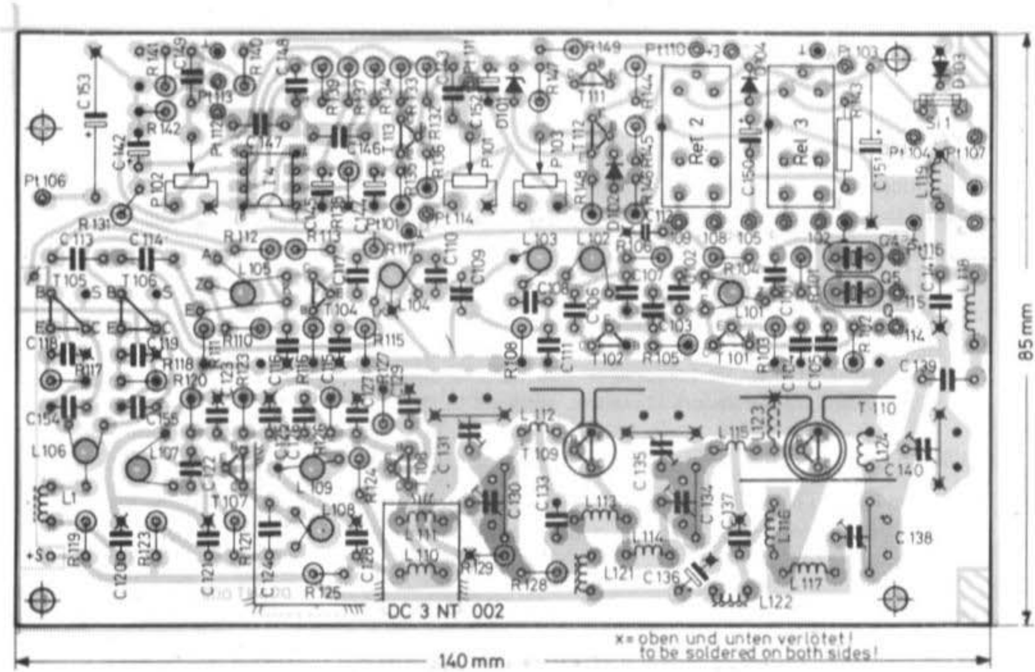


Fig. 7: PC-board DC 3 NT 002 (transmitter), double-coated

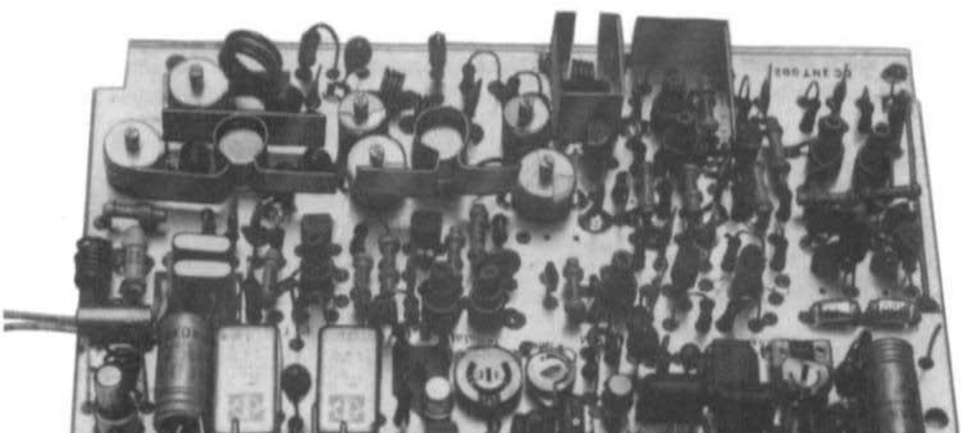


Fig. 9: Photograph of the transmit board DC 3 NT 002

6. CONSTRUCTION DETAILS FOR PC-BOARD DC 3 NT 002 (TRANSMITTER)

6.1. Mounting the Components

6.1.1.

The double-coated PC-board of 140 mm x 85 mm is drilled according to **Figure 7** in a similar manner to the receiver board (see 5.1.1.). The shaded areas are sawn off so that the board fits between the square bolts.

All resistors and diodes are mounted vertically. Exception: R 143 which is mounted horizontally in front of C 151 since the capacitor partially covers the resistor. C 151 and C 153 should be spaced 4 mm from the board so that the mounting screw is accessible. The positions marked with »x« should be soldered on the top and bottom of the board. All bypass capacitors (2.2 nF), and all transistors should be soldered to the board with short connections.

6.1.2.

The same is valid for the mounting of the coils as was given in 5.1.3. and 5.1.4. Chokes L 120, L 121 and L 122 comprise 10 to 12 turns of enamelled copper wire wound on a 1 kΩ / 0.5 W resistor.

6.1.3.

Since the metal case of the driver and output transistor can make contact of the ground surface on the other side of the board, an approximately 2 mm thick plastic spacer is placed on the wires of the driver, and the output transistor is insulated with a piece of mica (do not forget the heat conductive paste for heat dissipation to the ground surface).

6.1.4.

Two screening plates, two cooling brackets and a small tunnel should be constructed as shown in **Figure 8** from 0.5 mm brass plate. The angle piece and the tunnel are soldered to the ground surface on the component side of the PC-board according to the dashed lines.

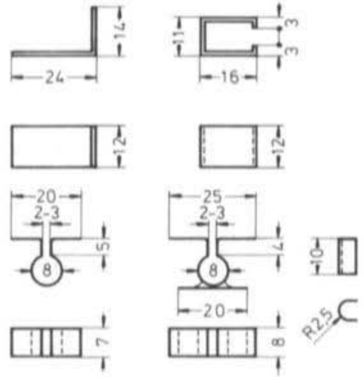


**Fig. 8:
2 screening plates,
2 cooling fins, and
1 tunnel for DC 3 NT 002**

6.1.5.

On the lower side of the board, an approximately 35 mm length of thin coaxial cable (e.g. RG 174) should be connected between the two points designated with »a«. The screening is connected to ground between the designations »ER« and »LED«. This is followed by soldering four damping resistors to the conductor side of the board: R 107 to the collector connection of T 104 and R 110 (C 116 side) R 109 to L 110; R 150 to C 113 / C 114 and to the ground connection of C 119; R 151 to the hot end of C 154 or C 155.

6.1.6.

An approximately 70 mm length of insulated stranded wire is connected to connection points Pt 114, 115 and 116. The three wires are placed through the tunnel.

Connection point Pt 101 is the free end of R 114. The other connection points should be prepared as given in 5.1.7.

6.1.7.

When using plastic foil trimmers for C 131, C 135 and C 140, firstly place a thin wire through »x« and solder at the top and bottom. After this, solder the trimmer into place. The ground side of capacitor C 112 (at Pt 109) should be soldered to the ground surface above.

6.2. Functional Test of Module DC 3 NT 002

The completed transmit board (see **Figure 9**) is now checked and preliminarily aligned:

6.2.1.

Connect connection point Pt 114 and Pt 115. Connect a signal generator (10.250 MHz, min. 200 mV) or the VFO on the receiver board to connection Pt 101 and ground. Connect a wattmeter with terminating resistor between Pt 103 and ground. Trimmers C 130, C 138, C 140 should be aligned for minimum capacitance. C 134 to approximately 10 pF, C 131 and C 135 to approximately 20 to 30 pF.

6.2.2.

Feed approximately 15 V to connection Pt 107. Connect a voltmeter between Pt 111 and ground and adjust the indicated voltage with the aid of P 102 to 12 V. Connect Pt 109 (LED) to ground.

6.2.3.

Provide connection Pt 107 with 13.5 V, connect Pt 109 to ground and align inductance L 101 for maximum indication on a dipmeter or absorption wavemeter (45 MHz). When aligned in this manner, the oscillator should operate reliably on switching on the operating voltage.

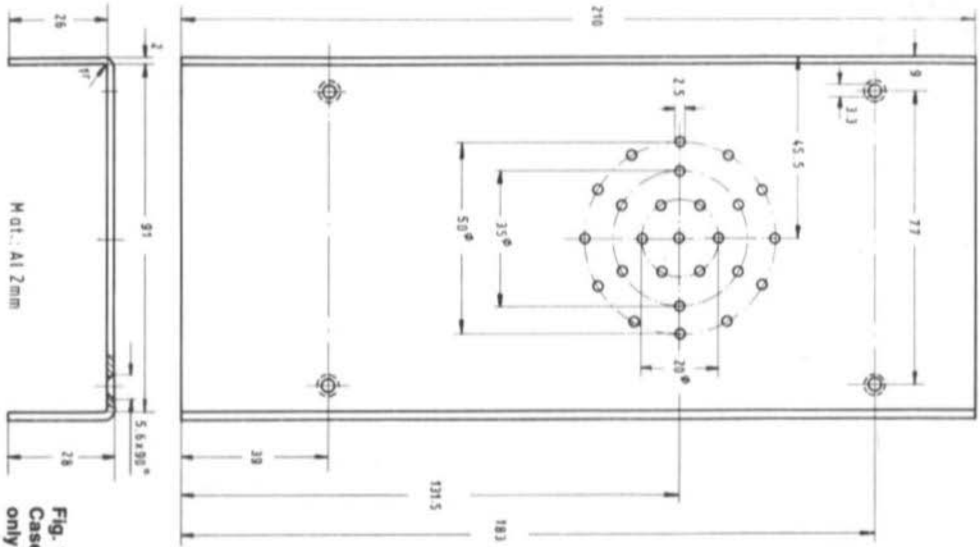


Fig. 10:
Case; loudspeaker holes should only be drilled on one side

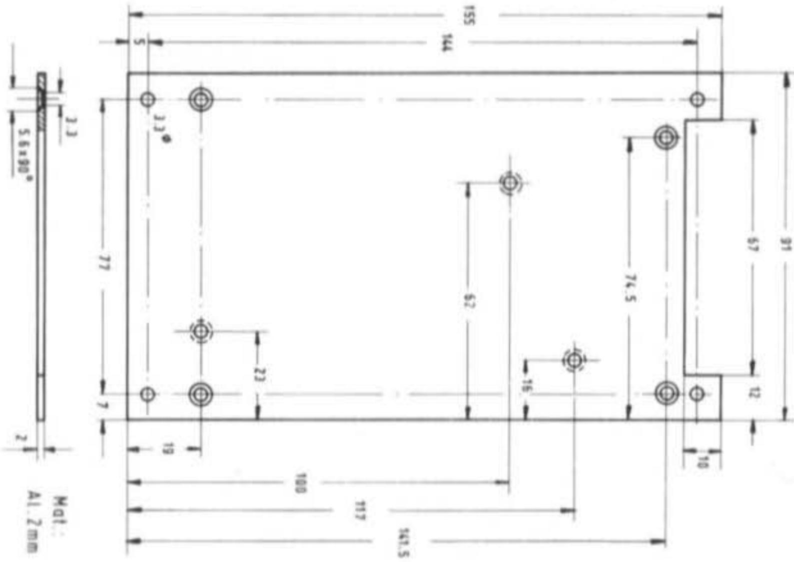


Fig. 11: Mounting plate

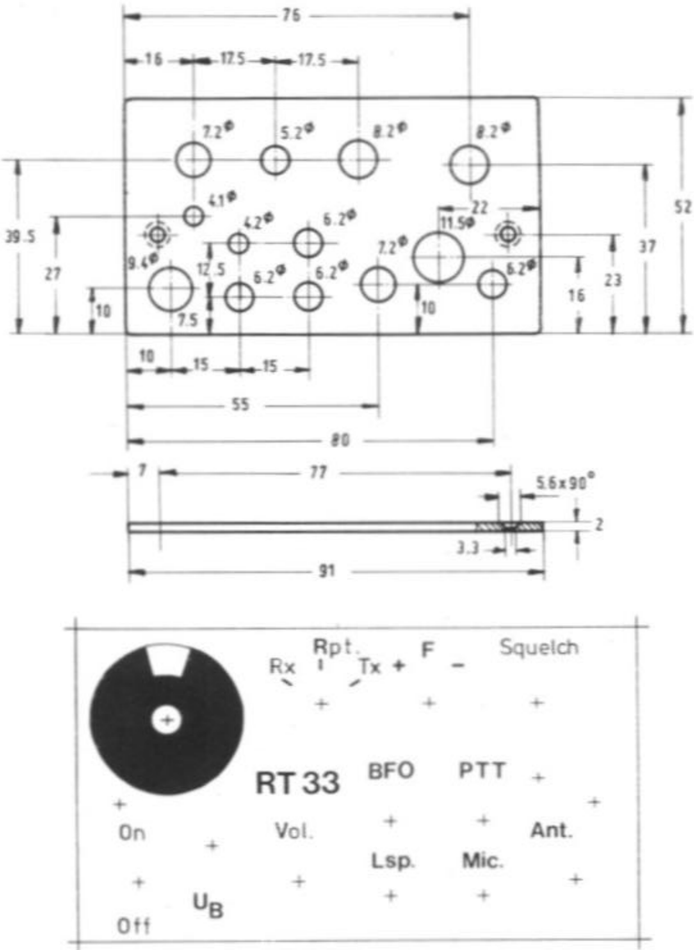


Fig. 12: Front panel (from the inside) and markings

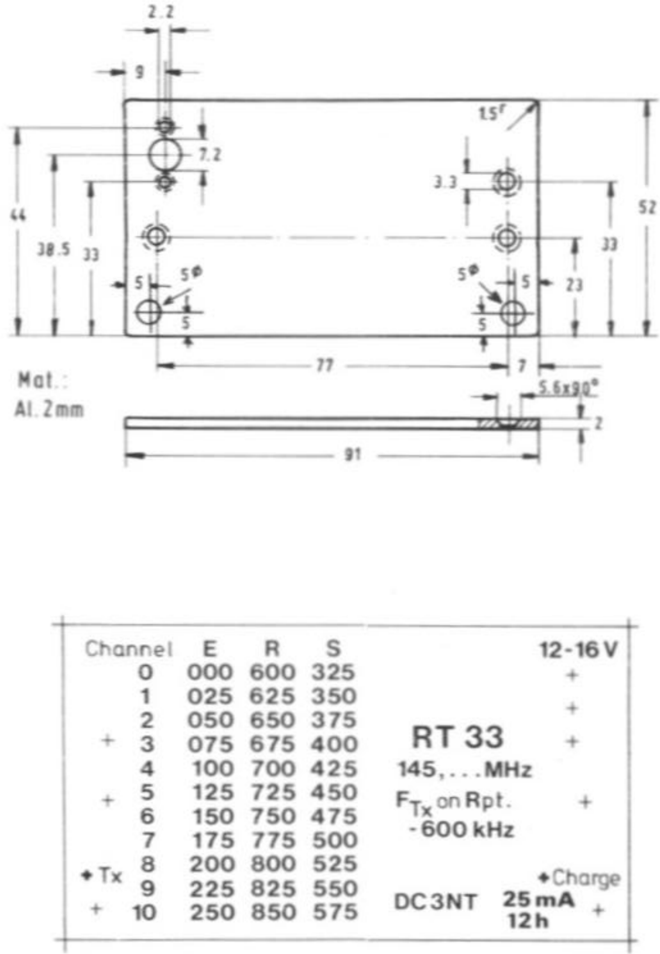


Fig. 13: Rear panel (from the inside) and markings

6.2.4.

Align L 102, L 103 and L 104 for maximum reading at 135 MHz.
Align L 105 for maximum at 10.250 MHz.
Align L 106 and L 107 for maximum reading at 145 MHz.
Finally, align L 108 and L 109.

6.2.5.

Place a dipmeter or absorption wavemeter in the vicinity of L 113 and align C 130 and C 131 for maximum reading. The following are then aligned for maximum reading on the wattmeter: C 134, C 135, C 138 and C 140. This alignment should be made several times. The output power should drop to zero on switching off the signal generator or removing the crystal.

6.2.6.

Connect a microphone between Pt 114 and ground. Place P 101 to its fully anticlockwise stop. P 102 to a central position. Connect an oscilloscope between Pt 113 and ground and speak into the microphone. Approximately 6 V peak to peak should be seen on the oscilloscope.

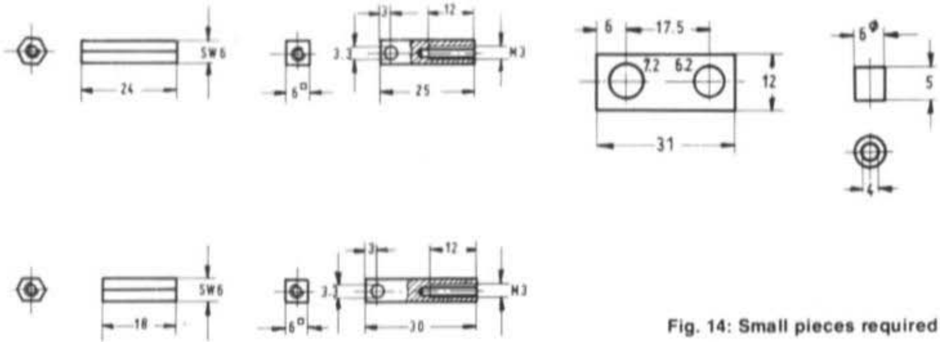


Fig. 14: Small pieces required

7. MANUFACTURE OF THE CASE AND MOUNTING PARTS

A 2 mm thick aluminium plate is used for all parts. **Figures 10 to 14** show drawings of the individual parts: two-piece case, one mounting plate, one front and rear panel as well as other small pieces. The following small parts are required as shown in Figure 14: four pieces of hextagonal bars of 24 mm in length on the receiver side (DC 3 NT 001), four pieces of hextagonal bars of 18 mm in length on the transmit side (DC 3 NT 002), two pieces of square bars of 25 mm in length for mounting the rear panel, and two pieces of square bars of 30 mm in length for the front panel. In addition to this, six insulating collars of 5 mm in length are required for mounting the PC-boards, as well as a 12 mm x 31 mm piece of PC-board material. This plate will only be required when a spindle trimmer for solder mounting is used for C 35.

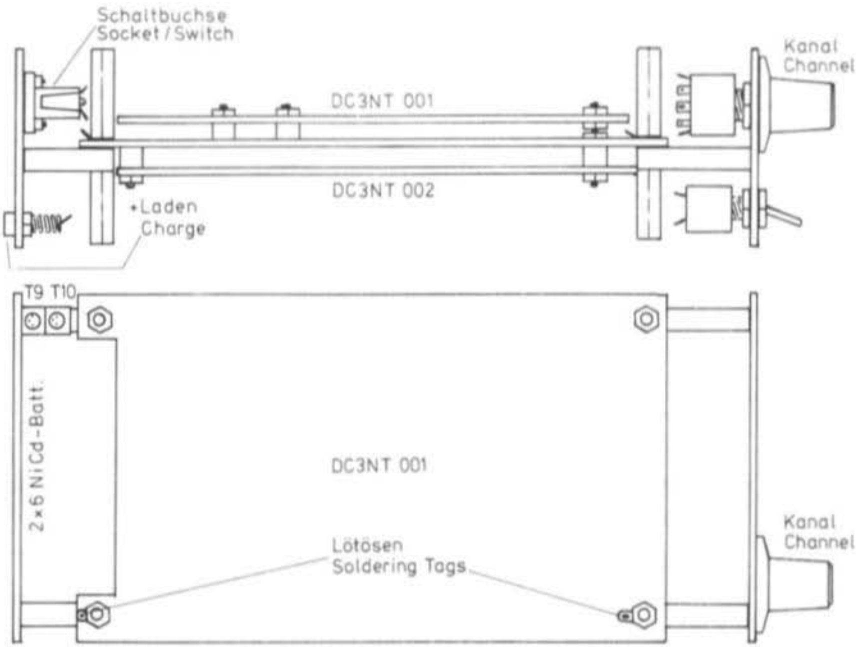


Fig. 15: Mounting of the PC-boards and other components

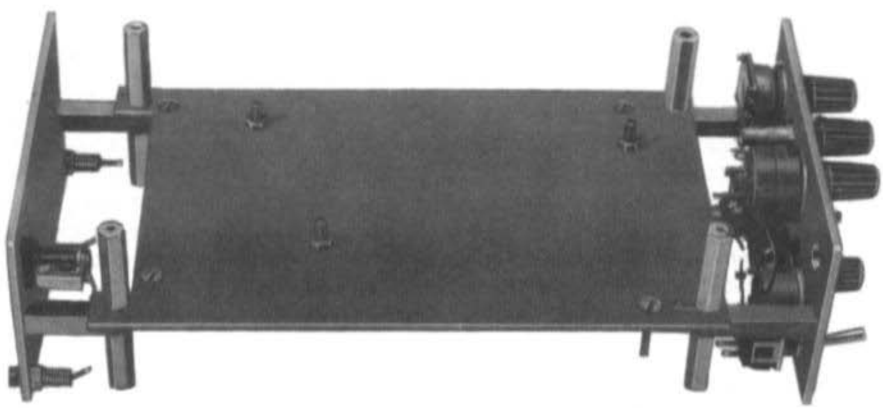


Fig. 16: Mounting plate, front and rear panels, and controls

These pieces are mounted together as shown in **Figure 15**. The square bars are mounted to the mounting plate with the aid of the hextagonal bolts after which the three sockets for charging (+), transmit (+), power supply and the two AF-output transistors are mounted to the rear panel. After this, the completed PC-boards are mounted with the aid of the insulated spacers to the mounting plate. The receiver board should be grounded via the mounting screw in the vicinity of the crystals. The transmit board is grounded via the mounting nuts on the upper side of the board. Finally, the front panel should be equipped. It is necessary for the meter to be mounted in an insulated manner, (glued) since there is sometimes an interconnection between the coil of the meter and the case. Section 8 gives further details regarding the soldering of the interconnection wires. The front and back panels are mounted into place after completion, after which the final alignment is made according to section 9.

8. WIRING DETAILS

Insulated stranded wires of several different colours should be used for wiring. Coaxial AF cable should be used for all screened connections, and Teflon (PTFE / RG 174) should be used at VHF. The following details indicate the most favorable order of wiring and combination into cable harnesses.

8.1.

It is advisable for the potentiometers for volume and squelch, as well as switch S 4 to be provided with wires before screwing the front panel into place. A common connection can be used for the ground of the loudspeaker and squelch (Pt 16).

8.2.

Two wires are connected to one contact of S 4: one goes down to the transmitter (Pt 111), and the other to the receiver (Pt 9). This means that a stabilized voltage of 12 V is connected to the IF and VFO. Another wire is connected to the second contact of S 4, which is later soldered to Pt 10. The front panel can now be mounted into place.

8.3.

Solder the range switch to the receiver and harness the four cables together. Screw the channel switch into place. The leads from the potentiometers and from S 4 should be fed together from P 3 along the outer edge of the PC-board up to L 7. From there, it is advisable to solder a lead to connection Pt 3 as well as a screened AF cable to Pt 11 and ground. The cable harness should then be fed to Pt 10. The lead from S 4 (switched operating voltage) should be soldered to Pt 10 and led further to Pt 20. The connections of P 3, P 2, Pt 3 and S 4 are then distributed from here according to the circuit diagram.

8.4.

Solder the connections to the AF output transistors. The lead from Pt 11 can be led with the interconnections of the output transistors. At the cutout for the accumulators (2 x 6 DEAC cells of 225 mAh), all leads from the receiver board (with the exception of the wire from Pt 109 to Pt 5) should be led to the transmitter past the hextagonal bolts on the same side as the sockets. Do not forget the connections for the loudspeaker.

8.5.

On the transmit side, the cable harness is passed via C 153 and is led along the outer edge of the PC-board until S 3 is reached. From here, the various leads are connected to the components on the front panel. C 156 should be directly connected to the microphone socket.

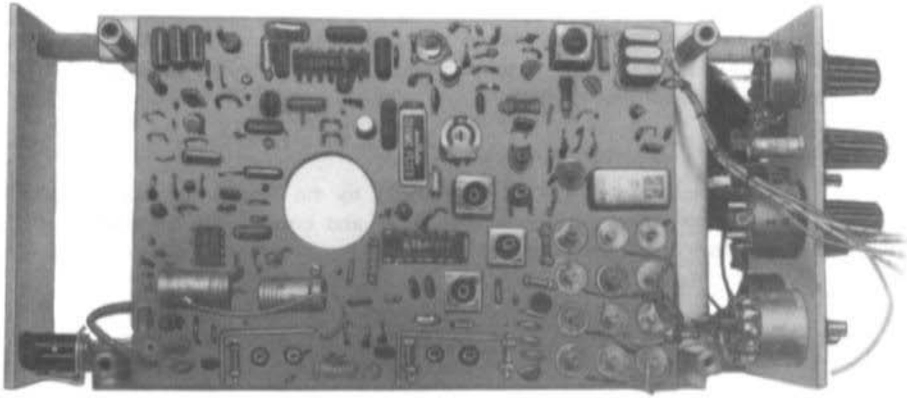


Fig. 17: Completed transceiver from the receiver side

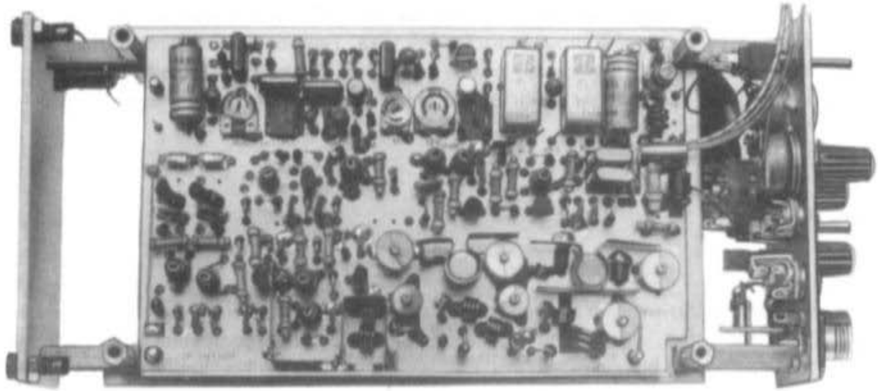


Fig. 18: Completed transceiver from the transmitter side

9. FINAL ALIGNMENT

9.1. Receiver

9.1.1.

Connect 13.5 V to the appropriate socket. Check the voltage at Pt 111 (12 V), adjust with Pt 103 if required.

9.1.2.

Check the operation of the squelch and volume control.

9.1.3.

Connect the frequency counter via a capacitor of approx. 1 nF to Pt 101. Set C 35, C 36 and C 37 to a central position and place S 2 to ∅.

9.1.4.

The indicated frequency should be variable in the range of 10.050 to 10.450 MHz with the aid of C 1. This range can be corrected if required by adjusting L 10. Fix the position of L 10 with the aid of a drop of dual-component glue.

9.1.5.

Align the trimmer capacitors C 1 - C 11, according to the frequency plan, to 10.120 - 10.370 MHz. Switch from one position to the other and correct the alignment until the deviations are not more than 1 kHz.

9.1.6.

Measure the BFO frequency and adjust if required (see 5.2.5.).

9.1.7.

Connect the signal generator to the antenna input socket and adjust to 145.450 MHz. Select channel 6, simplex and align the first IF as well as the VHF input stages for minimum noise. The final alignment point is the input inductances L 13. Two maximums are indicated during this alignment: for noise matching and power matching. In the case of noise matching, the receiver will be more sensitive as long as the antenna used possesses the same real impedance as the signal generator.

9.2. Transmitter

9.2.1.

Connect the terminating resistor via a wattmeter to the output socket. Key the transmitter. If no reading is indicated, check the operation of the crystal oscillator with a dipmeter. Continue as described in 6.2.

9.2.2.

Adjust the operating voltage to 12 V. All resonant circuits should now be aligned for maximum output power. In the case of L 119, this is made by varying the coil spacing.

9.2.3.

If possible, measure the spurious signals. Align L 104 and L 105 for minimum spurious output. Switch from one channel to the other. The spurious signal attenuation should be at least 60 dB.

9.2.4.

Set the channel switch between two ranges: the power output should drop to zero. Even when the VFO is disconnected from Pt 101, the output power should also be zero.

9.2.5.

Adjust P 101 to maximum, speak a loud »a« into the microphone and adjust the frequency deviation to 5 kHz with the aid of P 102. Remove the microphone plug and switch on the calling tone (BFO-switch). Check the frequency (1750 Hz) and adjust the frequency deviation to 5 kHz with the aid of P 1.

9.2.6.

Switch to receive and net in a signal with the BFO. Switch on the transmitter and align it to the same frequency with the aid of C 37. Check the tracking between transmitter and receiver at each channel. If deviations of more than 2 kHz are present, the ground contact of the receiver board should be checked (see section 5.1.9.)

9.3. Frequency Table

Channel	$f_{osc.}$ (MHz)	+ 455 kHz = $f_{IF\ 1}$
0	10.120	10.575
1	10.145	10.600
2	10.170	10.625
3	10.195	10.650
4	10.220	10.675
5	10.245	10.700
6	10.270	10.725
7	10.295	10.750
8	10.320	10.775
9	10.345	10.800
10	10.370	10.825

BFO: 455 kHz

Crystal frequencies:

Receive frequ.range:	LO-frequency:	Crystal frequency:	Application:
145.000 - 145.250	134.424	44.808 MHz (Q 1)	Relay input
145.600 - 145.850	135.024	45.008 MHz (Q 2)	Relay output
145.325 - 145.575	134.750	44.917 MHz (Q 3)	Simplex

Transmit frequ.range:	LO-frequency:	Crystal frequency:	Application:
145.000 - 145.250	134.880	44.960 MHz (Q 4)	Relay input
145.325 - 145.575	135.206	45.069 MHz (Q 5)	Simplex

CONCEPT OF A COMBINED SSB STATION FOR BOTH 2 m AND 70 cm

by A. Würzinger, DJ 4 BH

Under practical conditions, it is very advisable when one is able to switch from one band to another at a turn of a switch. This can be achieved in an economical manner by suitable combination of the various modules. The following article describes a principle that can be used to design a combined SSB transceiver for both the 2 m and the 70 cm bands. This station is suitable for operation from 12.5 to 13.5 V sources. The block diagram of this system is given in **Figure 1.**

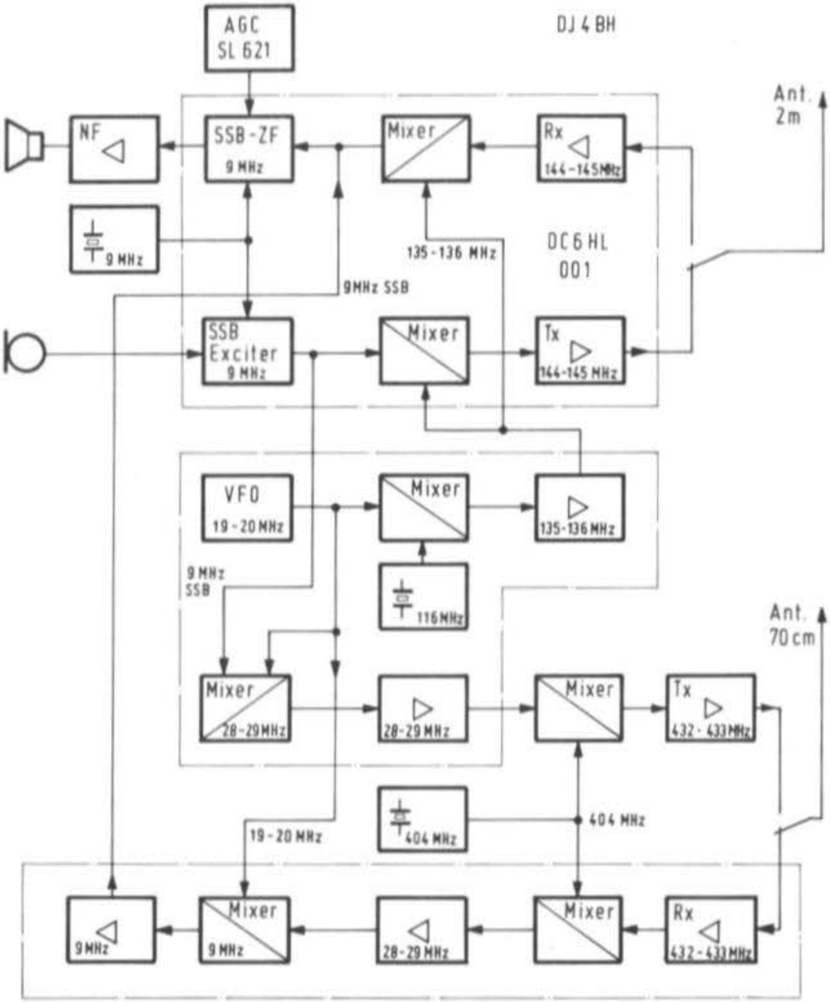


Fig. 1: SSB portion of a combined FM/SSB station for 2 m and 70 cm

1. OPERATION ON THE 2 m BAND

The synthesis VFO to be found in the center of Figure 1 mixes the crystal-controlled oscillator frequency of 116 MHz with a variable VFO frequency of 19 to 20 MHz. The resulting frequency is therefore 135 MHz to 136 MHz. This signal is amplified and fed to the SSB-transceiver board DC 6 HL 001 (1). In the 2 m-mode, this board operates in its original condition with the exception of the improved control voltage generation using a Plessey IC SL 621 C. The modules described in (1) or any other similar modules can be used for the AF-amplifier and carrier oscillator. A miniature ceramic relay or the National relay RH-12 can be used for antenna switching.

2. OPERATION ON THE 70 cm BAND

The following modules are disconnected from the operating voltage: input stages of the DC 6 HL receiver, and output amplifier of the transmitter, 116 MHz oscillator, mixer and 135 MHz amplifier. The VFO signal (19 - 20 MHz) is now mixed with the 9 MHz SSB signal taken from the second 9 MHz amplifier stage of DC 6 HL 001 with the aid of a coupling link on L 113. The resulting frequency range is from 28 to 29 MHz. After amplification, a further conversion is made with a frequency of 404 MHz to the required output frequency of 432 to 433 MHz. A modified module DJ 6 ZZ 002 (3) is used as local oscillator and mixer. This is followed by low-power amplifier using a transistor type BFS 86, which provides an output power of approx. 500 mW. It would also be possible to use a transistor type 2 N 5913 (RCA). In this case, it would be possible to connect a linear amplifier comprising a transistor 2 N 5914 or 2 N 5915 (RCA) via a bandpass filter, which would then provide an output power of 1.5 to 2.5 W.

In the 70 cm receive mode, a module DC 0 DA 001 (4) is used which has been extended by use of a further mixer from 28 MHz to 9 MHz. The local oscillator signal for the second conversion is provided by the VFO. The 9 MHz signal is now preamplified and fed to the crystal filter of the SSB-IF on board DC 6 HL 001. The antenna switching at 432 MHz can be made using a miniature ceramic relay or a small coaxial type.

The various DC voltage switching can be made with a relay having multiple contacts so that only one single switch needs to be actuated during the practical operation. The author has to actuate three toggle switches when not using the combined station.

3. REFERENCES

(1) G. Otto: A portable SSB transceiver for 144 - 146 MHz with FN attachment
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(2) R. Schmidt: Improvement of the AGC and the DC 6 HL transceiver
VHF COMMUNICATIONS 6, Edition 1/1974, pages 46 - 47

(3) F. Weingärtner: 28/432 MHz transmit converter with FET mixer
VHF COMMUNICATIONS 3, Edition 2/1971, pages 99 - 106

(4) J. Dahms: Receive converter 432/28 MHz matching the transmit converter DJ 6 ZZ 002
VHF COMMUNICATIONS 5, Edition 3/1973, pages 160 - 164

A PRECISION DIGITAL MULTIMETER

Part 1: Analog/Digital Converter, Decoder and Indicator Modules

by J. Kestler, DK 1 OF

This article is to describe a three and a half digit multimeter for DC, AC-voltages and resistance. Although the construction uses relatively cheap standard components, its accuracy is sufficient for laboratory measurements. The multimeter offers an automatic plus/minus switching as well as a blink indication when the range is exceeded.

1. CHARACTERISTICS

Range: 000 to 1999 (3.5 digits)

DC-voltage:

Maximum resolution:	100 µV
Measuring ranges:	199.9 mV, 1.999 V, 19.99 V, 199.9 V and 1.999 kV
Accuracy:	± 0.2 % ± 1 digit
Input impedance:	10 MΩ in 1.999 kV range; 1.1 MΩ in the other ranges

AC-voltage:

Frequency range:	20 Hz to 20 kHz (1 % error) 10 Hz to 50 kHz (5 % error)
Maximum resolution:	100 µV
Measuring ranges:	199.9 mV, 1.999 V, 19.99 V, 199.9 V
Input impedance:	1.1 MΩ, parallel 100 pF

Resistance:

Maximum resolution:	0.1 Ω
Measuring ranges:	199.9 Ω, 1.999 kΩ, 19.99 kΩ, 199.9 kΩ, 1.999 MΩ
Measuring current:	20 mA, 2 mA, 200 µA, 20 µA, 2 µA
Accuracy:	I 1.5 % ± 1 digit

Measuring rate: approx. 3 measurements/second, dependent on the measuring value
Integration time of the measured value: 200 ms ± 5 %, adjustable
Zero point drift: less than 1 digit/hour after a warmup period of 15 min.
Power requirements: 220 V / 50 to 400 Hz, approx. 35 VA

2. ANALOG/DIGITAL CONVERTER

2.1. Operation

From the various methods of A/D convertion, it is mainly the dual-slope method that is in general use since it allows a high accuracy to be obtained with relatively cheap components. The principle of operation was described in (1) in detail, which means that only a few notes together with the block diagram given in **Figure 1** are required.

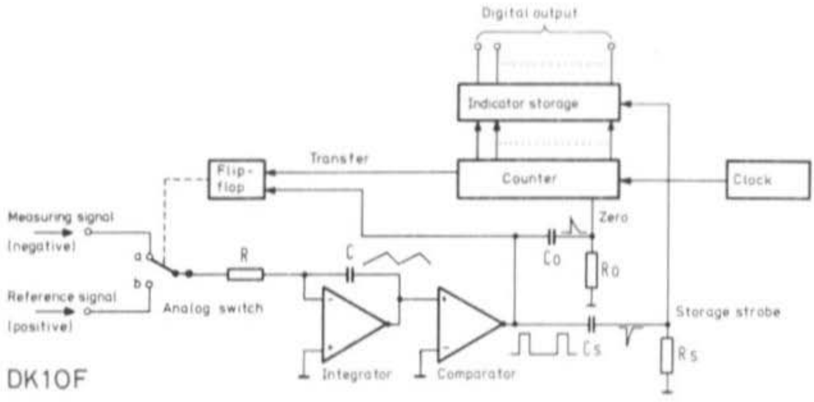

Fig. 1: Block diagram of a A/D converter according to the dual-slope method

The negative measuring signal and the positive reference signal are alternately connected to the input of an integrator with the aid of an analog switch. The integrator provides an increasing voltage at the output while the switch is in position »a«. The rate by which this voltage increases is proportional to the provided measuring voltage. The subsequent voltage comparator provides a negative voltage when, and as long as the sawtooth voltage from the integrator is less than 0 V. If this voltage is greater, the output voltage will jump to a positive value. This upward going slope is fed via the differential link C_O/R_O to the digital counter and sets this to zero.

The voltage to be measured is now integrated until the counter has obtained its maximum count and passes a pulse to the transfer output. This pulse triggers a flip-flop which brings the analog switch into position »b«. At this time, the counter contents are again zero, since the count is completed.

The reference signal is now integrated, and a falling slope of the sawtooth voltage appears at the output of the integrator. The falltime speed is dependent on the value of the reference signal. As soon as 0 V is obtained, the output voltage of the comparator will jump to minus. This pulse slope is differentiated by C_S/R_S and fed to the storage flip-flop. At this time, the indicator storage will take over the contents of the count and the measuring result will be available at the digital output until the next measurement is completed.

The falling slope of the comparator output voltage also resets the control flip-flop of the analog switch so that this returns to position »a« and the new measuring cycle can commence. **Figure 2** shows the operation of the A/D converter together with typical voltage slopes.

The advantages of the dual-slope method can easily be seen:

The time constant of the integrator, the zero-error of the comparator as well as the frequency of the clock do not have any affect on the measuring result as long as they remain constant within the measuring cycle. This means that only a short-time stability is required. Actually, it is the ratio between the measuring value and the reference signal that is measured.

The signal integration time is exactly defined and is independent of the measuring value. If the time is selected to be an even harmonic of an interference AC voltage (e.g. AC hum), this will allow the interference to be completely suppressed.

The quality of the A/D converter is completely determined by the stability of the reference voltage source, and from the balance of the analog switch.

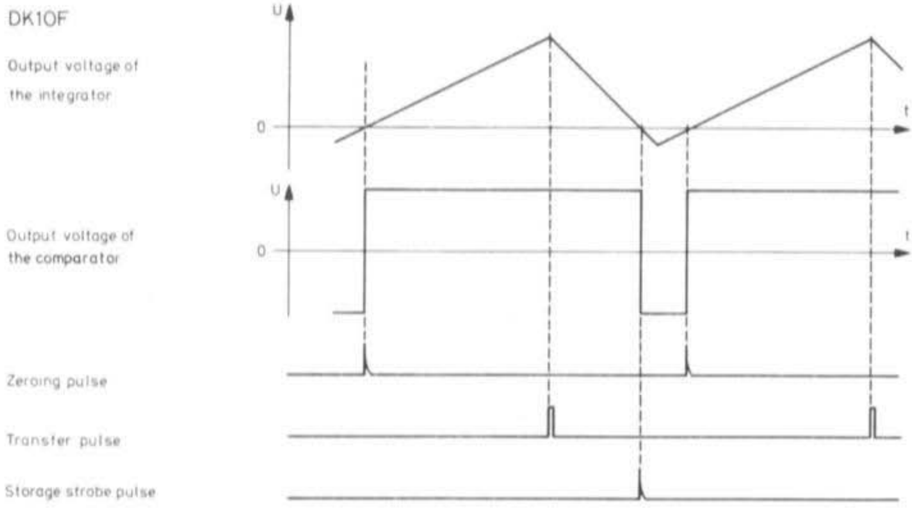

Fig. 2: Pulse diagram of the A/D converter

2.2 Circuit Diagram of the A/D Converter

The circuit diagram of the A/D converter is given in **Figure 3**. The DC-voltage to be measured is fed from the input (connection 3) via resistor R 1 to the analog switch. This switch comprises both systems of a double FET (T 251). The exact matching of these two transistors provides a good balance of the switch. The reference voltage is stabilized by the temperature-compensated reference diode D 252, is amplified to exactly 10 V in amplifier I 252 and fed via R 3 to the other input of the analog switch. The integrator (I 251) and the comparator (I 253) are also built up using integrated operational amplifiers. The two, antiphase diodes at the input of the comparator ensure that it cannot be overloaded. This also reduces the switching times.

The output of the comparator controls the control flip-flop of the analog switch via transistor T 252 and an inverter (I 257). This flip-flop is formed from two NOR-gates. Transistors T 258 and T 259 ensure that the output voltage of the gate (TTL-level approx. 4 V) is amplified to 20 V, so that the FETs of the analog switch are securely blocked. The decoupling diodes ensure that no current can flow via the appropriate control transistor when the FET is open.

The differential links R_O/C_O, or R_S/C_S form steep pulses (duration approx. 2 µs) from the squarewave output signal of the comparator. These pulses are fed via T 254 to the reset inputs of the counter, or via T 253 to the clock inputs of the storage flip-flops.

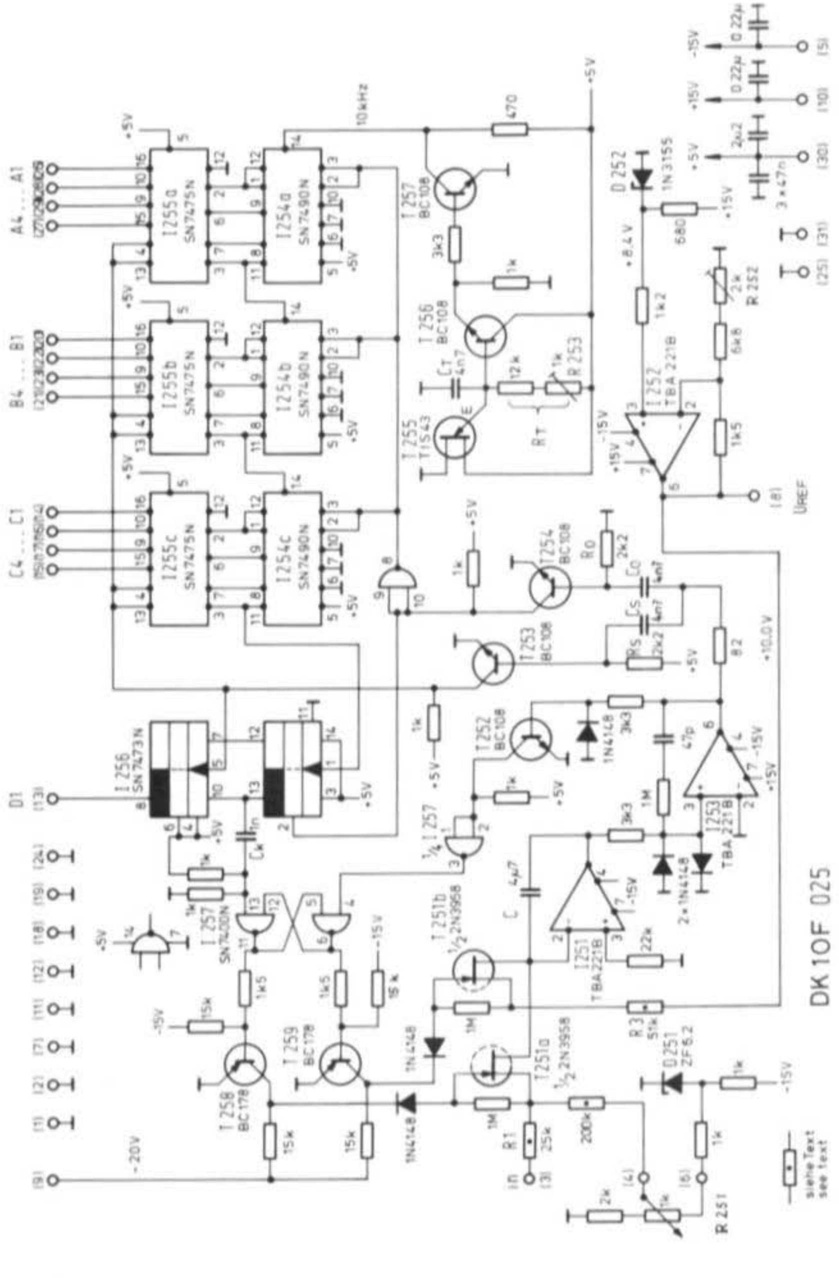

Fig. 3: Circuit diagram of the A/D converter

The clock generator is equipped with a unijunction transistor (T 255). C_T and R_T are the frequency dependent components. C_T is charged via R_T expotentially. When the actuating voltage of T 255 is reached, the capacitor is rapidly discharged. The sawtooth voltage obtained in this manner is taken via the emitter follower T 256 and limited to a squarewave voltage in T 257. It is then used to control a three-stage decade counter comprising the integrated circuits I 254 a, b and c. The fourth position is provided in a simple flip-flop (shown as the lower half of I 256 in the circuit diagram), so that a maximum count of 1999 is provided.

The indicator storage (I 255 a, b, c and the upper half of I 256) ensures that the measuring result is stored until the next measuring cycle has been completed, and a new result is provided. This information is fed via the outputs A_1 to D_1 to the decoder and indicator module.

Potentiometer R 251 is provided for zero adjustment. As can be seen in Figure 2, the output voltage of the integrator will be in the negative range for a short period. The cause of this is the inavoidable switching times of the comparator and the analog switch. If the input voltage of the A/D converter was zero, the positive range could never be obtained due to the finite integration time. This can be avoided by providing the measuring inputs with a bias voltage via R 2 which ensures that the measuring cycle is made correctly even when the measuring voltage is zero. This means that a finite voltage can be integrated. However, it is not the number 0000 that appears at the digital output, but a higher value. The described circuit has been designed so that a readout 0100 is indicated at a measuring voltage of 0 V. This »error« can easily be corrected in the indicator module. The zener diode D 251 provides the required stability of the zero voltage. If possible, stable-temperature resistors (metal layer) should be used for R 1, R 2 and R 3.

2.3. Construction

The PC-board DK 1 OF 025 has been designed for accommodation of the A/D converter. It is of the shortened, european standard size of 120 mm x 100 mm. This board is double-coated and possesses through-contacts. The connections can either be directly soldered to the board or be in the form of a 31-pin connector. Sockets should be provided for all ICs, since this simplifies faultfinding considerably. The component locations are given in **Figure 4**, and **Figure 5** shows a photograph of the author's prototype (the capacitance values 2.2 µF and 0.22 µF on the righthand side are not correct, and electrolytic capacitors were provided instead of plastic-foil types).

2.4. Components

I 251, I 252, I 253:	LM 741 CM (NS) or TBA 221 B (Siemens)
I 254 a, I 254 b, I 254 c:	SN 7490 N (TI) or FLJ 161 (Siemens)
I 255 a, I 255 b, I 255 c:	SN 7475 N (TI) or FLJ 151 (Siemens)
I 256:	SN 7473 N (TI) or FLJ 121 (Siemens)
I 257:	SN 7400 N (TI) or FLH 101 (Siemens)
T 251:	dual N channel FET 2 N 3958 (Siliconix)
T 252, T 253, T 254, T 256, T 257:	BC 108 or similar, NPN-Si-transistor
D 251:	ZF 6.2 or other 6.2 V zener diode
D 252:	1 N 3155 temperature compensated 8.4 V zener diode (Motorola)

R 1: 25 kΩ; R 2: 200 kΩ; R 3: 51 kΩ metal-layer resistors 1%
R 252: 2 kΩ; R 253: 1 kΩ, trimmer potentiometer, spacing 10/17.5

C: plastic-foil capacitor 4.7 µF / 25 V (e.g. Siemens B 32110-D 3475-M 000)
C_T: styroflex capacitor 4.7 nF
C_o, C_s, C_k: ceramic disc types 4.7 nF
Connectors: 31 pin Siemens C 42334-A55-A8 and Siemens C 71334-A10-A2

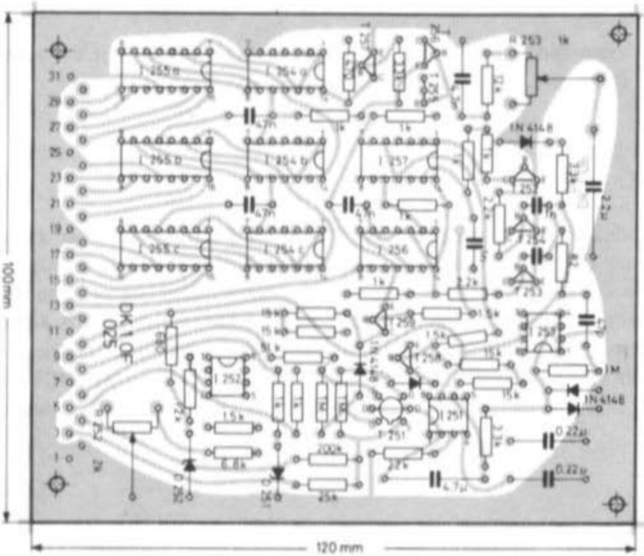

Fig. 4: Component locations on PC-board DK 1 OF 025

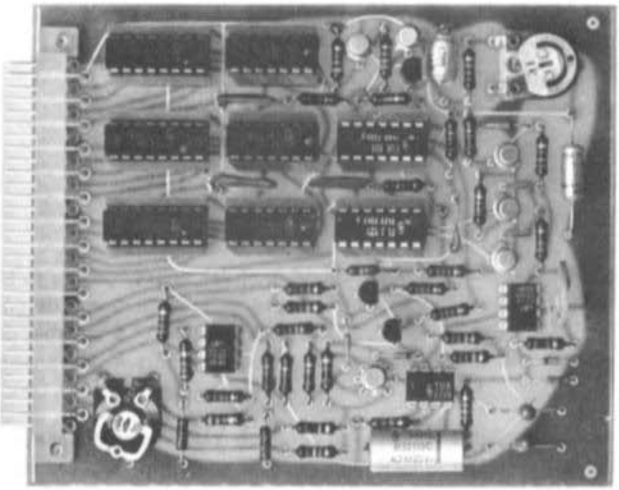

Fig. 5: Photograph of the A/D converter

3. DECODER AND INDICATOR MODULE

The circuit diagram of this module is given in **Figure 6**. The digital output of the A/D converter (A_1 to C_4) is connected to the appropriate inputs of the BCD/decimal decoders I 261, I 262, and I 263. The indicator tubes V 1 and V 2 (unit and tenth digits) are connected to the appropriate decoder outputs, whereas the sequence at V 3 is shifted by one digit. This ensures that V 3 indicates one digit lower than the input value (C_1 to C_4). This is the previously mentioned correction of the bias voltage at the signal input.

The gate circuit comprising I 264 and I 265 ensures that digit »1« of V 4 switches on when C = 0 and D_1 = L (low) or C ≠ 0 and D_1 = H (high) is valid.

3.1. Construction

The indicator module is accommodated on PC-board DK 1 OF 026. The dimensions of this board are 100 mm x 65 mm; it is also double-coated and possesses through-contacts. This board can also be used together with a 31-pin connector. LEDs are provided for the decimal points, however, it is possible for the decimal points of the readout tubes also to be used. In this case, the corresponding connection pins of the tubes should be connected with the aid of wire bridges to the inputs DP_1 (21), DP_2 (14) and DP_3 (10) on the PC-board. The component locations are given in **Figure 7**, and **Figure 8** shows a photograph of the author's prototype.

3.2. Components

V 1 to V 4:	indicator tubes ZM 1330 (Siemens)
I 261, I 262, I 263:	SN 74141 N (TI) or FLL 101 (Siemens)
I 264:	SN 7425 N (TI) or FLH 521 (Siemens)
I 265:	SN 7400 N (TI) or FLH 101 (Siemens)
T 261:	BF 258 (ITT), BF 110 or similar video transistor (breakdown voltage min. 200 V)

4. CONNECTION AND ALIGNMENT

After interconnecting the two previously described modules, (data lines A_1 to D_1, ground and + 5 V), it is possible to connect the supply voltages. A total of five different voltages are required: + 15 V, - 15 V, + 5 V, - 20 V, + 200 V. The description of a suitable power supply is to be given together with the description of the input amplifiers in the second part of this article.

A voltmeter of the highest possible accuracy is connected between connection 8 and ground. This voltage is adjusted to exactly + 10 V with the aid of resistor R 252. If possible, another, calibrated digital voltmeter or a compensation measuring bridge should be used for this alignment.

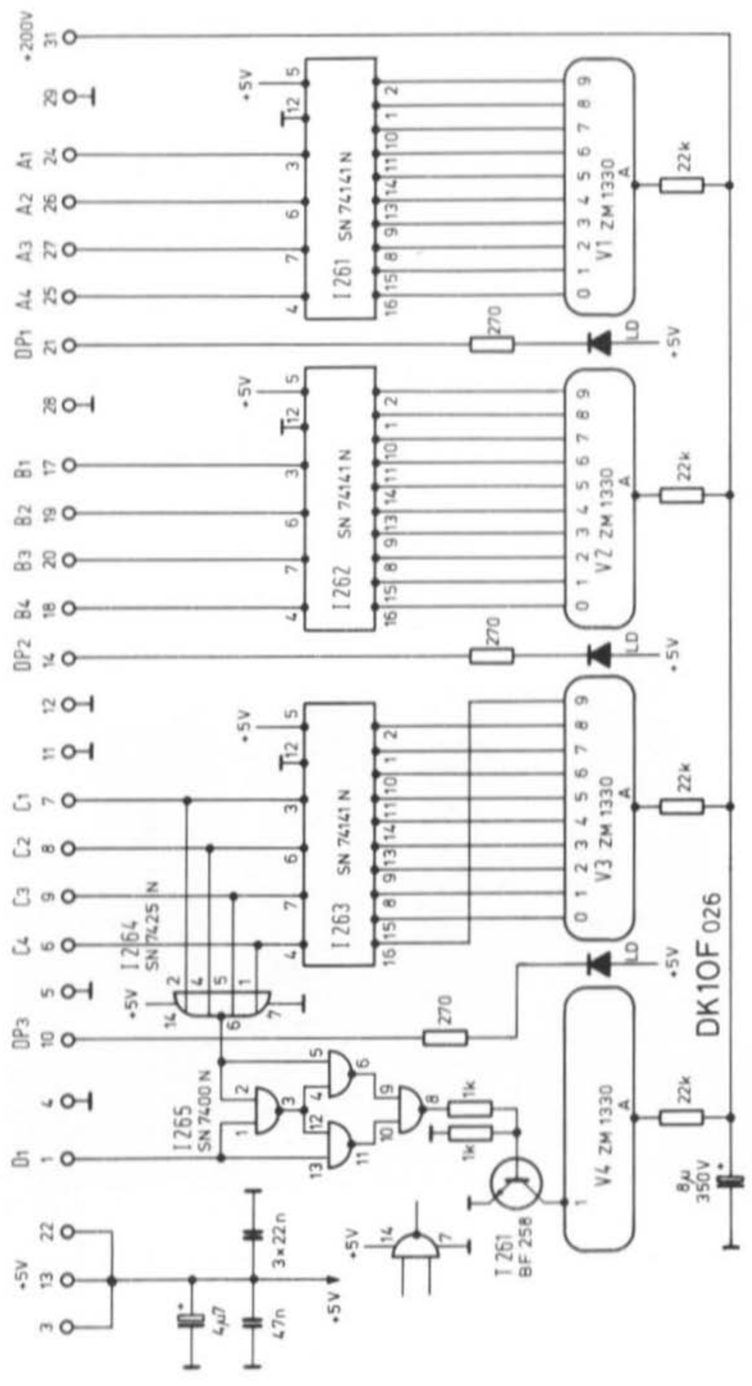

Fig. 6: Circuit diagram of the decoder and indicator module

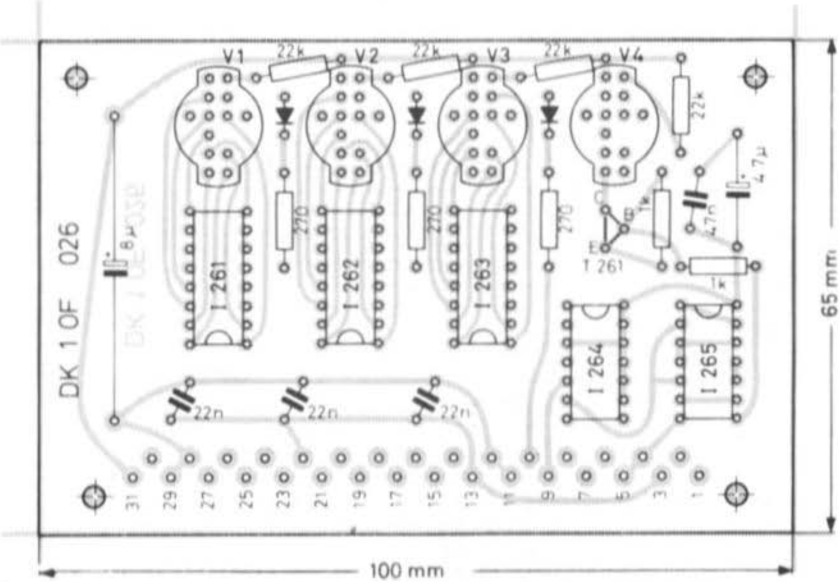

Fig. 7: Component locations on PC-board DK 1 OF 026 (decoder and indicator module)

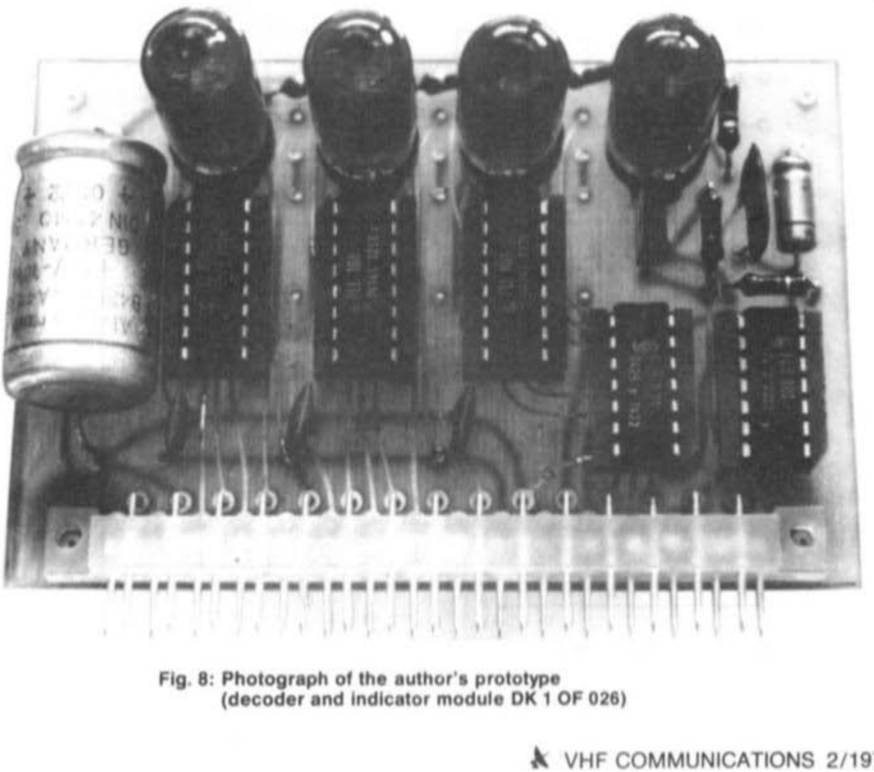

Fig. 8: Photograph of the author's prototype (decoder and indicator module DK 1 OF 026)

If a frequency counter is available, the inputs should be connected to the collector of T 257 and the clock frequency adjusted to exactly 10 kHz with the aid of R 253.

The digital readout should be brought to 000 with the aid of the external potentiometer R 251. A variable negative voltage of 0 to - 10 V should now be connected to the input (pin 3). The maximum readout of 1999 should be obtained at an input voltage of - 9.975 V.

Faultfinding on a dual-slope A/D converter is not very simple due to the multiple interaction between the analog and the digital portions. Of course, it is possible for the individual stages to be checked if suitable measuring equipment is available.

5. REFERENCES TO PART 1

(1) K. Wilk: A simple Digital Voltmeter
VHF COMMUNICATIONS 6, Edition 1/1974, pages 18 - 29)

MATERIAL PRICE LIST OF EQUIPMENT
described in Edition 2/1976 of VHF COMMUNICATIONS

DC 8 NR 006	**LINEAR TRANSMIT CONVERTER** **A. LOCAL OSCILLATOR CHAIN (1152 MHz)**		**Ed. 2/1976**
PC-board	DC 8 NR 006	(double-coated, no thru-contacts, with printed plan)	DM 20,—
Semiconductors	DC 8 NR 006	(6 transistors, 3 diodes)	DM 46,50
Minikit A	DC 8 NR 006	(3 coilformers with core, 11 trimmers, 6 feedthrough capacitors)	DM 32,—
Crystal	96.0000 MHz	HC-25/U	DM 34,—
Kit A	**DC 8 NR 006**	**with above parts ....**	**DM 128,—**
	B. TRANSMIT MIXER AND LINEAR AMPLIFIER		**Ed. 2/1976**
Tubes	DC 8 NR 006	(4 pieces 8255, 4 pieces tube bases)	DM 140,—
Minikit B	DC 8 NR 006	(10 trimmers, 12 feedthru-capacitors)	DM 28,—
Kit B	**DC 8 NR 006**	**with above parts ....**	**DM 165,—**
DJ 5 XA 004	**24 cm RECEIVE CONVERTER**		**Ed. 2/1976**
PC-board	DJ 5 XA 004	(double-coated, no thru-contacts)	DM 26,—
Semiconductors	DJ 5 XA 004	(6 transistors, 2 Schottky and 1 zener diode)	DM 48,—
Minikit	DJ 5 XA 004	(1 coilformer, 2 coilsets, 2 ferrite beads, 1 choke, 4 trimmer capacitors, 1 spindle trimmer, 2 chip caps., 1 trimmer pot.)	DM 17,—
Crystal	HC-25/U	either 70.4444 MHz or 66.90278 MHz	DM 26,—
Kit	**DJ 5 XA 004**	**with above parts ....**	**DM 115,—**
DC 3 NT 001/002	**FM TRANSCEIVER**		**Ed.1+2/76**
PC-board	DC 3 NT 001	(with printed plan)	DM 15,—
PC-board	DC 3 NT 002	(double coated)	DM 24,—
Semiconductors	DC 3 NT 01/02	(24 transistors, 9 diodes, 4 ICs)	DM 114,—
Minikit	DC 3 NT 01/02	(3 relays, 23 coilformers, 19 foil trimmers, 1 spindle trimmer, 10 styroflex capacitors	DM 74,—
Ceramic filters		SFE 10.7 MA and CFM 455 E	DM 40,—
Crystals	HC/25-U	(5 crystals see mag.)	DM 120,—
Kit	**DC 3 NT 01/02**	**with above parts ....**	**DM 380,—**

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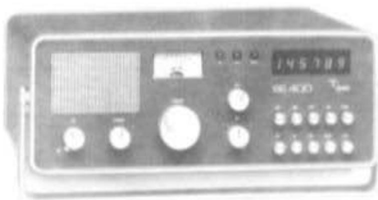
HIGH-PERFORMANCE VHF EQUIPMENT

Braun



2 m SSB/FM-Transceiver SE 400 digital

Astounding that such a high-quality Braun product is available at such a low price.

There is no competition with respect to the sensitivity, cross modulation rejection and selectivity of the Braun SE 400 digital. The required mode: CW, USB, LSB, FM or FM-repeater is selected at the push of a button. Continuous tuning from 144 MHz to 146 MHz. Digital frequency readout. Automatic frequency shift of 600 kHz in the FM-repeater mode. Automatic sideband reversal can be selected for satellite communications (OSCAR 7).

Fully solid state with silicon transistor complement. Output power 10 W. 12 V operating voltage, and built-in AC power supply.

Built-in loudspeaker, S meter, Wattmeter, receiver fine tuning (RIT), squelch, and calling tone.

2 m (70 cm) SSB/FM/AM-Receiver RX 420 digital

This receiver has been designed especially to provide an extremely high selectivity and large-signal handling capabilities. However, the high sensitivity has also been maintained. These characteristics make the RX 420 the ideal receiver for difficult applications, such as during contests, with satellite communications, as well as in the vicinity of high-power stations.
Operating modes: CW, USB, LSB, FM and AM. Continuous tuning from 144 to 146 MHz. Digital frequency readout. Receiver can be extended to 70 cm by provision of an optional 430 - 440 MHz switchable converter. The frequency readout can also be exchanged. An effective optional noise blanker can also be provided. Fully solid-state, 12 V operating voltage, switchable active audio filter, built-in speaker, squelch S meter and 220 VAC power supply.

2 m / 70 cm Linear Transverter LT 470

For linear conversion of a 2 m signal to the 70 cm band (430 - 440 MHz). Suitable for SSB, FM, AM, CW and RTTY.

The 70 cm band is split into segments of 2 MHz which are converted using any 2 m station. In the case of repeater operation, the frequency spacing between transmitter and receiver frequency is changed at the press of a button to the European standard. The 2 m transceiver remains transceive at the receive frequency. The sensitivity is excellent due to the use of a low-noise 4.5 GHz transistor in the input stage. A number of coaxial relays allow crossband operation 2 m / 70 cm or 70 cm / 2 m. Output power 10 W. Built-in output power meter and power supply. Built-in attenuator allows the transverter to be used with input power levels of 1 to 30 W PEP.

Write for full technical details

Karl Braun — **D-85 Nürnberg**

Communications Equipment — Deichslerstr.13 · W.Germany