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A Publication for the Radio-Amateur

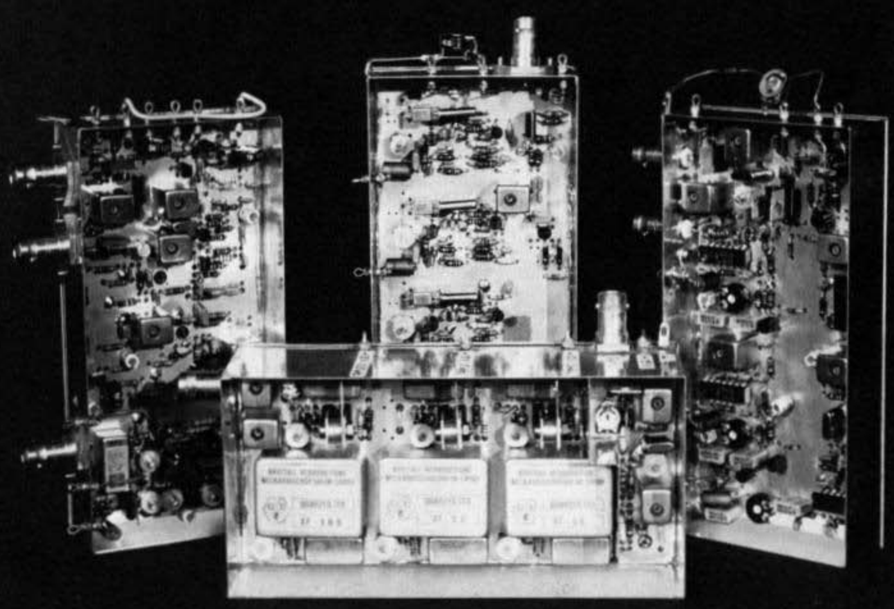
Especially Covering VHF, UHF and Microwaves

VHF communications

Volume No. 15 · Summer · 2/1983 · DM 6.50

For demanding radio amateurs:

The IF-system by DJ 3 RV



VHF communications

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Volume No. 15 · Summer · Edition 2/1983

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In the Focus

OSCAR 10 is in orbit!

We are sure that all VHF/UHF amateurs would like to congratulate AMSAT – namely Dr. Meinzer, DJ 4 ZC, and his team – on the successful launch of their latest radio amateur communications satellite!

According to Rolf, DK 2 ZF, the present status is that OSCAR 10 has reached an apogee of approx. 35,000 km and a perigee of roughly 3,900 km after the first firing of the kick motor. The perigee is to be lowered to around 2,000 km in a second attempt at the end of July, to be followed by switching the two transponders to the operational mode in mid August.

The transponders have already been tested by the staff of AMSAT-DL, prooving that RHC polarisation is essential for both, receive and transmit antennas.

It seems that a new and wide door has been opened to VHF/UHF DXing – so hear u later on OSCAR 10!

73 es 55 de

DL 3 WR

UKW berichte Terry D. Bittan · Jahnstr. 14 · Postfach 80 · D-8523 Baiersdorf
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Martin Dohlus

A Home-Made Automatic Noise-Figure Measuring System Final, Second Part

The first part of this article in VHF COMMUNICATIONS 1/1983 described the measuring principle, the noise-generator, and the first few modules. This part of the article is to describe the other modules of the noise-figure measuring system, as well as describing the overall circuit and final alignment.

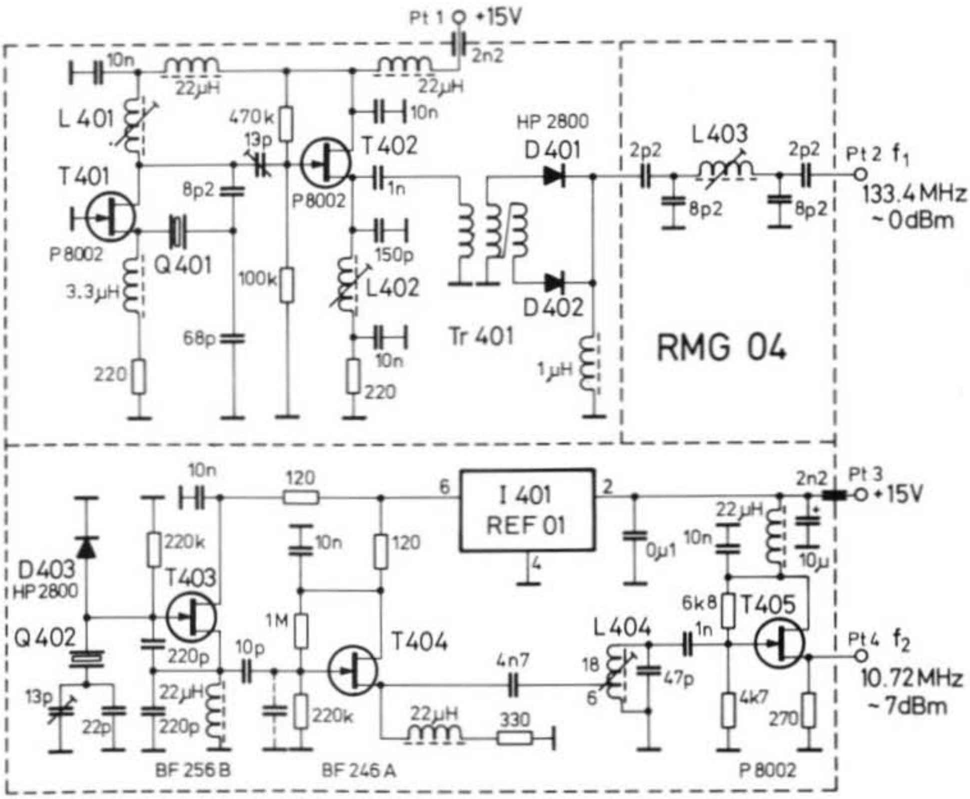

Fig. 13: Circuit diagram of the double-oscillator module RMG 04

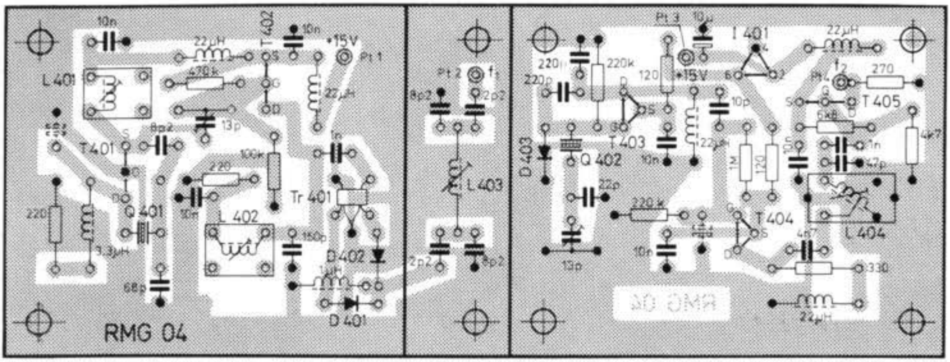

Fig. 14: Component locations on board RMG 04. A small chamber for the 133.4 MHz filter is to be seen in the center.

6.1. Oscillator Module

The circuit diagram of the two oscillators that were already mentioned in Part 1, are given in **Figure 13**. PC-board RMG 04 was developed to ease construction. The dimensions are 135 mm x 50 mm, and the board is therefore suitable for fitting in a standard metal case. The PC-board should be completed according to the component location plan given in **Figure 14** and provided with screening panels.

6.1.1. Component Details, RMG 04

T 401, T 402, T 405:	P 8002 (TI)
T 403:	BF 256 B (TI)
T 404:	BF 246 A (TI)
D 401 – D 403:	HP 2800 or similar Schottky diode

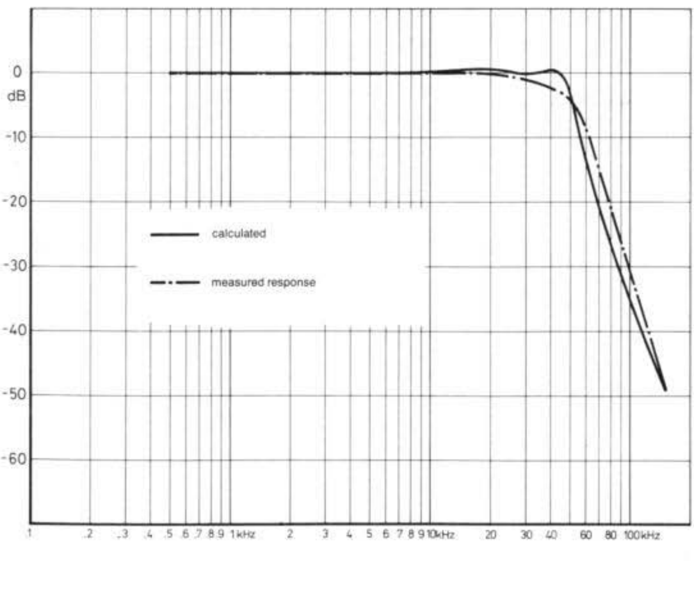

Fig. 16: Frequency response of the AF-lowpass filter

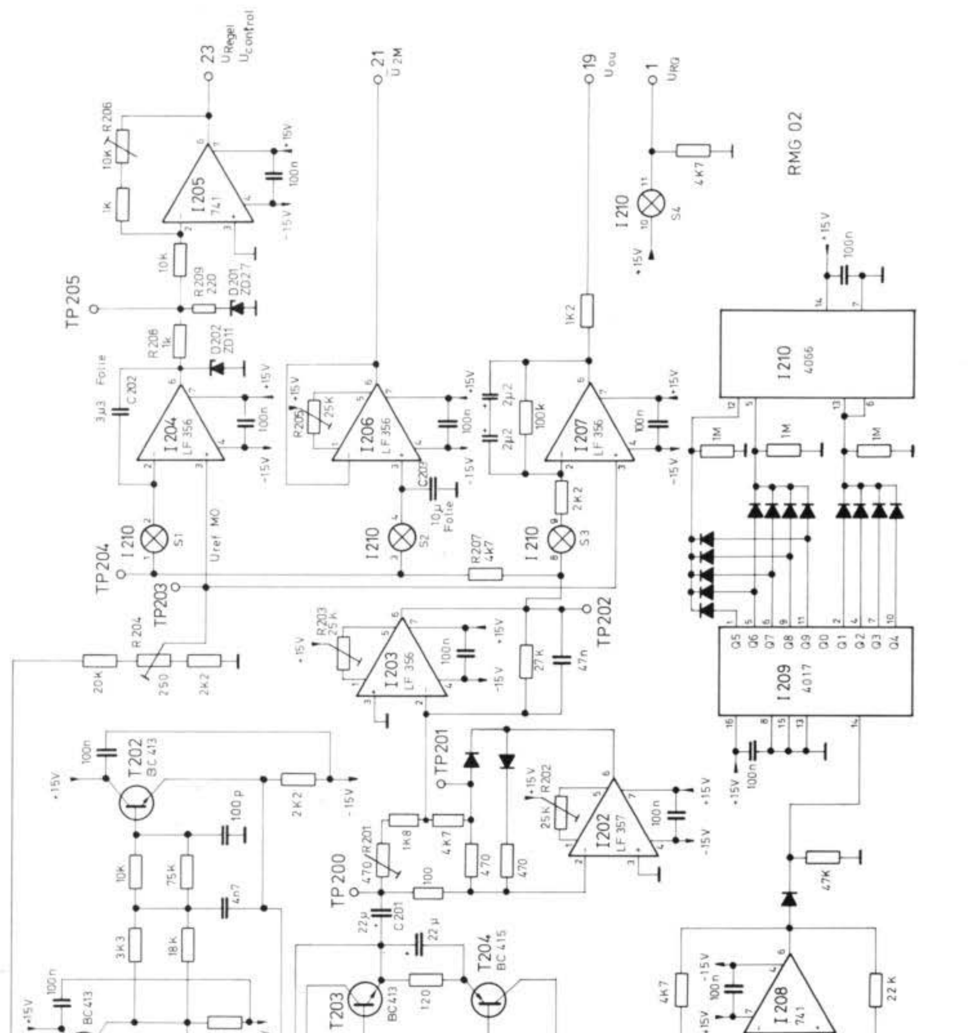

Fig. 15: Circuit diagram of the control module RMG 02

I401: REF-01 low-noise 10 V stabilizer

L401: 7 turns of 0.3 mm dia. enamelled copper wire, wound in a single layer in coil former D41-2165; do not use screening can!

L402: 2 turns, otherwise as L401

L403: 5 turns of 0.8 mm dia. silver-plated copper wire, wound on a 7 mm former, self-supporting, mounted vertically to the board. A 5 mm coil former with VHF-core is provided in the coil

L404: 24 turns of 0.3 mm dia. enamelled copper wire with coil tap 6 turns from the cold end, using coil set D41-2165

Tr401: Double-hole ferrite core (Siemens B62152-A8-X17) wound with 0.12 mm dia. enamelled copper wire: 4 turns at first, then 2 x 4 turns wound in a bifilar manner on top.

7 miniature chokes, spacing 10 mm
2 plastic foil trimmers 13 pF (Philips: yellow)
15 ceramic disk capacitors between 2.2 pF and 4.7 nF, spacing 2.5 mm
7 ceramic flat capacitors between 10 nF and 100 nF, spacing 5 mm
2 ceramic feedthrough capacitors
2.2 nF (value not critical), for solder mounting
1 tantalum electrolytic, 10 µF/25 V
13 composite carbon resistors, spacing 10 mm
1 crystal 66.700 MHz in HC-43/U holder
1 crystal 10.720 MHz in HC-43/U holder
1 metal case 135 x 50 x 30 mm

The PC-board is designed so that the two oscillators can be built up and operated separately.

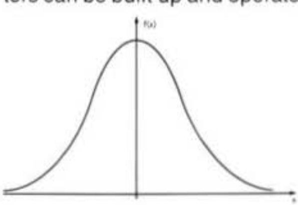

Fig. 17: Gaußian distribution of the momentary voltage of noise

7. CONTROL MODULE

7.1. Circuit Description

The control module whose circuit diagram is given in **Figure 15** has been designated RMG 02.
It represents the heart of the system.

The noise voltage U_N from module RMG03 possesses an upper limit frequency of 35 kHz in the described concept. The main selectivity is provided by the 10.7 MHz crystal filter. If one wishes to measure at 10.7 MHz (additional measuring input), and must do without the converter and crystal filter for this reason, it will be necessary for the main selectivity to be made in the AF-range. However, this will only be possible when no carriers are in the vicinity of the intermediate frequency, and when the IF-selectivity previous to the RMG03-module is sufficiently good. In this case, one will obtain two different noise spectra converted into the AF-range. The RF-bandwidth is then twice as large as the AF-bandwidth. For this reason, the AF-bandwidth is limited in a defined manner using a lowpass comprising transistors T201 and T202. This is a fourth-order filter which is designed for an upper limit frequency of 50 kHz. **Figure 16** gives the calculated and measured characteristics.

The distribution density of the momentary voltage of thermal noise corresponds to a Gaussian or normal distribution curve, as can be seen in **Figure 17**. Since this will disappear in the case of no voltage, this will mean that many high momentary voltages can appear, which must be processed by the measuring chain. Of course, real amplifiers, converters, etc. have only finite large-signal capabilities and will falsify the characteristic noise parameters. Since the effect of limiting is of extreme importance during noise-power measurements, an error curve has been given in **Figure 18**.

The rectifier must operate linearly in the whole frequency range (f_{max} = 50 kHz) and in a wide voltage range, in order to ensure that the correct noise figure can be determined.

As non-linear element, it is especially critical in

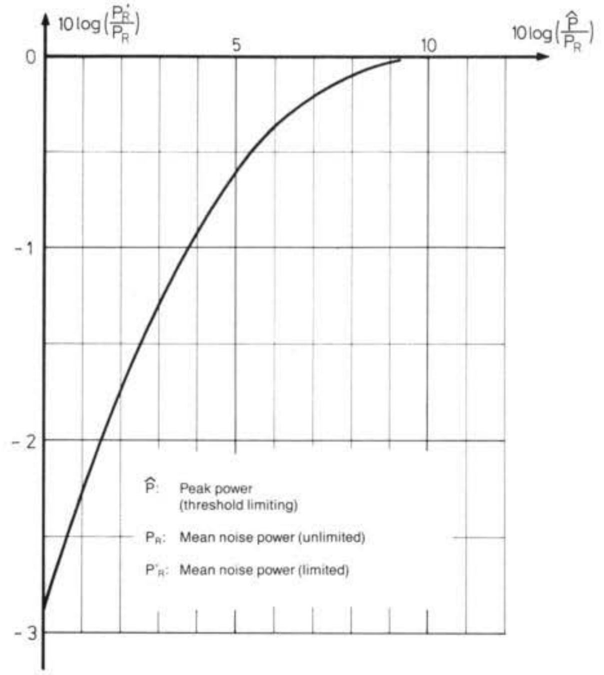

Fig. 18: The diagram shows the effect of limiting when measuring noise power

the case of voltage peaks. A circuit has been realized with I201, I202, I203, and the impedance converter T203, and T204 which corresponds to that given in (1). The fast operational amplifier LF357 with its FET-inputs provides useful characteristics here. Amplifier I203 has been provided with low-pass characteristics in order to smooth the voltage peaks before further processing. For this reason, it is possible to use the slower, but more stable type LF356 here and in the rest of the circuit.

The clock generator I208 provides the C-MOS decimal divider I209 with a 100 Hz clock pulse. The control signals for the C-MOS switches are generated via a diode network in I210. A measuring cycle has a duration of approximately 100 ms. According to Part 1, Figure 3, the measuring process is made as follows:

The C-MOS switch S_4 opens during t_1, and the noise source will output a passive P_1. Approximately 10 ms afterwards, switches S_1 and S_3 will also close. The control is now active: In other words it generates a voltage, which drives the amplifier (inverted in I205) so that $\overline{U}_{1M}$ is equal to 1 V. A difficulty exists here due to the statistic variations of the noise voltage, which means that the nominal value will never be exactly maintained. This will be seen as fluctuations of the reading. For this reason, an optimum must be found in the design of the control circuit: It should be fast in order to be able to compensate for gain variations, e. g. during alignment processes, and should be slow in order to average the noise. This is not difficult at constant, low-signal parameters of the control circuit. A simple calculation shows that the relationship between gain and control voltage must be expotential in order to obtain a low-signal behaviour independent of the operating point. In the case of module RMG 03, the relationship is different – see Part 1, Figure 12. Due to another nonlinearity (R208, R209, and D201 between control and amplifier-control voltage input), it is possible for the overall characteristic to be at least approximately brought into the required form.

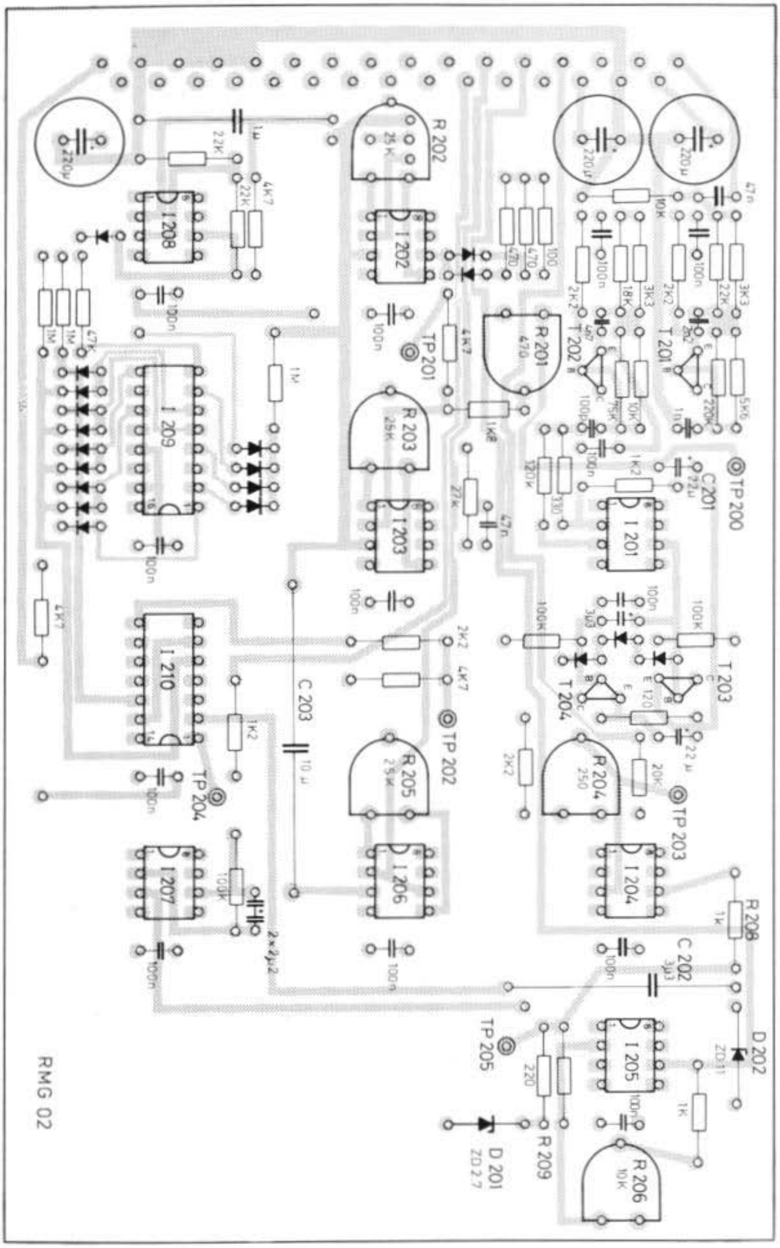

Fig. 19: Component location plan on the control board RMG 02

If the required gain cannot be obtained, the control voltage is limited by D202. The remaining deviation is registered in I207, and the error of the measuring result is indicated on the front panel using an LED. If the input level is too great, U_{out} will be in the order of −15 V, and will be approximately +15 V if the level is too low.

After period t_3, switch S_4 will close, which in turn opens S_1 and S_3: The noise generator is now active, and the control voltage remains constant. After a further 10 ms, S_2 will close: I 6 will operate as "mean value generator". Similar considerations as were made in the case of the control circuit are also valid for determining the time constant of the mean-value generator. After completing the measuring cycle, all switches are reopened. I207 will now operate as a scanning − hold link; $\overline{U}_{2M}$ remains stored until the next mean-value is formed (t_4).

7.2. Construction

The double-coated PC-board RMG 02 has been designed for accommodating this circuit. The dimensions are that of a Euro-board and it can be provided with a 31-pin connector. The module should be completed according to the component location plan given in **Figure 19**. It is only capacitor C201 that is only mounted during the alignment process.

7.2.1. Component Details for RMG 02

T201 − T203:	BC413 or other silicon NPN AF-transistor
T204:	BC415 or other silicon PNP AF-transistor
D201:	2.7 V zener diode
D202:	11 V zener diode
19 diodes:	1 N 4151 or other silicon switching diodes
I 1, I 2:	LF357 N very fast operational amp. with FET inputs (Siemens etc.)
I 3, I 4, I 6, I 7:	LF356 N fast operational amp. with FET inputs (Siemens etc.)
I 5, I 8:	741, TBA221 B operational amp. (Siemens, Fairchild, NS)
I 9:	4017 decade counter/divider (C-MOS)
I 10:	4066 quadruple switch (C-MOS)
C201:	22 μF/25 V tantalum electrolytic (drop-type)
C202:	3.3 μF/25 V or 63 V plastic foil capacitor (spacing 25 mm)
C203:	10 μF/25 V or 63 V plastic foil capacitor (spacing 40 mm)
C204:	1 μF/25 V or 63 V plastic foil capacitor (spacing 25 mm)

4 pcs. ceramic capacitors between 100 pF and 4.7 nF; spacing 2.5 mm

15 pcs. ceramic flat capacitors 47 nF and 100 nF; spacing 5 mm

5 pcs. tantalum electrolytics (spacing 2.5 mm)

3 pcs. aluminium electrolytics, round; spacing 5 mm

6 pcs. trimmer potentiometers, horizontal mounting, spacing 10/5 mm

40 pcs. composite carbon resistors, spacing 10 mm

1 31-pin connector (DIN 41617 Siemens etc.)

Figure 20 shows the author's prototype which did not use a PC-board with through-contacts.

7.3. Connection and Alignment

On connecting the operating voltage, the circuit takes approximately 53 mA of the positive voltage, and 56 mA of the negative voltage. The 100 Hz squarewave signal at I208/6, and the control voltages for the C-MOS switches can be checked with the aid of an oscilloscope. If everything is operating correctly, the signals given in **Figure 21** should be present at I210.

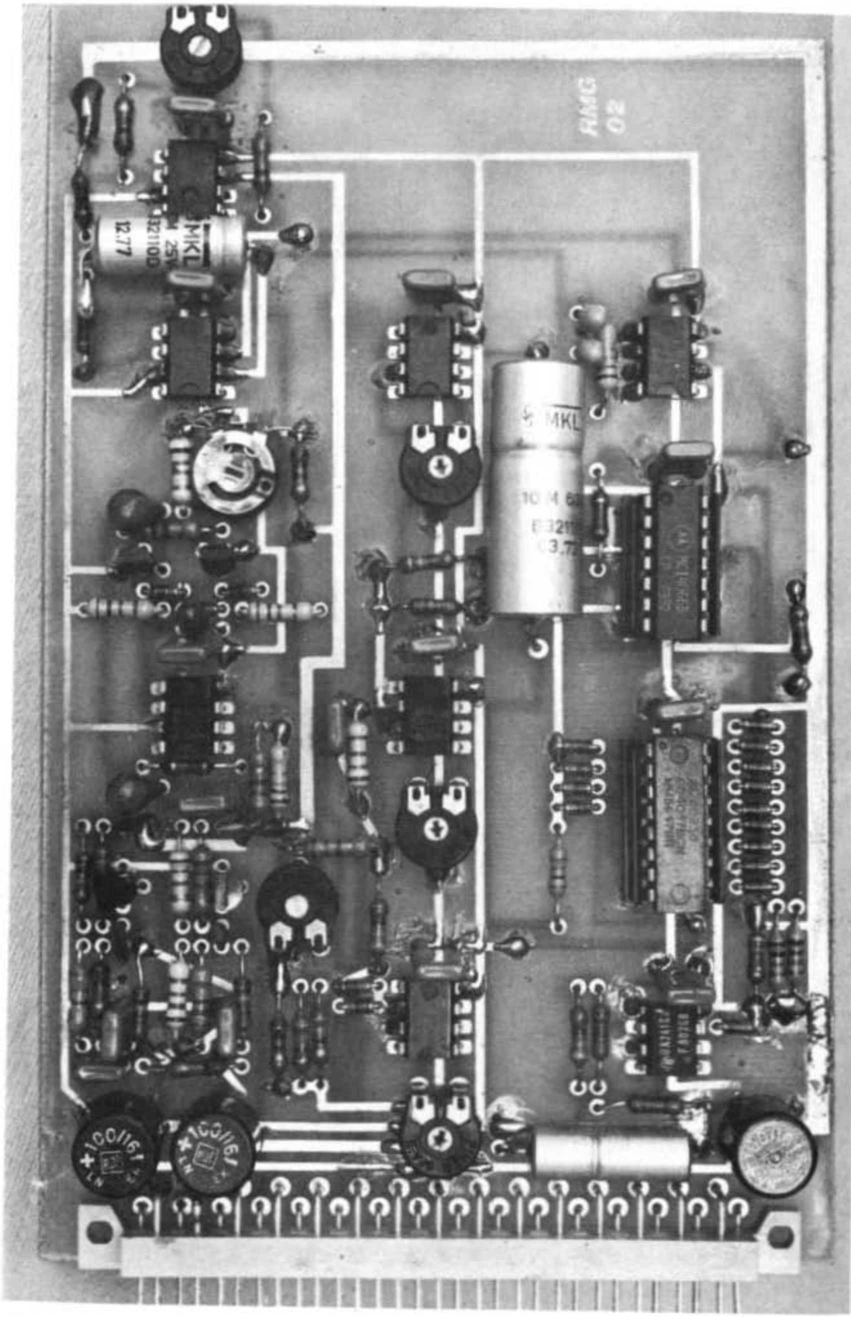

Fig. 20: The 3 large plastic foil capacitors will be seen on PC-board RMG 02

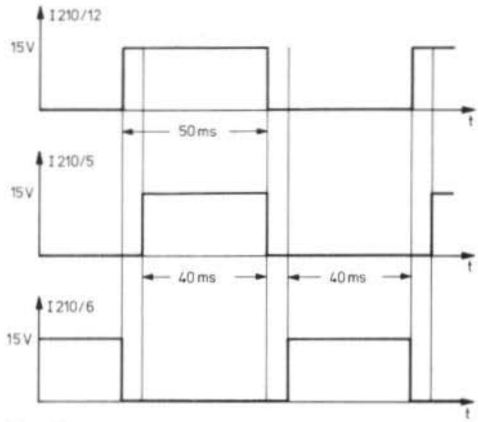

Fig. 21:
Control voltages for the C-MOS switches on RMG 02

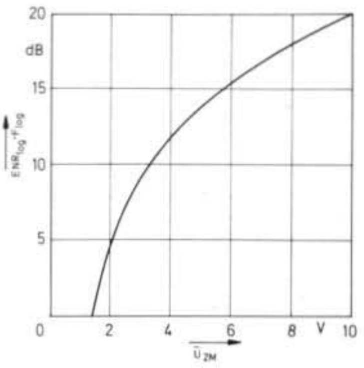

Fig. 22:
This characteristic of the readout-electronics allows F_{log} to be indicated on a linear meter scale

Firstly align the offset and then the balance at the rectifier. This is made by grounding TP 200, and aligning the operational amplifiers I 202 (test point TP 201) and I 203 (test point TP 202) to zero with the aid of R 202 and R 203. After this, connect a floating voltage source of approx. 0.7 V (battery and voltage divider) between TP 200 and ground. A voltage of approximately 10 V should be present at TP 202. While continuously changing the polarity of the voltage at TP 200, R 201 should be adjusted so that the output voltage remains independent of the sign of the input voltage.

The offset of I 206 is compensated with the aid of R 205 with C 203 bridged.

The frequency response of the 50 kHz filter can be checked after soldering C 201 into position by connecting an AF-generator to U_N and a voltmeter to TP 202.

Potentiometers R 204 and R 206 are not aligned until carrying out the final alignment process.

8. READOUT ELECTRONIC AND REFERENCE VOLTAGE CIRCUIT RMG 01

The relationship between F_{log}, ENR_{log}, and $\overline{U}_{2M}$ according to equation 5 (Part 1) is given in **Figure 22.**

This characteristic must be taken into consideration if $\overline{U}_{2M}$ is to be processed in an electronic circuit in such a way that F_{log} is to be indicated in a linear manner.

With the aid of a computer program it was possible to approximate the characteristic F_{log} – ENR_{log} in the range of −1 to −20 dB with the aid

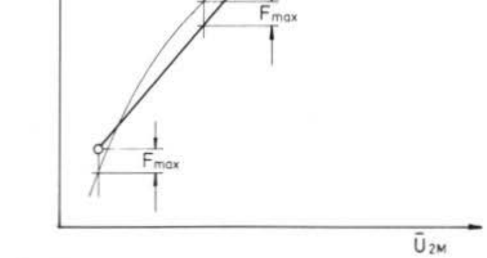

Fig. 23:
Principle of the straight-line approximation; showing 1 straight line between two positions

$\bar{U}_{2M}$/V	$(F_{log} - ENR_{log})$ / dB		$U_{F\,log}$/V
	exact	approx.	
1.500	− 0.97	− 1.03	− 0.514
1.790	− 3.43	− 3.49	− 1.746
2.230	− 5.99	− 6.05	− 3.024
2.890	− 8.66	− 8.72	− 4.362
3.860	− 11.43	− 11.49	− 5.745
5.250	− 14.24	− 14.30	− 7.151
7.220	− 17.09	− 17.15	− 8.573
9.990	− 19.95	− 20.01	− 10.004

Table 1:
Specifications of the bend points and voltage standardization of F_{log} − ENR_{log}

of seven straight-lines, so that the maximum error was less than 0.06 dB. The principle of the straight-line approximation is shown in **Figure 23. Table 1** provides the specifications of the individual points and the voltage standardization of F_{log} − ENR_{log} (0 to −20 dB corresponds to 0 to −10 V).

8.1. Circuit Description

The poligon characteristic is realized by superimposition of individual lines (see **Figure 24**). A partial circuit is given in **Figure 25** that generates the individual bent functions. Since 0 V (virtually ground) is present at the minus-input of the first operational amplifier, the following is valid for I_A, I_B, and I_C:

$$I_A = -\frac{U_{ref}}{R_2} \qquad I_B = \frac{\bar{U}_{2M}}{R_1}$$

$$I_C = I_A + I_B = \frac{\bar{U}_{2M}}{R_1} - \frac{U_{ref}}{R_2}$$

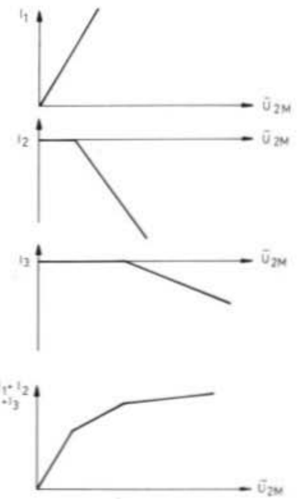

Fig. 24: Realization of a polygon characteristic as superimposition of individual lines

As long as $\bar{U}_{2M} < (R_1/R_2) \times U_{ref}$, I_C will be positive and D 1 will conduct, whilst D 2 will be blocked. Point P 1 is thus only connected via R_a and R_3 to the minus-inputs of the operational amplifiers.

$U_2 = 0$
$I_2 = 0$

As soon as $\bar{U}_{2M}$ exceeds the threshold value $(R_1/R_2) \times U_{ref}$, the sign of I_C will be inverted. The current will now flow via resistor R_a.

The following is valid:

$$U_2 = -I_C R_a = \frac{R_a}{R_2} U_{ref} - \frac{R_a}{R_1} U_{2M}$$

$$= \frac{R_1}{R_2} U_{ref} - U_{2M}$$

$$I_2 = \frac{U_2}{R_3} = \frac{1}{R_3}\frac{R_1}{R_2} U_{ref} - \frac{1}{R_3} U_{2M}$$

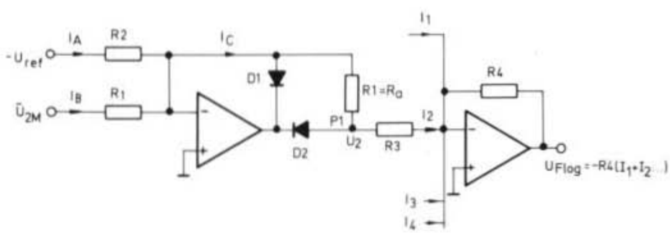

Fig. 25: Circuit for an individual bend function

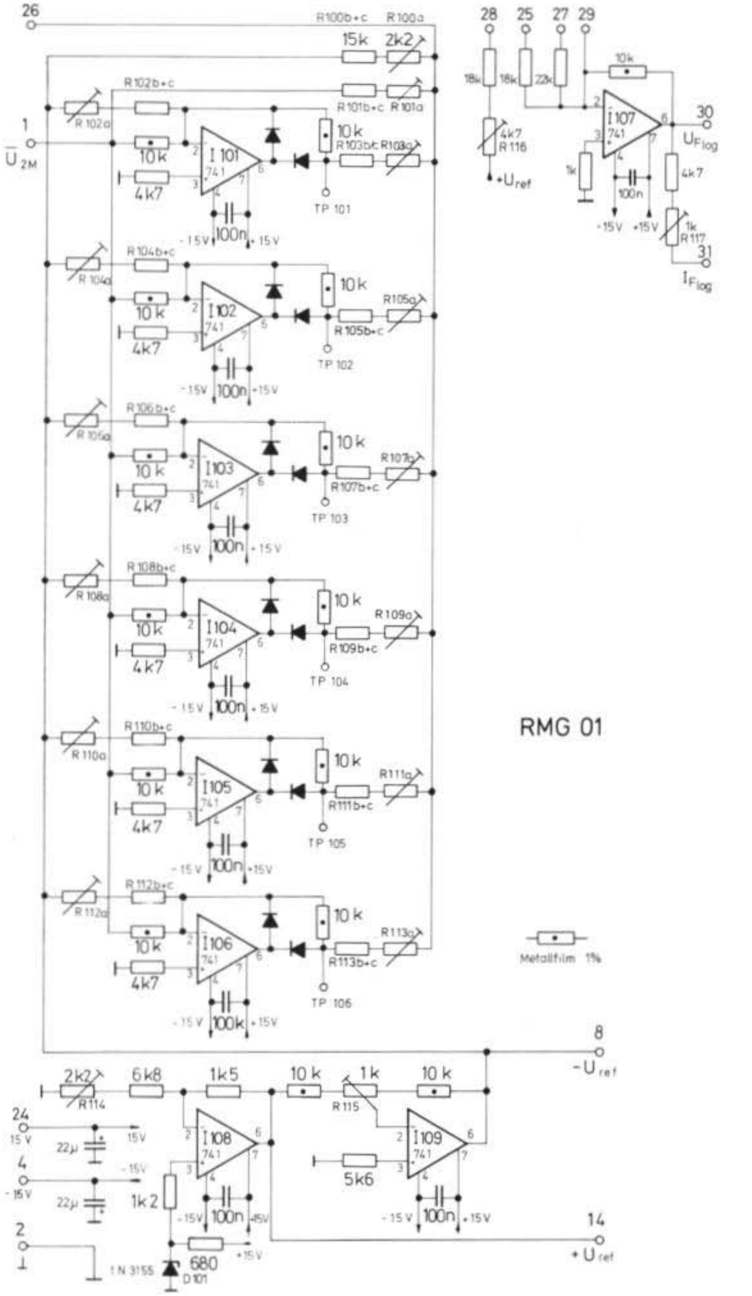

Fig 26: Circuit diagram of the readout electronics and reference voltage generator RMG 01

The second operational amplifier sums I_2, and I_1, I_3 . . . which are generated in a similar manner and forms

$$U_{F\,log} = -R_4 (I_1 + I_2 + I_3 + \ldots)$$

Poligon characteristics can, of course, also be realized in a less complicated manner than when using the given circuit, but are far more complicated with respect to the calculation and alignment. **Figure 26** shows the circuit diagram of the readout electronics and reference voltage generator. **Table 2** shows the calculated resistance values for the linearization.

R 100 = 17078 Ω	R 107 = 16641 Ω
R 101 = 2355 Ω	R 108 = 25907 Ω
R 102 = 55866 Ω	R 109 = 24144 Ω
R 103 = 7456 Ω	R 110 = 19048 Ω
R 104 = 44843 Ω	R 111 = 34521 Ω
R 105 = 11380 Ω	R 112 = 13850 Ω
R 106 = 34602 Ω	R 113 = 48660 Ω

Table 2: Calculated values

Since the offset error of the operational amplifiers I 101 to I 106 has virtually no effect, the accuracy that can be obtained with the calculated circuit is virtually only dependent on the accuracy of the resistors. For this reason, each of the resistors given in **Table 3** are formed by series connection of two fixed and one variable resistor. This allows the value of the potentiometer to be small, so that any possible misalignment due to shock etc. will have little effect.

The effect of aging of the resistors was checked in the computer. If metal-film types (as are described here) are used for the 10 kΩ resistors, the error will increase by approximately 0.04 dB. A more favorable result will be obtained when all resistors are metal-film types. In order to ensure the full measuring accuracy over a longer period of time, it is advisable for the alignment to be checked annually.

The operational amplifiers I 108 and I 109 generate the reference voltages of ± 10 V.

8.2. Construction

The PC-board for the readout and reference circuits is single-coated. The dimensions are standard Euro-board and a 31-pin connector can be used. **Figure 27** shows the component locations of this board, which has been designated RMG 01. If resistors having closer standard values and a lower tolerance are available (e.g. 1%), the PC-board can be equipped with these, so that potentiometers having a lower resistance value can be used.

Resistor No.	Trimmer Potentiometer Value	Resistor No.	Composite Carbon Value	Resistor No.	Composite Carbon Value
R 100 a	2k2 (2k5)	R 100 b	15k	R 100 c	1k0
R 101 a	220 (250)	R 101 b	2k2	R 101 c	47R
R 102 a	2k2 (2k5)	R 102 b	33k	R 102 c	22k
R 103 a	470 (500)	R 103 b	3k3	R 103 c	3k9
R 104 a	4k7 (5k)	R 104 b	39k	R 104 c	3k3
R 105 a	1k	R 105 b	10k	R 105 c	820R
R 106 a	2k2 (2k5)	R 106 b	33k	R 106 c	470R
R 107 a	2k2 (2k5)	R 107 b	15k	R 107 c	560R
R 108 a	2k2 (2k5)	R 108 b	22k	R 108 c	2k7
R 109 a	2k2 (2k5)	R 109 b	22k	R 109 c	1k0
R 110 a	2k2 (2k5)	R 110 b	18k	R 110 c	0
R 111 a	2k2 (2k5)	R 111 b	33k	R 111 c	390R
R 112 a	1k	R 112 b	10k	R 112 c	3k3
R 113 a	4k7 (5k)	R 113 b	39k	R 113 c	6k8

Table 3: The resistance values for the linearization of $U_{F\,log}$

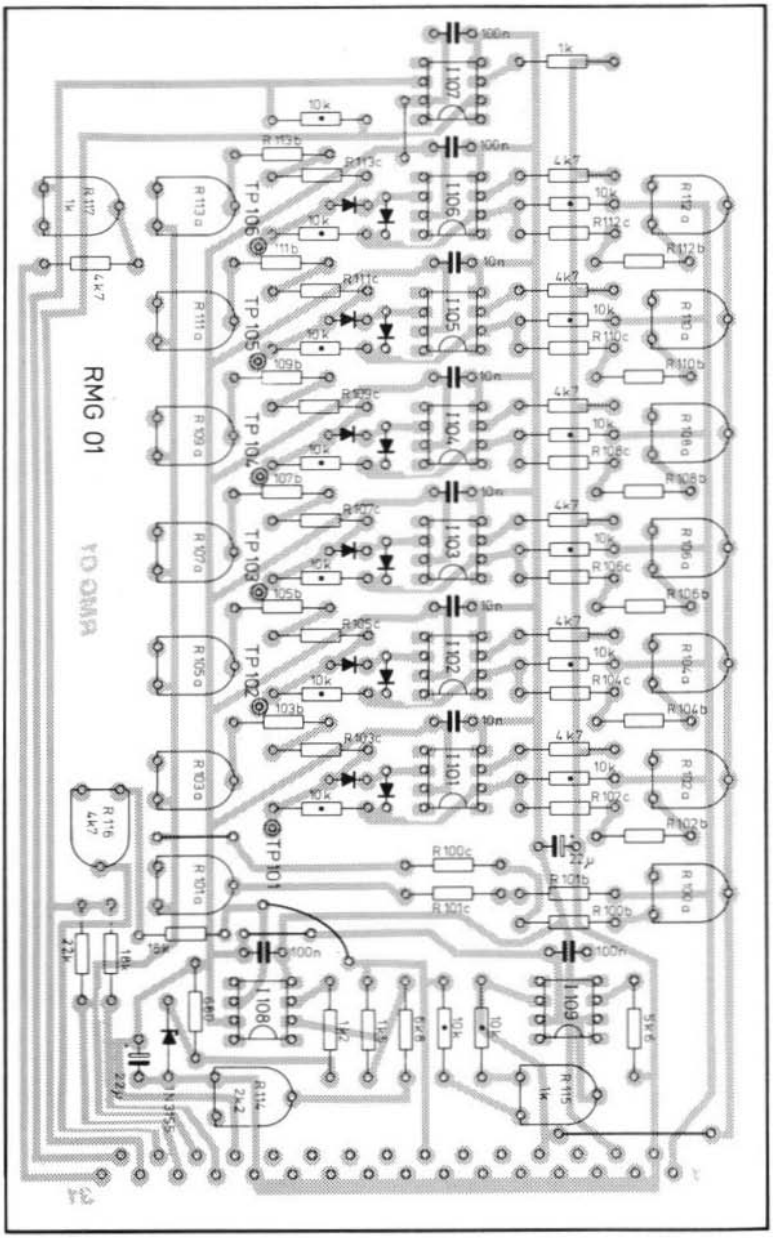

Fig. 27: Three bridges are required on the readout reference board RMG 01

8.2.1. Special Components for RMG 01

I 101 – I 109: 741 or TBA 221 B op. amp.
D 101: 1 N 3155, temperature-compensated 8.4 V zender diode
12 diodes: 1 N 4151 or similar
9 ceramic flat capacitors 100 nF, spacing 5 mm
2 tantalum electrolytics: 22 µF/25 V
18 trimmer potentiometers, horizontal mounting, spacing 10/5 mm.
Values: see circuit diagram and Table.
44 composite carbon resistors, 12 mm spacing.
Values: see circuit diagram and **Table 3**.
15 metal-film resistors, spacing 12 mm; 10 kΩ/1%
31-pin connector (DIN 41 617 Siemens, etc.)

Figure 28 shows the photograph of the author's prototype. Resistors R...c are still mounted below the PC-board at that time.

8.3. Connection and Alignment

The current drain of a correctly operating circuit is approximately 33 mA in the positive branch and approx. 22 mA in the negative. For the following alignment processes, $\overline{U}_{2M}$ is to be provided with a variable voltage of 0 – 10 V, for instance using a 1 kΩ potentiometer between ground and + 15 V. The alignments should now be made according to **Table 4.** They are not critical, but are important in order to obtain the full accuracy of the noise measuring system. For this reason, the alignment should be made carefully with the aid of a good digital voltmeter and in the given sequence. It is advisable to carry out a preliminary alignment before carrying out the final alignment in order to assure whether all adjustments are possible. If this is not the case, this will

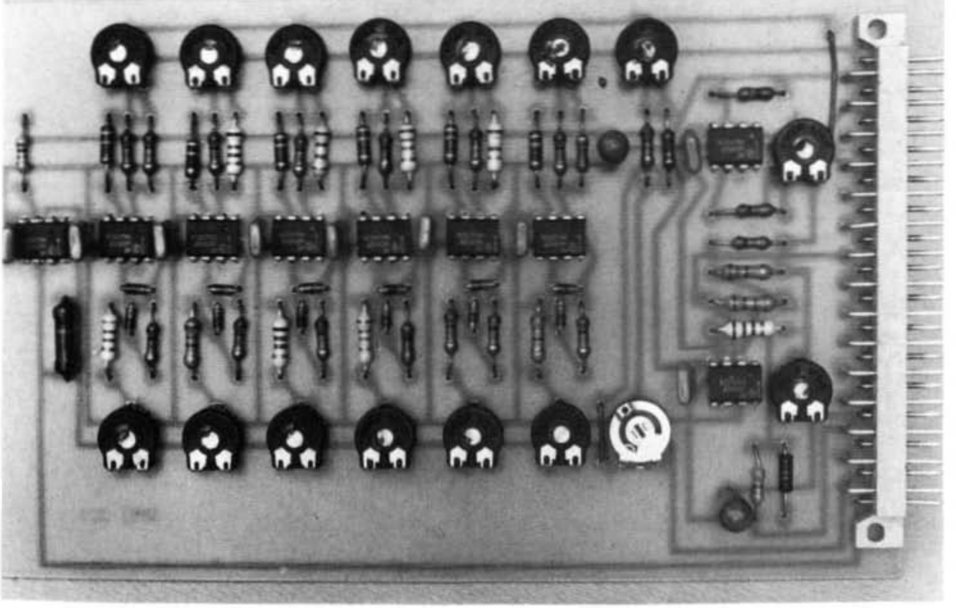

Fig. 28: This photograph of the author's prototype is still not in its final configuration

Preset voltage $\overline{U}_{2M}$	Instruction	Testpoint for voltmeter	Align	Alignment condition
	Connect 26 and 29			
Unconditioned		$+U_{ref}$	R 114	U_{ref}: = 10.00 V
Unconditioned		$-U_{ref}$	R 115	$-U_{ref}$: = − 10.00 V
0.00 V		$U_{F\,log}$	R 100	$U_{F\,log}$: = 5.86 V
1.50 V		$U_{F\,log}$	R 101	$U_{F\,log}$: = − 0.514 V
1.79 V		TP 101	R 102	*
2.23 V		TP 102	R 104	*
2.23 V		$U_{F\,log}$	R 103	$U_{F\,log}$: = − 3.024 V
2.89 V		TP 103	R 106	*
2.89 V		$U_{F\,log}$	R 105	$U_{F\,log}$: = − 4.362 V
3.86 V		TP 104	R 108	*
3.86 V		$U_{F\,log}$	R 107	$U_{F\,log}$: = − 5.745 V
5.25 V		TP 105	R 110	*
5.25 V		$U_{F\,log}$	R 109	$U_{F\,log}$: = − 7.151 V
7.22 V		TP 106	R 112	*
7.22 V		$U_{F\,log}$	R 111	$U_{F\,log}$: = − 8.573 V
9.99 V		$U_{F\,log}$	R 113	$U_{F\,log}$: = − 10.004 V
	Loose conn. 26 – 29 connect 28 – 29			
Unconditioned		$U_{F\,log}$	R 116	$U_{F\,log}$: = − 5.000 V
Unconditioned	Connect 1 mA meter with "−" to $I_{F\,log}$ and "+" to ground.	$U_{F\,log}$	R 117	$I_{F\,log}$: = − 1.00 mA**

** Align using the meter that is to be used in practise.
Pay attention to correct position and zero adjustment.

Table 4: Values for the alignment of module RMG 01

mean that a previous alignment is not correct, or that the resistors in the voltage divider have too large a tolerance and must be exchanged or corrected. After carrying out the final alignment, all adjustments should be fixed with lacquer so that no unwanted adjustment is possible.

9. OVERALL CIRCUIT

9.1. Circuit Description

The interconnection of the individual modules is shown in **Figure 29**. Only a small number of external components are required in addition to the described modules. Two LEDs will indicate that the measuring value cannot be used because the control is limiting. With the aid of a 5 kΩ potentiometer, it is possible for the ENR-constant of the noise source to be inserted. The adjustment range is in the order of 10 to 20 dB. The ENR-value of the home-made source described in Part 1 should be within this range. The input can be checked using the 1 mA-meter which also indicates the noise figure. For this reason, it can be switched with the aid of switch S. If the switch is in position ENR_{log}, a range of 10 – 20 dB will be indicated in the spread scale, whereas noise figures between 0 dB and 10 dB can be read off from the meter in the other position.

9.2. Construction

The receive converter and modules RMG 01, RMG 02, RMG 03, RMG 04 are accommodated together with a ± 15 V power supply in a cabinet. A suitable power supply could use a transformer with two separate 15 V windings and two fixed-voltage stabilizers (TO 5). If a PC-board is to be used, this is possible using PC-board DK 1 OF 028.

After completing the final alignment, a further resistor is exchanged in module RMG 03. For this reason, it is advisable for this module to be mounted in an accessible position. Attention should be paid during the wiring that no ground loops are possible. Either a BNC or N-connector can be used for the measuring input. Output U_{NS} for the noise source only has to carry AF-voltages. In order to ensure that it cannot be confused with the measuring input, it is advisable for a PL-connector to be used. The meter should have a full-scale deflection at 1 mA. Since the

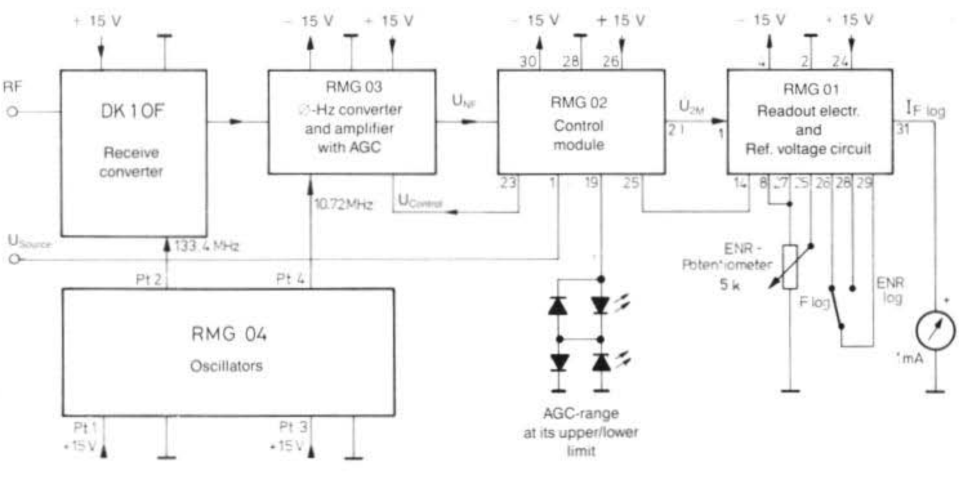

Fig. 29: Overall circuit of the noise measuring system

precision of this meter is used twice in the measuring accuracy (firstly when adjusting the ENR-value and secondly on indicating the noise figure), it is advisable not to save with respect to this component. It is advisable to use a "class 1"-meter which is not too small.

The 5 kΩ potentiometer allows the ENR-value alignment to be made easily if a 10-turn type is used.

9.3. Final Alignment

Potentiometers R 204 and R 206 on PC-board RMG 02 must still be aligned. This is carried out with the 10.720 MHz crystal oscillator switched off. This means that the control circuit is broken and the control will go into limiting. The LED indicating too low an input level should now light up. Align resistor R 206 so that voltage $U_{control}$ (negative voltage) is adjusted to the value $U_{control\ G}$, which was determined in section 5.3.

A further precision alignment is now required. The **same** voltmeter should be used as was used for alignment of module RMG 01. It should have an input impedance of more than 10 MΩ, which is usual with DVMs. If required, an LF 356-impedance converter (with offset correction) can be used. The voltage at TP 203 should be aligned to 1.000 V with the aid of potentiometer R 204. This alignment should also be fixed with lacquer. The 10.720 MHz oscillator is switched on again, after which the measuring system will be ready for operation if all modules are operating correctly.

The noise source is now connected to the control output U_{NS} and plugged to the 144.1 MHz measuring input "RF". It is now possible for the first noise alignment to be made: Namely that of the built-in receive converter as described by DK 1 OF. If the ENR-value of the noise source is known, it is possible for it to be set in switch position ENR_{log} with the aid of the potentiometer while observing the meter. The value 0 on the meter coresponds to ENR = 10 dB, and the full-scale deflection (100) corresponds to ENR = 20 dB. If an ENR-value of 16 dB is to be used, the potentiometer will be aligned for a reading of 60 scale units.

If, on the other hand, the ENR-value of the noise source is not known, firstly adjust any value that is able to produce a reading after switching to F_{log}. This allows the receive converter to be aligned for minimum noise figure. In the author's prototype using a DK 1 OF converter, a minimum noise figure of approximately 4.5 dB was obtained. If the ENR-value potentiometer is now adjusted until this noise figure is indicated (45 scale units), this means that the ENR-value is at least approximated in the 2m-band. It is possible afterwards to calibrate one's own noise-source by carrying out comparative noise figure measurements with precision equipment over the widest frequency range, and at the highest possible accuracy.

After the ENR-value and thus the noise figure of the measuring input is known sufficiently accurately, it is possible for the components of the second stage to be taken into consideration. For this, one requires the gain of the test object together with the following equation:

$$NF_{tot} = NF_1 + \frac{NF_2 - 1}{G_1}$$

where: NF_1 = noise figure of the test object (insert as a factor and not in dB!)

NF_2 = noise figure of the measuring input (e.g. 4.5 dB ≙ 2.8)

G_1 = power gain of the test object, (also insert as factor)

Resistor R 302 of PC-board RMG 03 was designed to have such a high value in order to carry out the noise alignment of the receive converter. In operation later, it is more favorable to reduce the gain: A value of 22 kΩ should be used for resistor R 302.

10. FINAL NOTES

It would exceed the scope of this article if all pos-

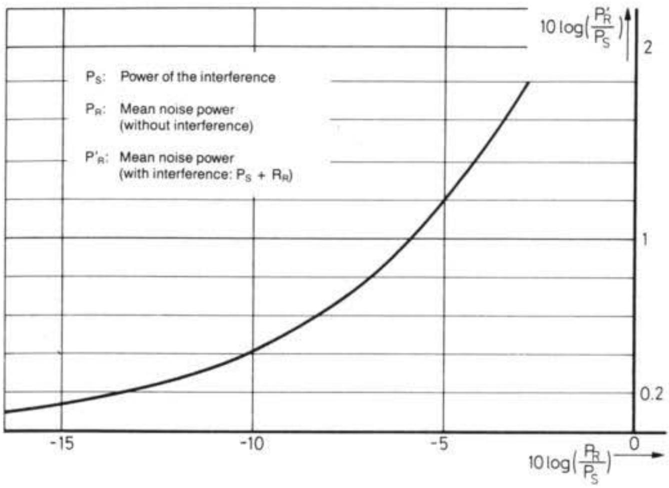

Fig. 30: An interference signal that is 6 dB weaker than the mean noise power will falsify a power measurement by 1 dB!

sible errors of noise figure measurements were to be mentioned. A previous article "Some Pitfalls in Noise Figure Measurements" (2) describes a large number of possible errors. At this point we would like to underline the extremely low value of the measured power levels:

$$1\ kTo \times 30\ kHz = 0.4 \times 10^{-20}\ Ws \times 30000\ s^{-1}$$
$$= 1.2 \times 10^{-16}\ W$$
$$\triangleq -129\ dBm$$

Figure 30 shows by how much interference signals must be **below the noise level** in order to obtain a certain accuracy during the measurements.

11. REFERENCES

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(2) J. Gannaway, G 3 YGF and D. Holmes, G 4 FZZ:
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Matjaž Vidmar, YU 3 UMV

A Digital Storage Module and Scan Converter for Weather Satellite Images

Part 3: Synthetic Colour Module

This description of a synthetic colour module equipped with a PAL modulator is to complete the series of articles regarding a system for reception and display of weather satellite images. This module converts the grey levels of the video signal from the digital storage YU 3 UMV 002 into synthetic colours.

1. INTRODUCTION

Weather satellites transmit images that are observed in the various spectral ranges. The most important spectrum for providing information on the weather situation is in the infrared range (IR) at a wavelength of approximately 11 μm. As you will probably know, these images have an extremely large dynamic range and require, for this reason, considerably more grey levels than required for images in the visible light range (VIS). Modern digital storage modules are well able to process this large dynamic range, however, our eyes are not able to determine very slight intensity differences on the screen of a monochrome monitor tube. Since the human eye is very much more sensitive to slight colour differences than to slight intensity differences, it is more favorable to replace the grey levels of an image by corresponding colour shades.

Of course, this simple trick is also useful for the visible images: One can, for instance, colour the sea deep blue, Europe green, the Sahara yellow and the high clouds pink/white.

Of course, the best results are obtained with a professional colour video monitor with separate RGB-inputs, however, it is also possible to use a PAL-colour TV-receiver with its limited bandwith if one is able to accept reduction of the geometric resolution. In order to ensure that a video input need not be installed in the TV-receiver, the synthetic colour module is equipped with a simple VHF modulator for TV-band I.

2. CIRCUIT DESCRIPTION

The block diagram of the synthetic colour PAL-modulator is given in **Figure 21.** The composite video signal from the digital storage drives three main functions:

- The colour coder for generating the two colour-difference signals;
- The VHF-modulator for generating the video signal and the synchronizing impulses;
- The synchronizing logic for generating the various impulses required by the PAL-modulator.

An integrated circuit type TBA 520 is used as PAL-modulator. Since the PAL-TV standard requires a very accurate colour carrier frequency, the module uses a crystal-controlled

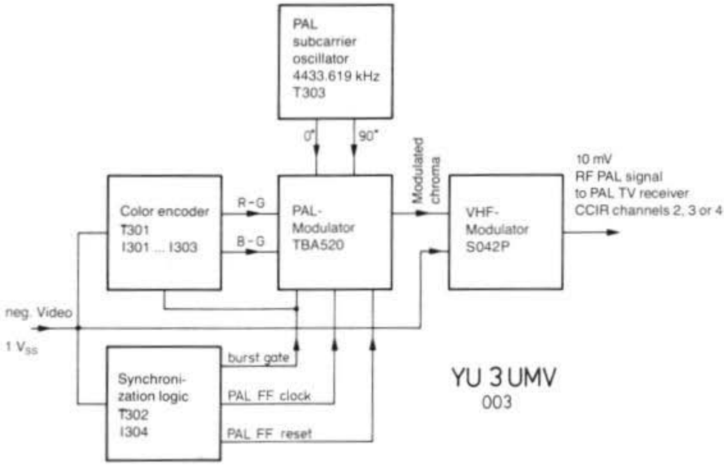


Fig. 21: Block diagram of the synthetic colour module

oscillator. The video signal is passed through a delay line before being fed to the VHF-modulator where it is combined with the colour signal. This delay line is required to compensate for the delay in the colour coding and modulation stages. The VHF-modulator converts the signals to an unused VHF-(band I) channel. The whole circuit requires approximately 50 mA at a voltage of 12.6 V.

As can be seen in **Figure 22**, the colour coding

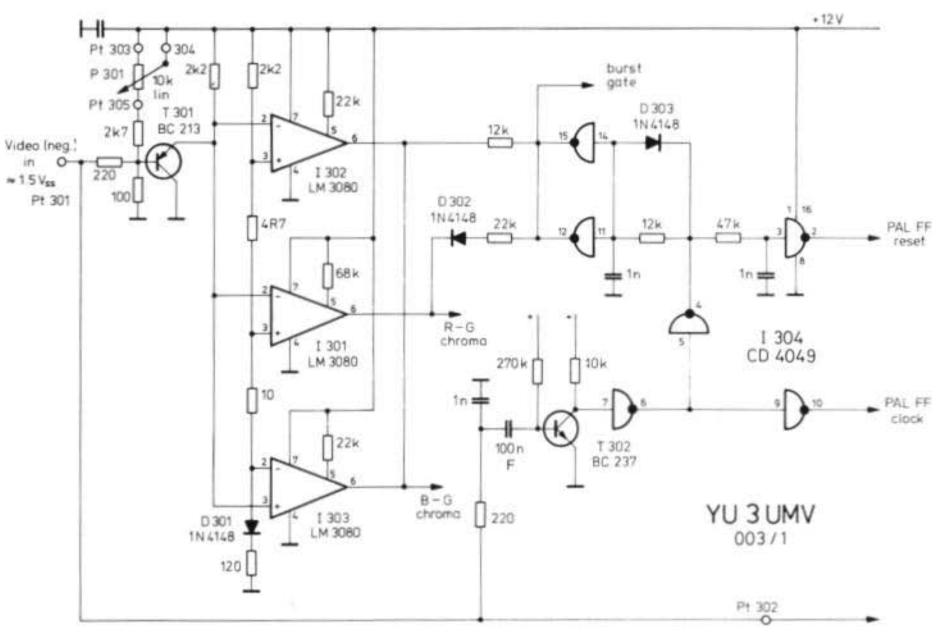


Fig. 22: Colour coder and synchronizing logic

circuit includes a stage for shifting the DC-voltage level (P301 and T301), as well as three level comparators (I301 – I303). Potentiometer P301 allows the colour scale to be shifted. Since the brightness levels vary during the day, and especially between infrared and visible images, P301 should be provided as a potentiometer on the front panel of the system.

The integrated circuits LM 3080 only provide a moderate gain and provide a gradual transfer characteristic as shown in **Figure 23.** The LM 3080 operational amplifiers provide a current, which means that their outputs can be combined together in order to sum the signals. This ensures that there are no problems with DC-voltage drift when connected to the TBA 520 (I305 in Figure 24).

It is favorable to have a higher resolution in the dark parts of the image both for IR and visible images. The divider network for the reference voltage is therefore not symmetrical (4.7 Ω and 10 Ω).

Transistor T302 separates the sychronizing pulses from the composite video signal. A monoflop built up using the inverters of I304 delays the horizontal synchronizing pulses in order to obtain the burst-gate pulses. These pulses also

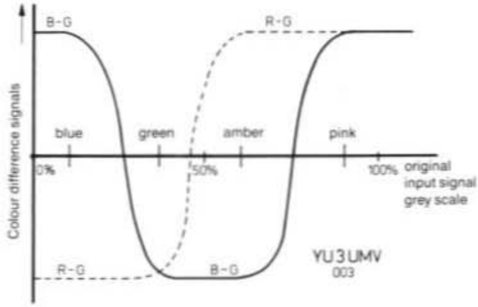


Fig. 23: Conversion characteristic of the colour coder

ensure that the signals R – G and B – G are forced to have the constant burst pulses of the required level. The horizontal synchronizing pulses are also used for timing the PAL-flipflop. Unfortunately, they are not available during the vertical synchronizing cycle. However, since the image generated in the digital storage posesses an even number (320) of lines it is possible to use the vertical synchronizing pulses for resetting the PAL-flipflop at the beginning of each image.

The colour carrier oscillator **(Figure 24)** provides

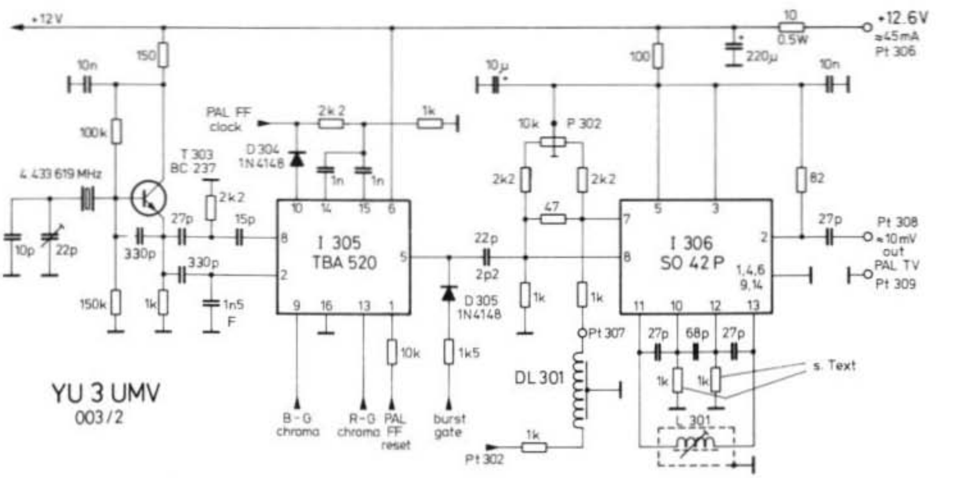


Fig. 24: PAL-colour carrier oscillator, PAL-modulator, and VHF-modulator

the PAL-modulator I305 with the two reference signals. The B–G reference signal is obtained using a phase-shift network. The TBA 520 was developed as a PAL-demodulator in colour-TV receivers, however, it also operates excellently as a PAL-modulator. It contains two push-pull modulators, the PAL-flipflop, and the PAL-switch. The PAL-flipflop is a simple two-transistor circuit that requires two external capacitors for operation. Pin 10 of I305 is connected internally to one tap of the bias-voltage divider network. During the horizontal synchronizing pulses, it is grounded via D304, in order to suppress the colour signal. This signal is taken from pin 5, which was originally intended as G–Y output. Since the gain values of the two modulators for B–G and R–G, respectively, are not identical with respect to the output voltage at pin 5, the amplitude of the R–G modulation signal should be lower than that of the B–G signal.

In a PAL-TV receiver, the gain control of the colour signal is controlled by the burst amplitude. This means that the colour saturation is defined by the ratio of colour amplitude to burst amplitude. In our case, this ratio is determined by the 1.5 kΩ resistor in series with D305 (at pin 5 of I305), as can be seen in **Figure 25**.

Although not usually used in such a circuit, the S042P (I306) is an excellent video modulator. The oscillator portion of this integrated circuit oscillates in the lower VHF-range between approximately 45 and 65 MHz using the three external capacitors and the coil. The push-pull modulator within the IC must, of course, be unbalanced (trimmer P302) in order to obtain an amplitude modulation. The colour signal is injected via a capacitor of only 2.2 pF in order to suppress the lower-frequency components of the output voltage of I305. The VHF-output signal at pin 2 of I306 already provides an output level suitable for feeding a colour TV-receiver.

3. CONSTRUCTION

The synthetic colour module is built up on a single-coated PC-board having the dimensions 100 mm x 70 mm. The component location plan is given in **Figure 26**, and the board has been designated YU 3 UMV 003. All resistors and capacitors are mounted horizontally. Attention

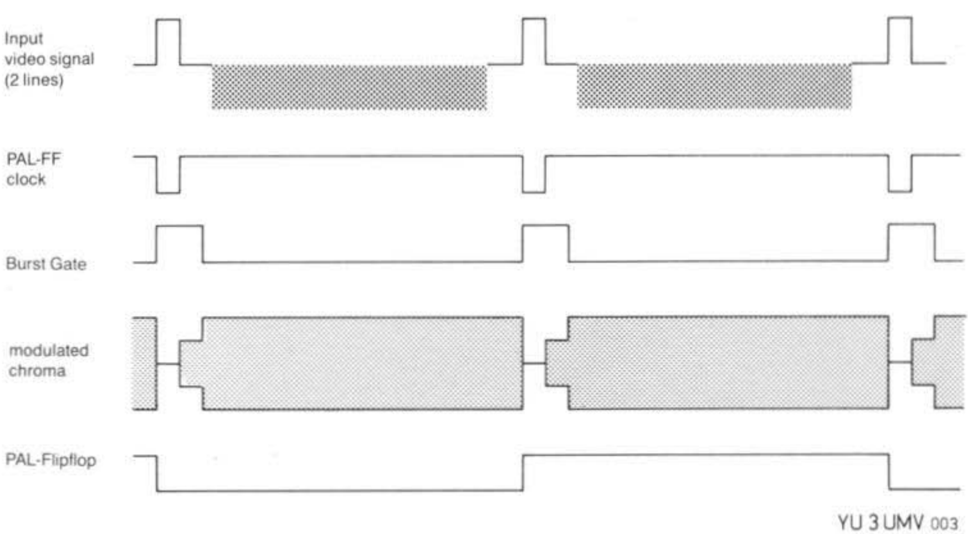


Fig. 25: Generation of the colour signal

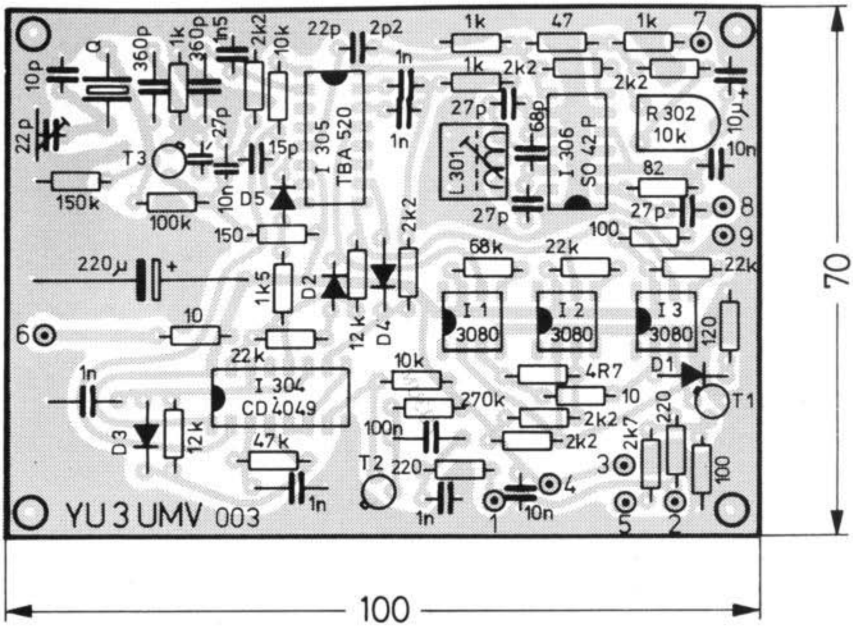


Fig. 26: PC-board YU 3 UMV 003 of the synthetic colour module

must only be paid that two resistors are to be mounted on the conductor side of the board below the S042P, and that the delay line is not directly mounted onto the board. It is soldered together with the required terminating resistor of 1 kΩ between the connection points Pt302 and Pt307, as can be seen in the photograph of the author's prototype given in **Figure 27**. Other types of delay lines can be mounted on the inside of the case, if required. CAUTION: These are **not** the usual 64 μs PAL-delay lines but have only 470 ns. The oscillator coil can be constructed using a coil set, or using a Japanese IF-coil with a suitable number of turns. The PC-board is designed to use a coil having a case of 10 mm x 10 mm. The number of turns should be established most favorably using a dipmeter, with a capacitance of 15 pF parallel to the coil. This value corresponds to the resulting capacitance of the three capacitors and the internal capacitance of the I306.

It is recommended that the completed, and tested module YU3UMV 003 be mounted in a screened case, since TV-receivers are very sensitive to interference caused by the digital circuits, especially in the lower VHF-range. The VHF-connection to the TV-receiver should also be well screened and grounded carefully in order to ensure that no interference signals are received, and no other TV-receivers are interfered with.

3.1. Special Components

T301:	BC213, BC415, BC560 or similar silicon PNP-AF-transistor
T302, T303:	BC237, BC413, BC550 or similar silicon NPN-AF-transistor

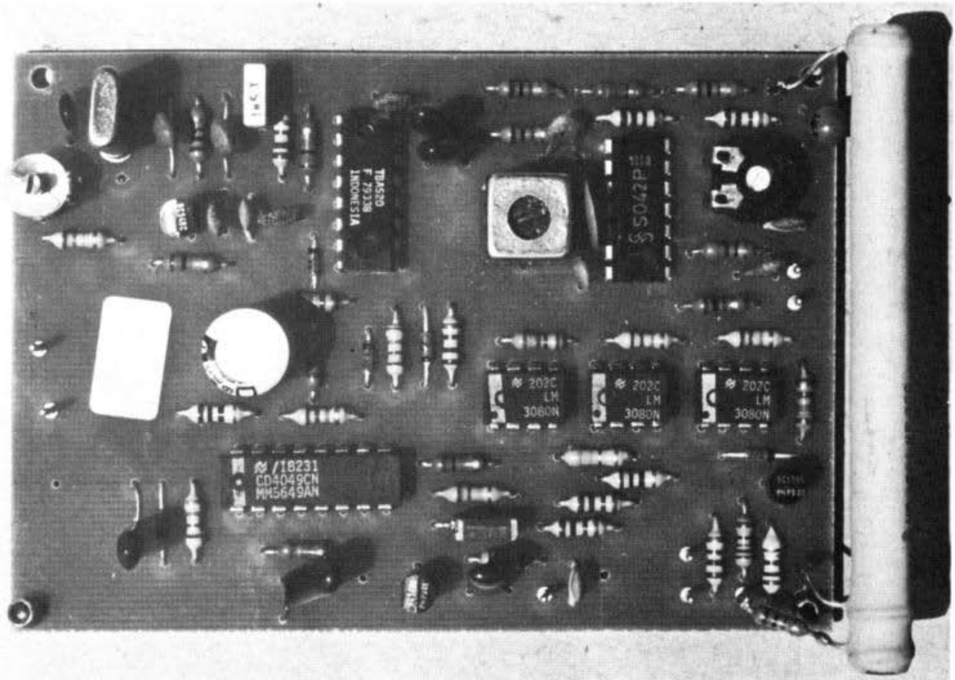


Fig. 27: Photograph of the author's prototype of the synthetic colour module using a tubular delay line (right)

D301–D305:	1 N4148 or 1 N4151 or similar silicon switching diode
I301–I303:	LM3080 or CA3080, if possible with suffix "A" (lower tolerance)
I304:	4049 CMOS 6-times inverter/ buffer
I305:	TBA 520 PAL demodulator (Telefunken, etc.)
I306:	S042P, VHF-modulator (Siemens)
Q:	PAL-colour carrier crystal 4433.619 kHz, parallel resonance with 20–30 pF load capacitance in HC-6/U or HC-18/U
DL:	$t = 470$ ns, $Z_0 = 1.15$ kΩ – Philips, type DL470 or similar type having the same values
L301:	Approx. 5 turns of enamelled copper wire of approx. 0.5 mm dia. in a Japanese 10.7 MHz coil, further details given in the text
C301:	22 pF plastic foil trimmer (Philips: green)
P301:	10 kΩ linear potentiometer located on the front panel
P302:	10 kΩ linear trimmer potentiometer, spacing 10/5 mm

220 µF/16 V, aluminium electrolytic, max. spacing 25 mm

10 µF/16 V, tantalum electrolytic,

1.5 nF plastic foil capacitor, spacing 5 mm, at pin 2 of I5

100 nF plastic foil capacitor, spacing 10 mm, at base of T2.

All other capacitors: ceramic, spacing 5 mm

All resistors: spacing 10 mm

4. ALIGNMENT

The frequency of the PAL-crystal oscillator should be aligned exactly with the aid of the plastic foil trimmer since an error of only a few hundred Hz will not allow the locking-in of the PAL-demodulator in the colour TV-receiver.

The PAL-delay line in the colour TV-receiver provides a delay of exactly 64 μs; if the line period of the digital storage does not correspond exactly to 64 μs, two superimposed images will appear on the screen of the TV-receiver. This is corrected easily by adjusting the frequency of the 1 MHz clock oscillator on YU3UMV 001 to exactly 1 MHz (L 101).

The oscillators in the synthetic colour module and in the digital storage module are independent, and are therefore not coherently phase-locked. Normally, this fact will not cause any problems; however, in some cases the various possible beat frequencies could cause visible interference such as a brightness modulation of the image. In such cases, it is recommended that the two oscillators should be slightly detuned until the interference disappears.

5. FINAL NOTES

The described PAL-colour modulator converts a black-and-white video signal into a synthetic colour PAL-signal. It should be possible to combine several video signals to a single colour signal. It could, for instance, be possible for the video signal from a visible image to determine the brightness, and the video signal from the associated IR image to determine the colour. However, one would require two perfectly synchronized digital storages for such an experiment.

Finally, it should be mentioned that the synchronizing logic circuitry of the synthetic colour PAL-module is exclusively designed for use with the video signal of the described digital storage YU3UMV 001/002. If the synthetic colour module is to be used with other video storage modules, it will probably be necessary to modify the synchronizing circuitry.

Editors

Preliminary Experience with the Digital Storage Module described by YU 3 UMV

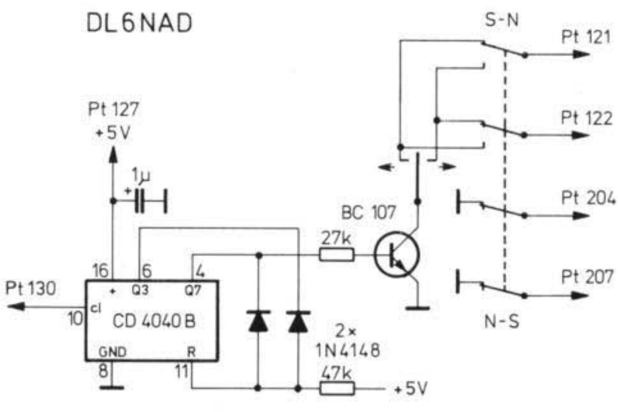
All digital storage modules built up by the editors operated without problems. However, a few modifications were made afterwards to improve operation, and these are now to be described.

Firstly, however, it should be mentioned that some of our readers have problems with the six 64 K-memory ICs, which were seen as strips of missing pixels. In all cases, it was found that sockets were used. It seems that the access times of the TMS 4164-15NL memories are so near to the permissible limits that the delay in the IC-sockets is too great even when using expensive, flat socket types. This problem was solved by deleting the sockets, or when using memories having a better access time from other manufacturers. Up to now, types MCM 6665 and D 4164 C-3 have been found to be fast enough for use in sockets. If any of our readers has had further experience, please do not hesitate to contact the editors.

In the component location plan for board YU3UMV 002 on page 22, I212 should be a **LS 123**, and not LS 153 as given.

If the image is diagonal on the screen of the monitor, this will indicate that the synchronization is not locked into the 2400 Hz subcarrier. In the case of some 4046 (I 103), the range of trimmer R 105 will not obtain the nominal frequency of 38.4 kHz. In such cases, a 50 kΩ potentiometer should be used for R 105, and one should possibly bridge the 10 kΩ dropper resistor. Furthermore, a value of only 82 pF is more favorable for the coupling capacitor at pin 14 of I 103 instead of the original 1000 pF. The resistor between pins 2 and 9 of this IC should preferably be 330 kΩ instead of the original 100 kΩ.

The push-buttons designated "fast" and "slow" are used for manual synchronization. Their use is better designated as "shift-to-right" or "shift-to-left". This shifting is made in such large jumps,



Additional circuit for YU3UMV 001/002 to ease manual alignment of the image

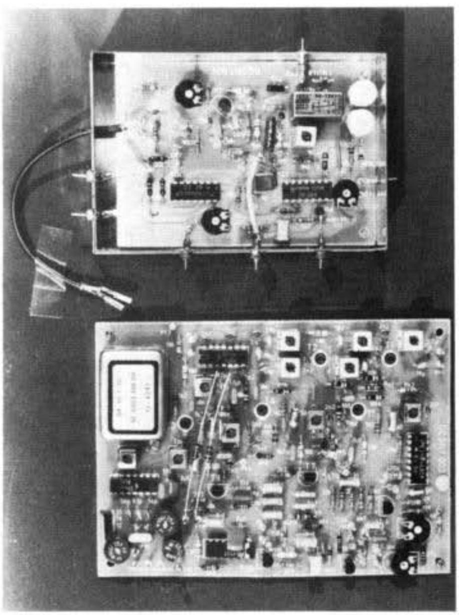
even when depressing the pushbutton quickly, that it is difficult to find the required position of the image sector. The small **circuit diagram** shows an additional circuit and has been designed for this so that no modifications must be made to the PC-board.

A divider is driven by the line clock and connects the base of the two pushbuttons to ground via a transistor – it is advisable to replace these pushbuttons by a switch with two sprung-make contacts and a neutral position. The designation "links" and "rechts" is, of course, exchanged on switching from N/S to S/N (Pt 204 and Pt 207). For this reason, it is advisable for the described synchronizing modification to be combined with the mentioned switches. This ease of operation also results in a cleaner front panel.

If the colours and colour transitions are not to your liking, one can experiment by varying the resistors between +12 V and pin 5 of the LM 3080 (I 101 – I 303). For those readers that with to see the satellite image in black and white on the colour TV receiver, it is possible for an additional switch, connected between the collector of T 302 and ground, to short out the control signal for the PAL flipflop. In this manner one will obtain the monochrome image at VHF, which can be of interest for those readers that do not have a video monitor; however, the resolution will suffer due to the limited bandwidth of TV-receivers.

In one case, the contrast of the colour image was too low, because the modulator I 306 did not receive enough drive. This problem was solved by increasing the value of the coupling capacitor between I 305 and I 306 from 2.2 pF to 22 pF.

DL3WR/DL6NAD



Gerd Otto, DC 6 HL

A Mini SSB-Transceiver for the 2 m Band

Part 2

4. CONSTRUCTION

4.1. AF/IF Board DC6HL 011

The components can be installed as shown in the component location plan (**Figure 5**) and soldered into place.

It is only necessary for the four mounting holes on the corners of the board, and possibly the ground holes of inductances L52, L53, and L54, to be drilled out.

Thin wires should be soldered directly into the connection points. These wires serve as connection points during the preliminary testing of the boards, and are shortened after installing the board. They are used for the interconnection to the feedthrough capacitors mounted in the screening box. Inductances L51 and L55 must be connected with the aid of a short piece of RG-174 coaxial cable on the lower side of the board in order to connect the oscillator signal to the receive mixer.

A spacer bushing of 4 mm dia. x 4 mm should be

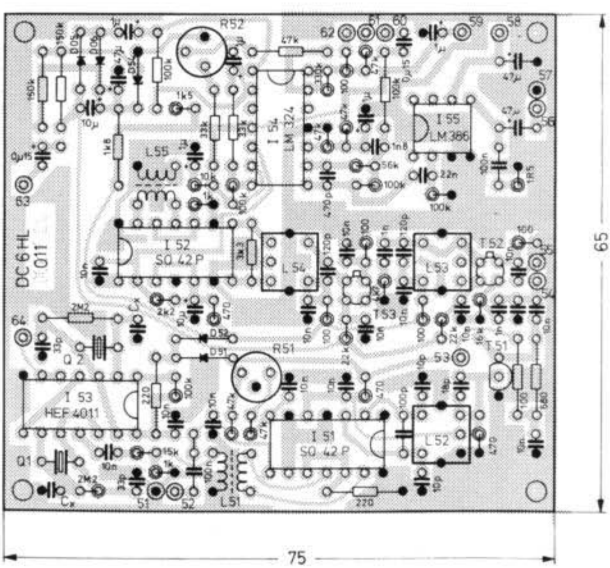


Fig. 5: The AF/IF board DC6HL 011 has through-contacts and its dimensions are 65 mm x 75 mm

soldered to each mounting hole. The PC-board is later fixed into the case using M2 screws placed through these bushings.

4.2. RF-Board DC6HL 010

The component locations on this 60 x 65 mm PC-board are given in **Figure 6**. The same is valid for the holes on this board as was mentioned for the AF/IF-board. It is necessary for the mounting holes for the trimmers C01 and C02 to be drilled out (3 mm dia.). The ready-wound inductances L07, L08, and L10 are inserted so that the cold end of the coil faces towards the board.

It is now possible for all components with the exception of the inductances and capacitors in the screening cans to be mounted into place. Special attention must be paid when mounting the mixer to ensure that it is in the correct position. It should also not be directly touching the board but should have a spacing of 1 mm. All vertical resistors should be mounted in the direction shown in the component location plan, which is, that the shorter connection of the resistor is connected to the "hot" conductor lane. This is followed by soldering the screening panels of the bandpass filter to the upper side of the board. After this, it is possible for the trimmers to be installed. The ground connections should be soldered both to the component and conductor side of the board. The prepared inductances L04 and L05 are placed through the ground and coil tap holes and soldered into position. Finally, it is only necessary for the four fixed capacitors to be soldered into place together with the connection wires. The PC-board is ready for testing after the two wire bridges shown as dashed lines in Figure 6 have been installed.

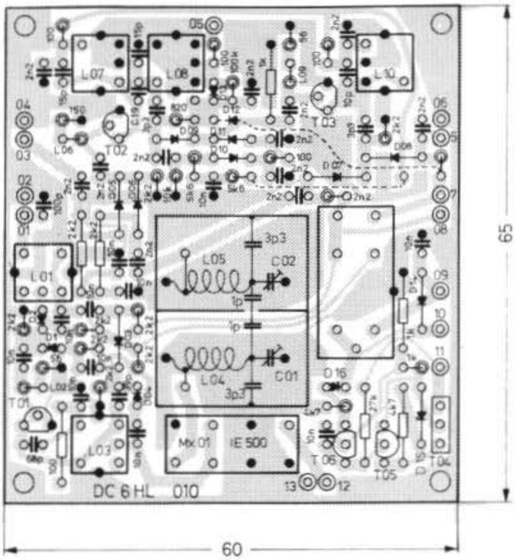


Fig. 6: **The RF-board DC6HL 010 also has through-contacts and is 65 x 60 mm**

5.1. Preliminary Testing of the AF/IF-Board

a) Connect the board as shown in **Figure 7**.

b) Connect the operating voltage and place the transmit-receive switch to position Tx.

c) Place sideband selector to position LSB.

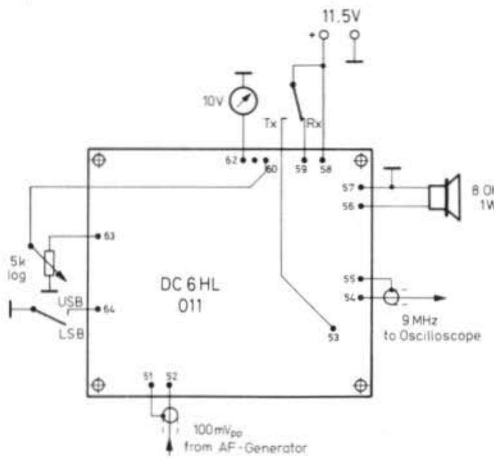


Fig. 7: **The operation of the AF/IF board can be checked as shown**

5. TESTING AND ALIGNMENT

A test and alignment procedure is now to be described that requires a minimum of measuring equipment. Before carrying out an electrical test, it is always advisable to carry out a **careful**, visible check for exchanged components, solder shorts on the conductor lanes, etc.

Crystal Q2 should commence oscillation. A frequency counter connected to the voltage divider indicates the crystal frequency. Vary C_X of Q2 until 9.0015 MHz is indicated. Switch to USB and align C_X of Q1 until 8.9985 MHz is indicated.

d) Connect a 1 kHz-signal of 100 mV (peak-to-peak) to the microphone input. A modulation envelope should be seen on the oscilloscope connected to the 9 MHz output. This should be aligned for maximum by aligning L 52. If limiting is already occuring, reduce the AF-drive signal.

e) Align the mixer for best balance with the aid of R 51. The envelope should now pass through zero.

f) Place the transmit/receive switch to position Rx, and turn up the volume control until noise can just be heard. Broadcast signals should be heard when placing one's finger or a piece of wire to the 9 MHz input.

g) Without signal, align trimmer R 52 until a voltage of +9 V is present at the output for the PIN-control voltage.

5.2. Preliminary Testing of the RF-Board DC6HL 010

a) Connect 12 to 15 V to connection Pt 11. A stabilized voltage of 11 to 11.5 V should now be present at output Pt 10. If this is not the case due to the greater spread of the zener diode D 16, it is possible for the ratio of the two 1 kΩ resistors to be changed somewhat. The current drain should drop to zero on shorting Pt 10.

b) With the PTT-contact open, the operating voltage should be present at $+U_{Rx}$, and at $+U_{Tx}$ when actuated.

5.3. Final Test and Alignment

a) Wire both boards according to **Figure 8**.

b) Switch to receive and set the oscillator signal to 136 MHz. A 145 MHz signal should now be

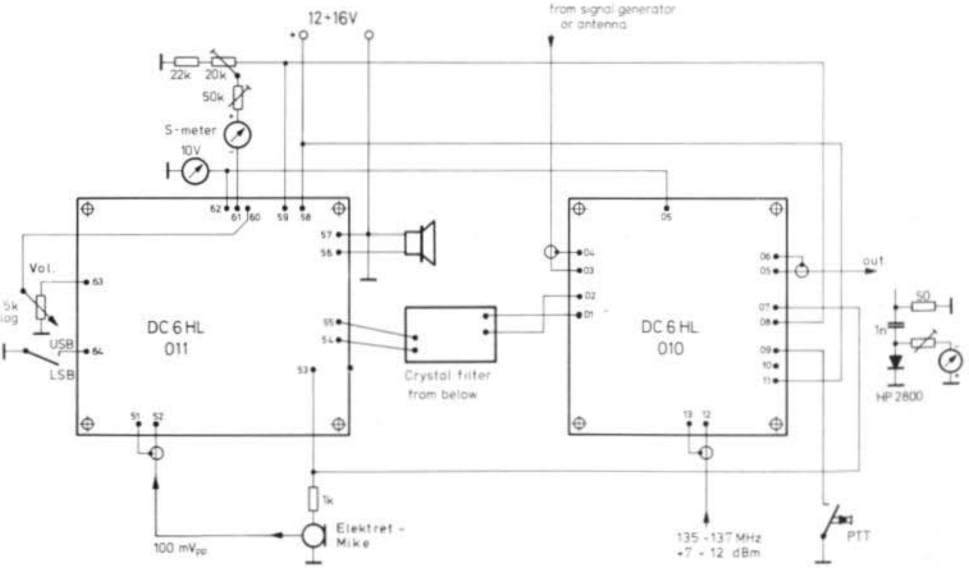


Fig. 8: Wiring diagram of the transceiver; the crystal filter is to be seen in the center. The 10 V-meter shows the testpoint for the stabilized voltage; the circuit for the relative RF-output power indication is seen on the right.

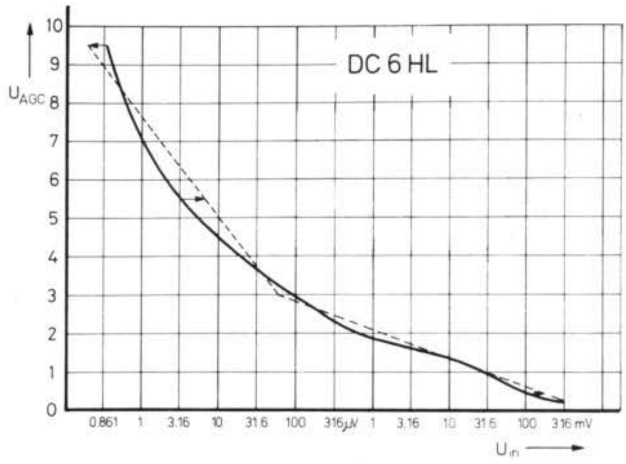


Fig. 9:
The control voltage of the PIN-diodes as a function of the RF-input voltage

injected into the RF-Rx input (Pt03), and increased in level until a tone is audible in the loudspeaker.

c) The following should now be aligned to maximum reducing the RF-signal in steps:
L54 and L53 on the AF/IF-board, L01 (wide maximum), L03, C01, C02, L10, L08, and L07 on the RF-board. This alignment should be repeated again and again until no further improvement is possible.

d) For alignment of the PIN-control threshold, connect a signal generator with an output of 1 μV to the RF-Rx input (Pt03). Adjust R52 on the AF/IF-board so that a PIN-control voltage of 7 V results. (**Figure 9**). If a signal generator is not available, R52 should be adjusted without signal so that the PIN-control voltage just starts to fall from the maximum value (approx. 9.5 V).

A 100 μA-meter is used as S-meter. A scale as shown in **Figure 10** should be used for this meter. The "zero alignment" is made to the −120 dBm point without signal using the external 20 kΩ trimmer. With an input signal of −70 dBm, the external 50 kΩ trimmer should now be aligned to the −70 dBm point. These two alignment steps should also be repeated several times.

e) Switch to transmit. Feed an input voltage of 100 mV (peak-to-peak) at 1 kHz to the microphone input. A milliwatt-meter connected to the RF-Tx output should now indicate approximately +7 dBm.

If the AF-drive is reduced until the RF-output level is reduced by 3 dB, and the oscillator frequency tuned from 135 to 137 MHz, the level should not drop by more than 1 dB compared with the center frequency. If this is not achieved immediately, one will require a slight correction at C01 and C02, or L07 and L08 on the RF-board.

f) The ripple of the crystal filter can be checked

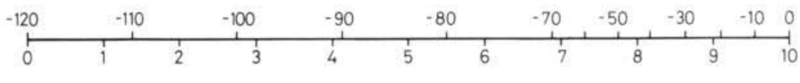


Fig. 10: The scale of a 100 μA-meter can be calibrated as S-meter.

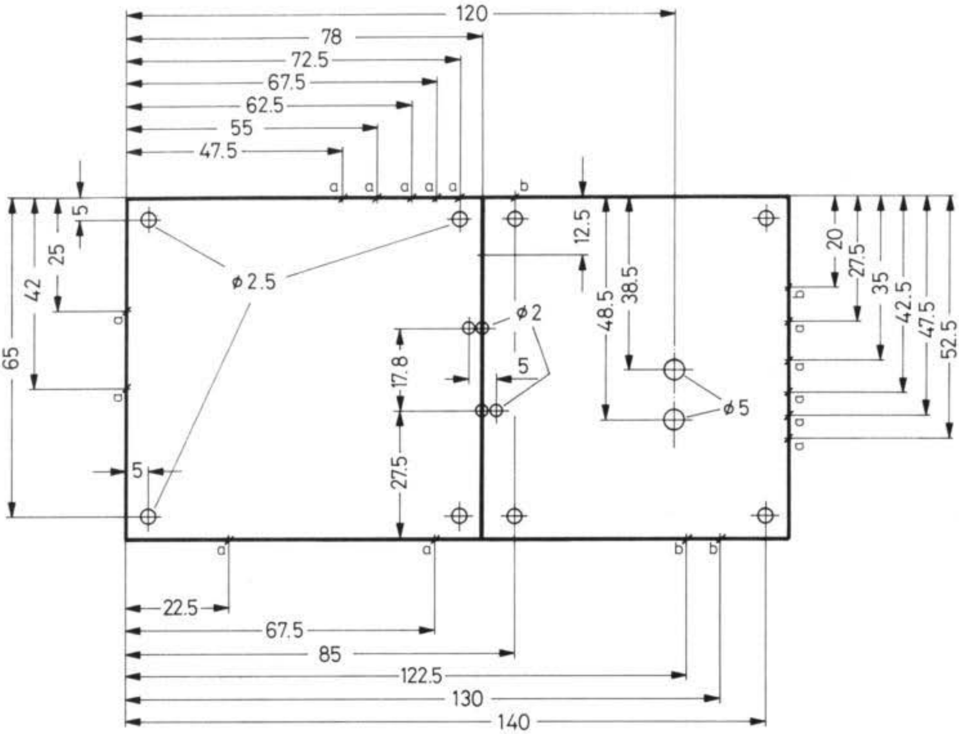
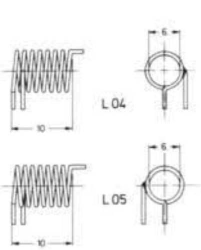


Fig. 11: Required holes in the metal case. A 28 mm high screening panel is placed between the connections of the crystal filter and is also provided with a hole for a feedthrough capacitor approx. 9 mm below the upper edge (as is also the case for the other feedthroughs).

by varying the AF-control frequency. If it is more than 2 dB, the following should be made assuming that no swept-frequency generator is available:
Vary the AF-frequency until a level minimum is obtained. Attempt now to increase the level as much as possible by adjusting L 01 (RF-board), or altering the capacitor between Pt 01 and Pt 02, or between Pt 54 and Pt 55 (AF/IF-board).
If the ripple is then checked as described above, one will usually have determined an improvement.

g) Short-circuit the microphone input and align R 51 for maximum carrier suppression (check with the aid of a 2 m receiver). A carrier suppression of at least 60 dB should be achieved. If this is not possible, exchange I 51 or change the ratio between the two 10 pF capacitors. It must then be followed by aligning L 52 for maximum.



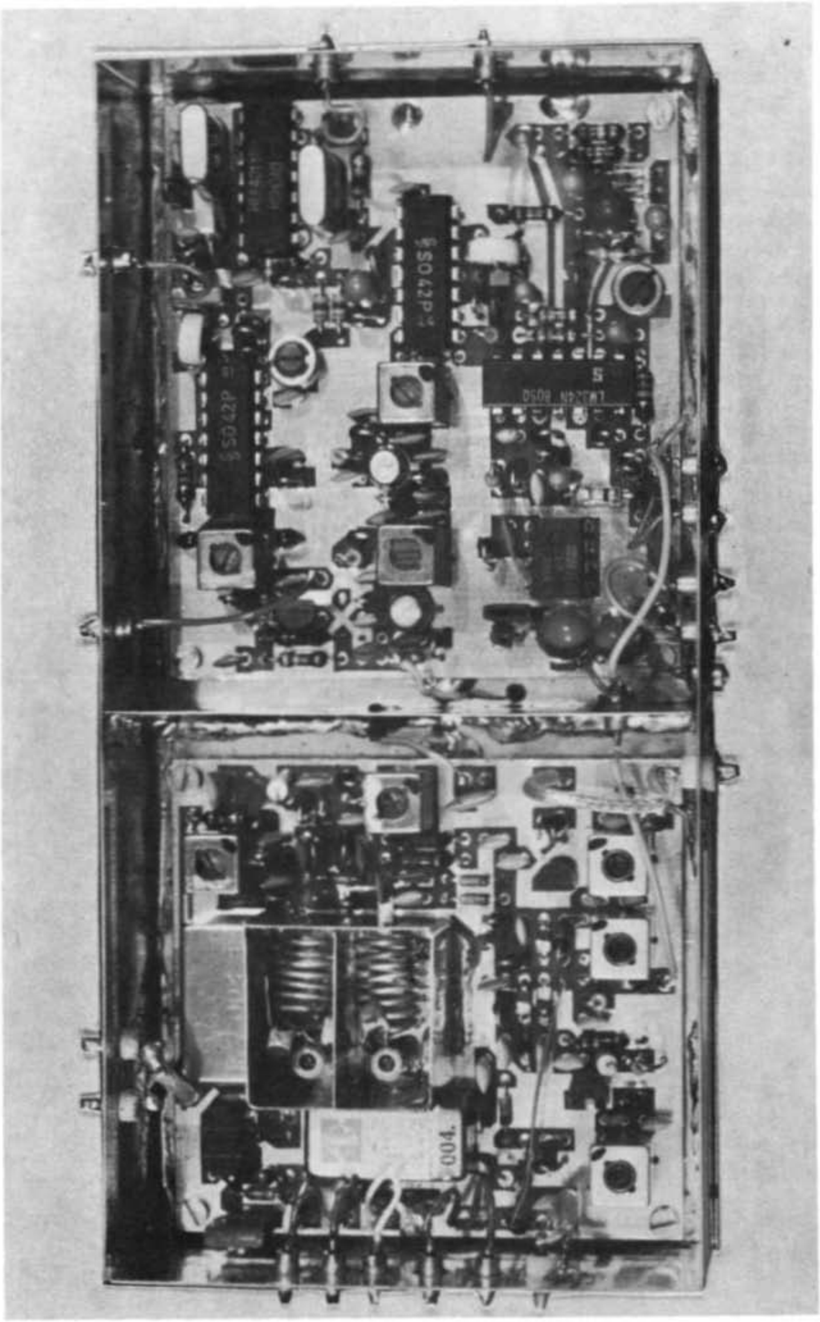


Fig. 12: Photograph of the completed SSB mini-transceiver for 145 MHz

6. INSTALLATION AND CONNECTION

The PC-board module should only be installed into the screening box alfter all the test and alignment work described in 5. has been carried out. The required holes are shown in **Figure 11**. Since the 144 MHz circuits will be slightly detuned, the alignment given in e) of section 5.3. should be repeated after installation.

Figure 12 shows the photograph of the completed transceiver.

7. MEASURED VALUES

The author and DCØZS constructed a prototype from the original PC-boards and kits available from the publishers. The measured values of both prototypes were determined in detail by the author; the resulting values are to be given in the following table. The values of the second prototype are given in parenthesis.

7.1. General Specifications

Minimum unstabilized operating voltage		12.1 V	
Stabilized operating voltage		11.6 V	(11.4 V)
Overall current drain (receive)		90 mA	(82 mA)
Overall current drain (transmit)		97 mA	(90 mA)

7.2. Receiver Specifications

Sensitivity:		RF-voltage for 10 dB (S+N)/N:	0.125 μV	(0.09 μV)
Noise ratio at U_{in} = 1 mV:			51 dB	(48 dB)
Control slope:		Variation of the AF-level on altering the RF-voltage from 1 μV to 100 mV:	6 dB	(4.6 dB)
Image selectivity:		Reference level 1 μV, control fixed, interference signal 127 MHz:	70 dB	(69 dB)
Intermodulation rejection:		$f_1 = f_{in}$ + 100 kHz; U_1 = 10 mV $f_2 = f_{in}$ + 200 kHz; U_2 = 10 mV	64 dB	(62 dB)
		Corresponding intercept point:	+5 dBm	(+4 dBm)
Intermodulation rejection in passband:		$f_1 = f_{in}$ + 1 kHz; U_1 = 10 mV $f_2 = f_{in}$ + 1.4 kHz; U_2 = 10 mV (evaluated with AF-analyzer)	48 dB	(47 dB)
Control time constants:	Level jump:	from −110 dBm to −40 dBm:	1.8 ms	(2 ms)
	Level jump:	from −40 dBm to −110 dBm:	2.5 s	(2 s)
AF-output power for 3% distortion:		(into 8 Ω)	650 mW	(820 mW)

7.3. Measured Values of the Transmitter

Output power	(into 50 Ω)	5 mW	
AF-input voltage	for drive to nominal output power:	100 mV (peak-to-peak)	
Intermodulation rejection:	f_1 = 1 kHz; f_2 = 1.4 kHz $U_1 = U_2$ adjusted so that $P_1 + P_2$ = 1 mW	35 dB	(30 dB)
Spurious rejection	(at full drive to 5 mW): between 135 and 137 MHz: at 9 MHz x 16 = 144 MHz:	 67 dB 74 dB	 (65 dB) (70 dB)
Image rejection	(126 – 128 MHz):	70 dB	(69 dB)
Carrier suppression	(at full drive to 5 mW):	65 dB	
Harmonic rejection	(at full drive):	32 dB	(31 dB)

This completes the description of the mini-SSB-transceiver. At present, the author is designing a VXO having a pull range of approximately 300 kHz and a spurious rejection of 65 dB, which can be installed in a metal box of 74 x 37 x 30 mm. A 1 W linear amplifier is also being designed. However, the author and the editors request that no technical information is requested until publication.

Jan-Martin Noeding, LA 8 AK

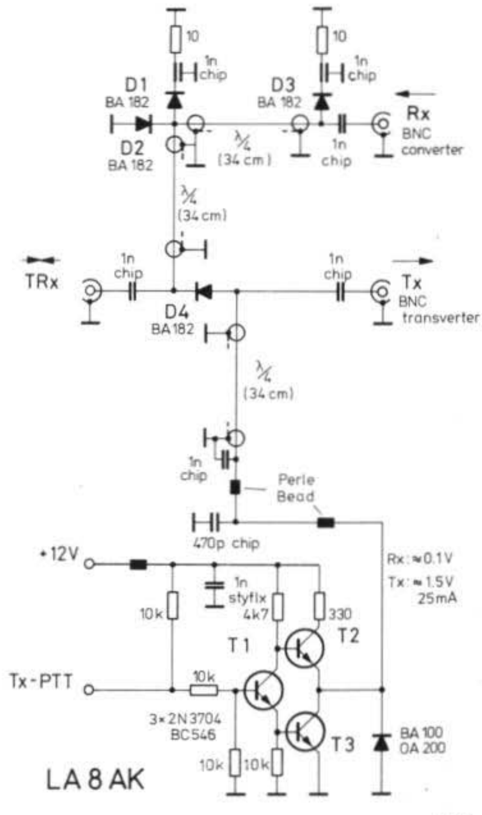
Improved Pin-Diode Switch for Transmit/Receive Switching

A simple circuit is to be described to switch the signal at the antenna connector of a 144 MHz transceiver such as the IC202 to a transmit or receive converter for the UHF or Microwave bands. This circuit has similar switching functions as the PIN-diode switching circuit described in Edition 1/1982 of VHF COMMUNICATIONS.

As can be seen in the **circuit diagram**, a total of four PIN-diodes type BA 182 (or BA243, BA282), are used which all conduct in the transmit mode. The good characteristics given in the table are obtained by replacing the previously used RF-chokes by λ/4 coaxial lines, and the general use of chip capacitors. A simple control circuit is used to generate the required voltage and current values required for switching.

Operation

When the input "TX-PTT" is not grounded, a voltage of 50 – 100 mV will be available at the output of the three-stage transistor circuit, which is more than sufficient to switch the PIN-diodes. In this mode, the signal at connector "RX" is fed to the transceive connector "TRX". The path to the "TX" connector is blocked. If, on the other hand, TX-PTT is grounded, the transistor circuit will supply approximately 25 mA, which means that D 4 to D 1 will conduct. The receive path will now attenuate signals in both directions, and the transceiver is connected through to the "TX" connector.



From connector	To connector	Attenuation	Measuring level	Drive mode
RX	TX	15 dB	– 10 dBm	PTT high
RX	TRX	≦ 0.4 dB	– 20 dBm	PTT high
TRX	TX	15 dB	– 10 dBm	PTT high
TRX	TX	≦ 0.4 dB	– 20 dBm	PTT low
TRX	RX	55 dB	+ 10 dBm	PTT low
TX	RX	55 dB	+ 10 dBm	PTT low

Measured Values

The following equipment was used during the measurements:
Signal Generator WAVETEK 3001, Fieldstrength Meter PRESTEL MC 26, Power Meter BIRD 43, as well as several attenuators. All unused connectors were terminated with 50 Ω. A power level of 5 W was available for attenuation measurements in the transmit path.

All measured values in the **Table** were measured at 144 MHz.

Friedrich Krug, DJ3RV

A Versatile IF-Module Suitable for 2 m Receivers, or as an IF-Module for the SHF Band

Part VI: Construction of the Demodulator Module DJ 3 RV 003

This description of the demodulator module DJ3RV 003 completes the series of articles regarding the construction of the IF-module of a 2 m receiver. Due to the wide range of applications, and use of high-quality state-of-the-art components, the circuitry is rather extensive. However, since each of the modules can be used individually, they allow high-quality, reliable circuits to be used and also allow room for one's own experiments.

4.2.5. Demodulator Module DJ3RV 003

Module DJ3RV 003 is provided with a selective amplifier at the input, which feeds three individual demodulator circuits for FM, AM, and SSB/CW. The required demodulator is selected by switching the operating voltage. The FM demodulator also generates the control voltage for the squelch circuit.

This PC-board also has the same dimensions as the previously described modules of the series: 74 mm x 148 mm, and can also be enclosed in a standard metal box.

Circuit Description

Figure 54 shows the circuit diagram of this module. The operation was described in detail in sections 3.5 to 3.8. of edition 3/1982 of VHF COMMUNICATIONS. The **selective** amplifier at the input is used to improve isolation between the output of the filter (XF-910) and the demodulator inputs to a greater degree than was shown in Figure 13. This is obtained by adding an additional FET P8002. The isolation using a single source-follower is too great, and the filter characteristics will change too much on switching the demodulators.

If only narrowband demodulators are to be used, it is possible to also decrease the IF-bandwidth by using a narrowband filter XF 914 or XF 915 (see Table 6) instead of the XF-910. In this case, it is necessary to also change L 1 and the base-voltage divider values of R 2 and R 3.

The two P8002 used as unbalanced differential amplifiers should be provided with the same gate-source voltage U_{GS}, and the source resistor R 1 should be calculated as described in Section 4.2.1.

The switching of the individual demodulators is made at the input and output using switching

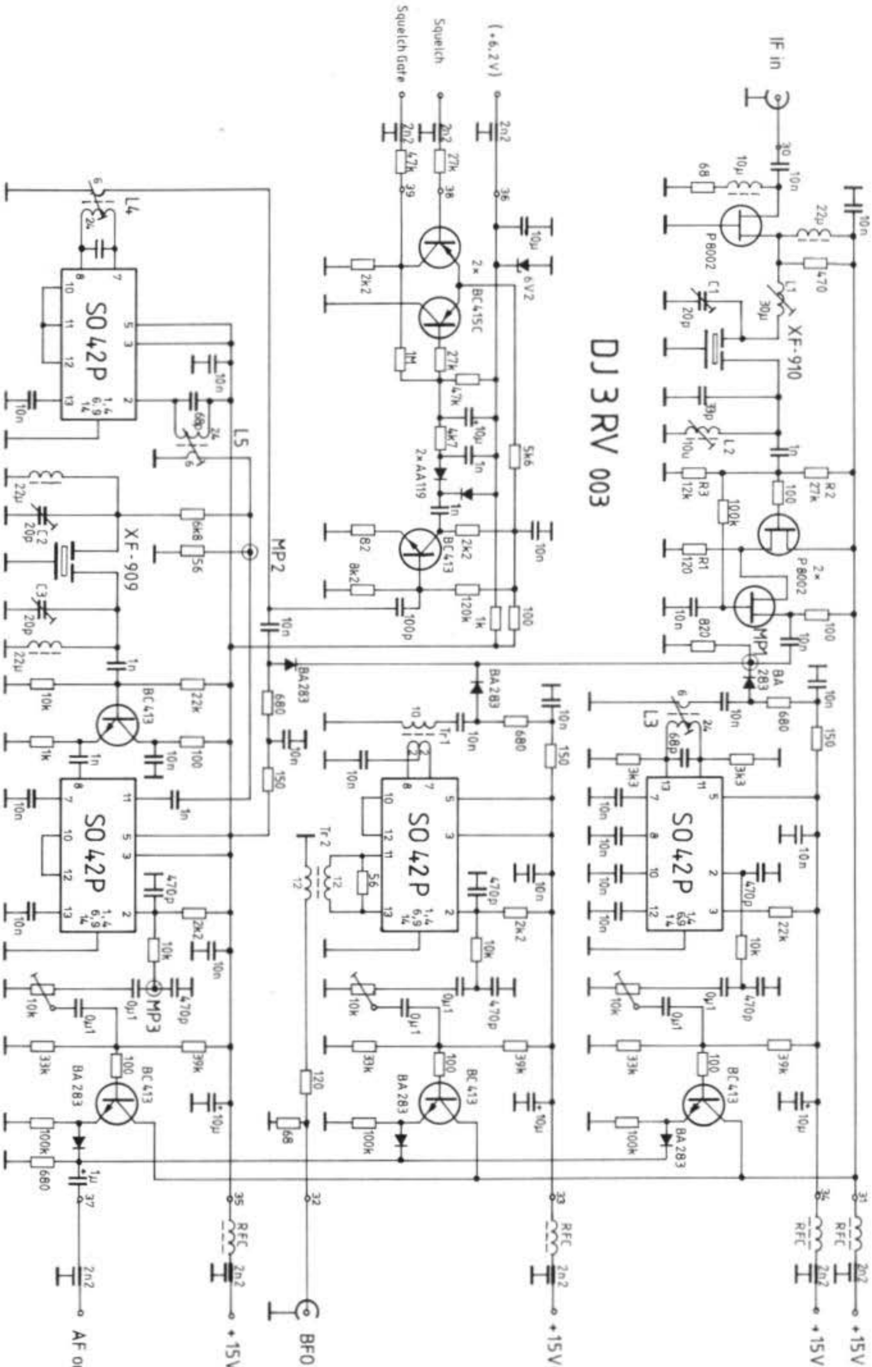


Fig. 54: The selective buffer amplifier and the switchable demodulators

diodes that are actuated using the operating voltage. During operation, it is important that only one demodulator is switched on at any time.

The envelope demodulator shown in Figure 31 is used as **AM-demodulator:** the audio signal is coupled out using a source follower and a switching diode and is fed to the AF-output. This output coupling is identical for all demodulators. Unfortunately, the AF-filter shown in Figure 34 could not be accommodated on the PC-board.

A push-pull mixer as given in Figure 32 is used as **CW and SSB demodulator** in conjunction with the BFO-signal. As described in Section 3.8., the attenuator can be deleted at BFO-levels of less than 1 mW and the input directly connected to transformer Tr2.

The circuit diagram of the **FM-demodulator** is the circuit recommended by the manufacturer of the crystal filter XF 909. The discriminator characteristic has the greatest hump-spacing. However, all conductor lanes and holes required to obtain the lower hump-spacing described in Section 3.6.2., are also provided. The values of the required components are given in Section 5.

The control voltage generation for the squelch has a greater switching hysteris than shown in Figure 30, since the resistor at the base of the first transistor BC 415 C is no longer grounded but connected to the collector of the second transistor BC 415 C.

Components

All components not specially designated in the circuit diagram are standard types of the given values.

Resistors:
Composite carbon resistors with a spacing of 10 mm
Capacitors:
Ceramic capacitors for a spacing of 2.5 mm;
Miniature types with an intrinsic resonance frequency in excess of 20 MHz should be used especially for the 10 nF bypass capacitors.
Feedthrough capacitors:
for solder mounting, approx. 2 nF.
Fixed inductances:
RF-chokes for a spacing of 12.5 mm and an intrinsic resonance frequency in excess of 10 MHz.

Wideband chokes:
6-hole ferrite-core chokes

The number of turns are valid for the special coil set 5140500000 (old designation D41-2165, orange).
The center pins not fitting the spacing should be removed.

L 1:	30 μH; 50 turns of approx. 0.2 mm enamelled copper wire
L 2:	10 μH; 30 turns, approx. 0.2 mm enamelled copper wire

L 3, L 4, L 5 have the same number of turns, but different pin connections:

	24 turns, approx. 0.2 mm enamelled copper wire
	6 turns, approx. 0.35 mm enamelled copper wire
Tr 1:	10 turns of approx. 0.35 mm dia. enamelled copper wire; 2 x 2 turns, twisted together from 0.35 mm dia. wire wound on a toroid core Siemens R6,3 K1
Tr 2:	2 x 12 turns of twisted 0.35 mm dia. wire wound on a toroid core Siemens R6,3 K1
C 1, C 2, and C 3:	20 pF plastic foil trimmer, 7.5 mm dia. (Philips: green)
R 1:	see text!

Mounting Instructions

The component location plan is given in **Figure 55**, and **Figure 56** shows a photograph of the author's prototype.

The prototype board is double-coated, but does not possess through-contacts. This means that the ground points of the components must be soldered on both sides of the board at the designated positions.

The mechanical work should be carried out first, according to the information already given in Section 4.2.1. When installing the module in a 30 mm high metal box, the spacing between the conductor side of the board and the base plate should amount to approximately 4.5 mm.

After this, it is possible for all components to be mounted on the board. The following sequence

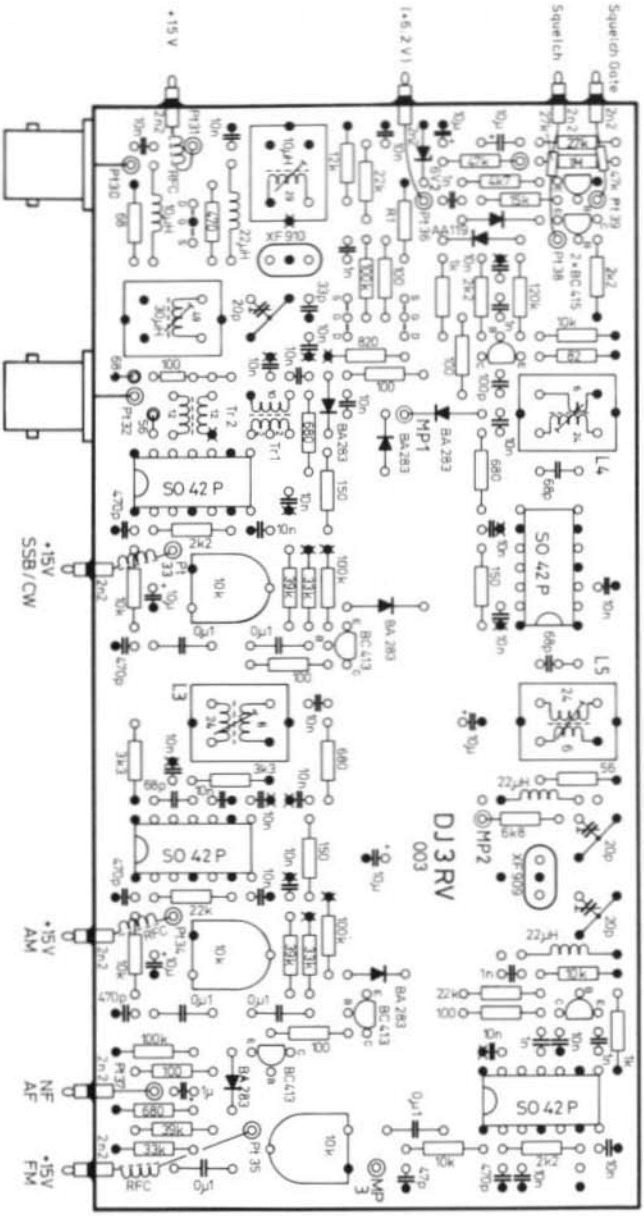


Fig. 55: The connections marked with crosses should be soldered on both sides of the PC-board DJ 3 RV 003.

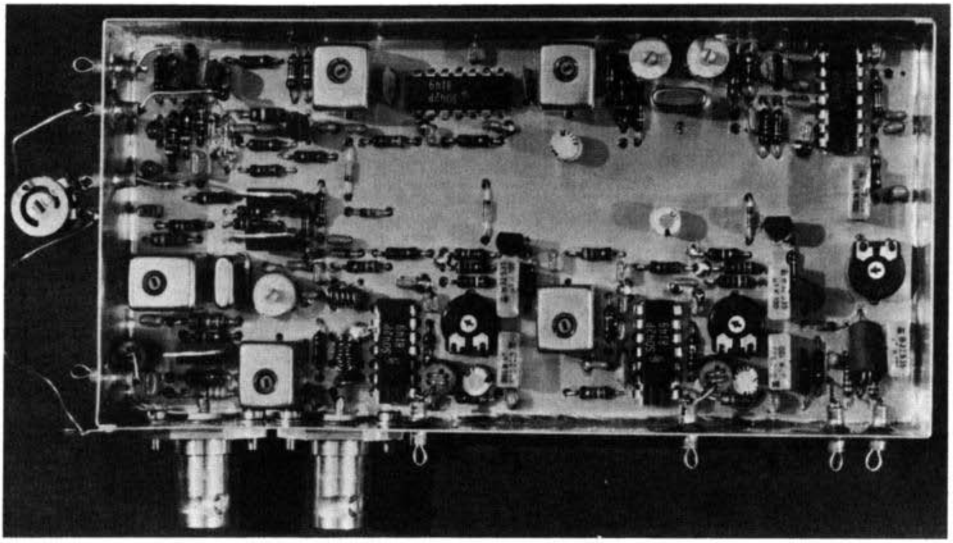


Fig. 56: Photograph of the author's prototype of demodulator module DJ3RV 003.

has been found advisable by the author:

- Resistors and ceramic capacitors, not forgetting the designated ground points, which must be soldered on both sides
- Plastic foil capacitors and electrolytics
- Inductances and transformers
- Diodes
- Plastic foil trimmers
- Fixed inductances
- Crystal filter
- Transistors and ICs
- And finally the connections to the feed-through capacitors and connectors.

Preparations and Alignment

The preparations and alignment are made in steps. Firstly align the selective buffer amplifier for the most favorable passband curve. This is achieved by feeding a swept-frequency signal of approximately 10 mV to the IF-input (Pt30), and +15 V to Pt31. The current at Pt31 should amount to 70 to 80 mA. The output signal is tapped off at test point MP 1 with the aid of a probe.

The alignment is made with L 1, C 1, and L 2 for minimum ripple in the passband range. The amplifier should then possess a nonload voltage gain of at least 20 between the input and MP 1.

After connecting a BFO-signal, it is only necessary to align the AF-amplitude at the SSB/CW demodulator. The current drain of the SSB, or the AM demodulator circuit amounts to approx. 35 mA, and approx. 50 mA for the FM-demodulator.

The alignment of the AM-demodulator is made with the aid of inductance L 3 in conjunction with an amplitude modulated 9 MHz signal of approx. 10 mV at Pt30 for maximum AF-amplitude at the audio output.

The alignment of the FM-demodulator is made in two steps. Firstly, the limiter is aligned for maximum voltage at test point MP2 by aligning L4 and L5 in conjunction with an unmodulated 9 MHz signal fed to Pt30 having an amplitude of approx. 0.3 mV. If the input signal is increased to 10 mV (+30 dB), it should be clearly limited at MP2; this means that the amplitude will not increase proportionally with the input level. This effect can easily be observed in conjunction with an amplitude-modulated signal.

The alignment of the FM-phase shift filter XF 909 is made with C 2 and C 3 to obtain the most symmetrical discriminator curve at test point MP 3. Since the phase behaviour of crystal filter XF 910 has an effect on the balance, it is advisable to inject the signal at a level of approximately 100 mV to testpoint MP 1 via a capacitor, without connecting the operating voltage to Pt 31.

In order to check the operation of the control voltage generator for the squelch, a 10 kΩ potentiometer is connected in series with a 33 kΩ resistor between Pt 36 (6.2 V) and ground, and the wiper of the potentiometer connected to Pt 38 (squelch).

The switching voltage can be observed at Pt 39 (squelch gate), and the switchover point can be varied with the aid of the potentiometer from 1 mV to 10 mV input voltage.

4.2.6. AF-Amplifier

No PC-board is offered for the AF-amplifier, as shown in Figure 35. The author constructed the AF-amplifier together with the voltage stabilizer on a Vero board. It is not necessary to screen this circuit.

The supply voltage of the AF-amplifier is not stabilized. It is taken from an electrolytic previous to the voltage stabilizer for the 5 V supply. At this point, it amounts to approximately 14 V with a residual hum of approx. 0.5 V, which does not have any adverse effect.

4.2.7. Interconnection of the IF-Module

The interconnection of the individual modules to form a complete IF-module is given in **Figure 57**. As can be seen in the circuit diagram, one virtually only requires the external controls to operate the modules, and these are usually mounted on the front panel.

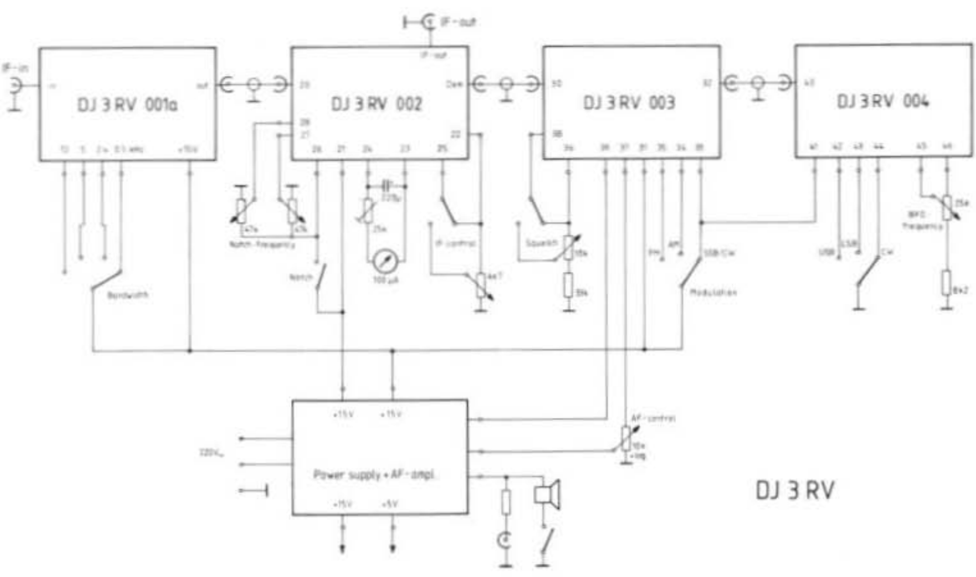


Fig. 57: Interconnection of the modules to form a complete IF-circuit

PC-Board	Power Supply	Power
DJ3RV 001	+ 15 V; 120 mA	1.8 W
DJ3RV 002	+ 15 V; 100 mA	1.5 W
Notch	+ 15 V; 100 mA	1.5 W
DJ3RV 003	+ 15 V; 110 mA	1.65 W
DJ3RV 004 Without sweeper	+ 15 V; 40 mA	0.6 W
AF-amplifier	+ 15 V; 80 mA	1.2 W
DJ7VY 002	+ 15 V; 80 mA	1.2 W
DJ7VY 004	+ 15 V; 80 mA	1.2 W
DK1OF 044/45	+ 5 V; 350 mA	1.75 W

Table 5: Power requirements

4.3. Power Supply

It is possible to feed modules DJ3RV 001 to 004 from a common power supply. It is, of course, more expensive to provide a separate voltage stabilizer for each module, however, the heat-sink problems can be solved more easily in this manner.

The design of the power supply is based on the current or power requirements of the individual modules as are given in **Table 5**. The IF-module has a mean power consumption of 7.5 W. In conjunction with an input circuit as described in Figure 1 (comprising DJ7VY and DK10F modules) the mean power consumption will amount to more than 12 W without noise blanker.

If one assumes a dissipation power in the same order for the stabilization, it will be seen that the cooling problems can only be solved when using a favorable construction. One should not forget that even the best oscillator will not be stable when it is really "baked". The amount of heat that can be produced by 25 W, can be seen easily in the case of a soldering iron!

The power supply circuitry used by the author in a VHF-receiver is given in **Figure 58**. The individual modules are connected to different voltage stabilizers so that the given dissipation powers result. The heat sinks should be designed accordingly. On switching on, it is advisable to check each individual voltage stabilizer using an oscilloscope to ensure that no oscillation or noise generation is being made. If necessary, it can be neutralized using suitable bypass capacitors.

A 50 VA toroid-core transformer using two series-connected windings is used (RK 509). A transformer of this category is required since the large peak currents flowing due to the operational rectifier will magnetize the core material to saturation.

5. MODIFICATIONS TO THE CIRCUITS

The following section is to indicate a number of possible modifications to the circuit. These comprise the reduction of the IF-bandwidth previous to the demodulators, the circuits having a lower hump spacing in the FM-discriminator, as well as the modification of the control time constant in the IF-amplifier. Holes and connector lanes are already provided on the PC-boards for these modifications.

The possibility of reducing the noise bandwidth by using narrower-band filters previous to the demodulators was mentioned in the circuit descriptions. A filter XF-914 or XF-915 could be used instead of the filter XF-910 (see **Table 6**).

Type	Application	Hump spacing/ band width	Impedance
XF-909	Discriminator	± 14 kHz	6.8 kΩ
XF-910	Two-pole filter	± 7.5 kHz	6 kΩ//0 pF
XF-914	Two-pole filter	± 1.75 kHz	1.8 kΩ//10 pF
XF-915	Two-pole filter	± 3,75 kHz	5.7 kΩ//2 pF
XF-919	Discriminator	± 1.2 kHz	470 Ω

Table 6: Suitable two-pole crystal filters

When using a crystal filter XF-915, no modifications need to be made to the components, normally used together with filter XF-910. An alignment is possible using the values given in the circuit diagram.

In the case of crystal filter XF-914, the inpedance values have been changed from the values originally given by the manufacturer. The new impedance of 1.8 kΩ/10 pF requires changes of the component values. Since the filter can be used on PC-boards DJ 3 RV 001, 002, and 003, the data is given for all boards, and not only for the demodulator.

Module DJ 3 RV 001:
L5: 7 μH, 25 turns of approx. 0.2 mm dia. enamelled copper wire. The capacitor parallel to L 6 is to be increased to 22 pF, and the two base-voltage divider resistors at T 2 should be reduced to 3.9 kΩ, each.

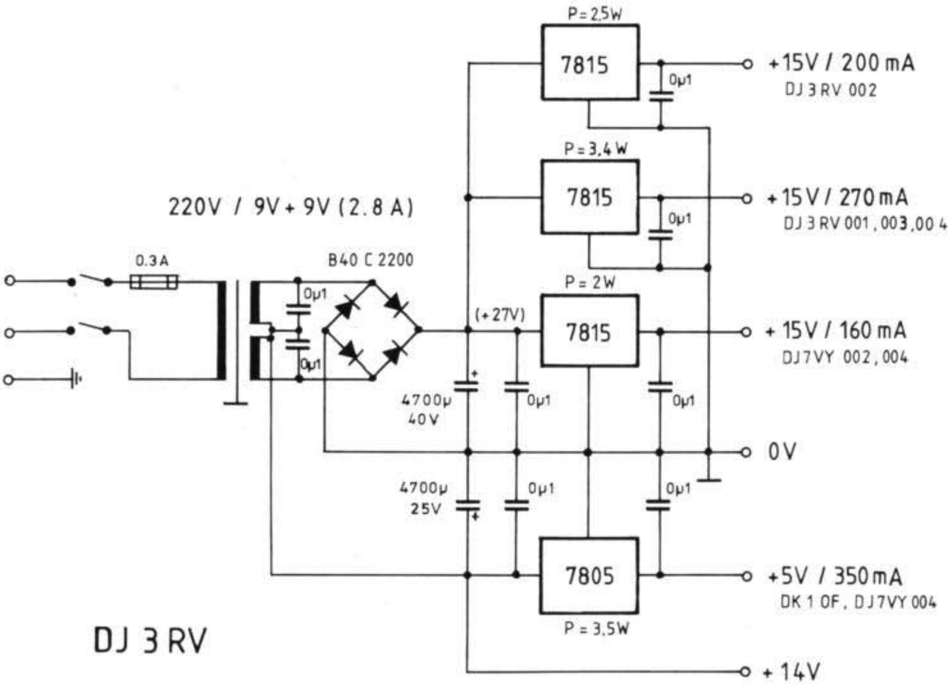


Fig. 58: Power supply with voltage stabilizers for feeding a complete 2 m receiver

Module DJ3RV 002:
The resistor between the collector of T9 and the filter should be reduced to 820 Ω. Solder a capacitor of 8.2 pF in parallel to the input of the filter. No holes are provided on the PC-board for this capacitor. It should be soldered on the conductor side of the board. At the output of the filter, a resistor of 2.2 kΩ should be connected in parallel to L7. This resistor is mounted in a space between L7 and T12.

Module DJ3RV 003:

- L1: 14 μH, 35 turns of approx. 0.2 mm dia. enamelled copper wire
- C1: 40 pF plastic foil trimmer
- L2: 14 μH, otherwise as L1
- R2: 6.8 kΩ
- R3: 2.7 kΩ

The gain of the selective buffer amplifier is thus reduced by approximately 3 dB.

The FM-demodulator operates as a phase shifter using a crystal filter; types XF-909 and XF-919 are suitable.

The circuit diagram given in Figure 54 shows the circuit recommended by the manufacturer for the Dual XF-909. In the case of filter XF-919, the value of the resistor between L5 and C2 should be changed from 6.8 kΩ to 470 Ω. In this case, the discriminator has a hump spacing of 2 kHz.

In the circuit given in Figure 26 (VHF COMMUNICATIONS 14, Ed. 3/1982), the filter is driven at high impedance via an LC-link from the 22 μH-inductance and 40 pF plastic foil trimmer. This allows even lower hump spacings to be obtained, as can be seen in Figures 27 to 29. This circuit can be built up on the PC-board by shifting the 22 μH inductance by one hole spacing. The 6.8 kΩ resistor is then deleted.

The control time constant is determined by C_T and R_T and the control-up behaviour is very non-linear, operating according to an expotential function. A linear behaviour is shown by the circuit given in **Figure 59**. A charge resistor R_T1 is connected to +15 V, and the limiting of the maximum control voltage is provided by the Schottky diode. Before commencing operation, (see Section 4.2.2.) (VHF COMMUNICATIONS

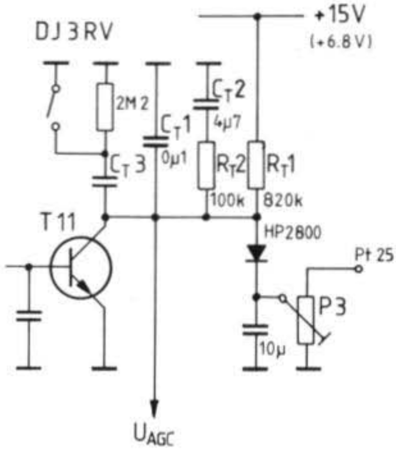


Fig. 59:
Modified control time constants (DJ3RV 002)

1/83), the wiper of P3 should be fed to a voltage of +5.2 V. A further version of the control behaviour is given by switching C_T to C_T1 and C_T2. The control-up is made rapidly after short signals, e.g. interference signals, according to time constant $t = C_T1 \times R_T2$, since only C_T1 will be discharged in the case of short signals. In the case of signals having a longer duration, C_T2 will also be discharged with the time constant $C_T2 \times R_T2$. The control-up is then made slowly with the time constant $(C_T1 + C_T2) \times R_T1$.

The time constants can also be varied by switching the capacitors, for example, as shown with C_T3.

Modifications on the board are that the Schottky diode and R_T1 are mounted between T14 and T12 instead of R_T.

In order to obtain a less linear behaviour, R_T1 can also be connected to +6.8 V instead of +15 V. These possibilities allow the adjustment of any individually required control behaviour.

The 80 MHz circuit mentioned in Part 1 of this series of articles is still under development. This will allow the construction of a receiver for the frequency range of 100 kHz to at least 30 MHz having characteristics similar to those of measuring equipment.

Erwin Schaefer, DL 3 ER

A Stripline GaAs-FET Preamplifier and Mixer for the 10 GHz Band complete with IF-Preamplifier, Image Frequency Filter, and Power Supply.

Part 2

4. 10 GHz PREAMPLIFIER IN STRIPLINE TECHNOLOGY

The following is to report on experiments with the new Siemens GaAs-FET type CFY 11, whose noise figure amounts to approximately 3 dB in the 10 GHz band, together with gain values in the order of approximately 5 to 6 dB. Some assistance was taken from (1). The construction is made using low-loss, double-coated PTFE PC-board material RT/duroid 5870. The dimensions are selected so that a simple construction can be made using the common waveguide WR 90 (R 100). The design allows also the use of 50 Ω lines such as RG 141 semi-rigid cable.

Two different constructions are to be realized and examined with the measuring equipment available:

a) An amplifier with integrated hybrid mixer and IF-amplifier,

b) Amplifier with subsequent image frequency filter, mixer, and IF-preamplifier.

4.1. Circuit Diagram and Layout

The circuit diagram is given in Figure 14. The following components were used:

T:	CFY 11 (Siemens)
D 1, D 2:	BAT 14-074, or -084, or -094 (Siemens)
L 1:	Printed $\lambda/4$-transformation link, $Z = 61\ \Omega$
L 2:	Printed 5 $\lambda/8$-line, $Z = 70\ \Omega$
RFC 1:	Printed $\lambda/4$-choke, $Z \approx 120\ \Omega$

All non-designated lines have $Z = 50\ \Omega$

C 1, C 2:	Isolating capacitors made from cellotape and copper foil (see text)
C 3:	680 pF – 1 nF ceramic disk capacitor (uncritical)
C 4, C 4':	$\lambda/8$-line capacitance, $Z = 86\ \Omega$
C 5 – C 9:	Printed bypass capacitors
C 10, C 11:	Approx. 150 pF chip capacitors

The amplifier is integrated with the mixer as described in Section 1. R 2 is designed to leak static charges to ground when no power supply is con-

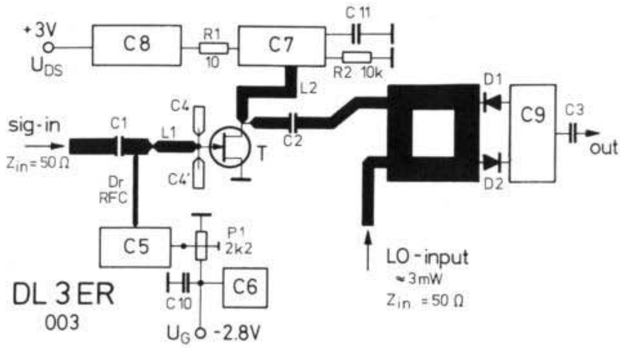


Fig. 14:
10 GHz amplifier equipped with GaAs-FET CFY 11

nected. C 10 and C 11 are chip capacitors, and are designed to suppress RF-interference (HF, VHF, UHF).

The RT/duroid PC-board shown in Figure 15 is 55 mm x 25 mm. If the amplifier is to be used on its own, it is possible for the mixer to be deleted after the dashed line, so that the amplifier is then only 30 mm long.

4.2. Construction Details for the Amplifier Board

The GaAs-FET used does not have any protection diodes, which is usual for active components for the highest frequency range. For this reason, extreme care should be taken when working with such components. The highest risk is present during unpacking the transistor and soldering it into place.

It is very advisable to prepare a grounded work surface. It is usually sufficient to use a copper-coated board, which is grounded, and connected to the ground of the soldering iron. The transistor should be only held with the tweezers at the source connection. In order to avoid electrostatic charge, it is advisable to ground oneself to the board before touching the transistor. The rest of the board should already be completed so that the soldering-in of the transistor is the last operation. One should ensure that the protective resistor R 2, and P 1 are already connected, and are making good contact.

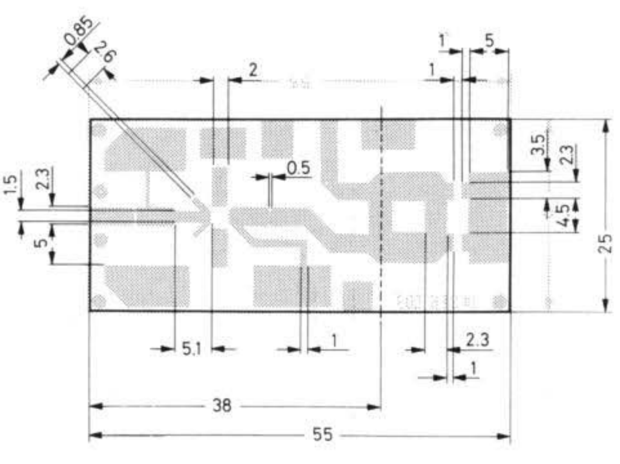


Fig. 15:
RT/duroid board for the 10 GHz amplifier/mixer

The safest way is to solder the transistor into place with the soldering iron just switched off. The author uses a "Weller Magnastat" soldering iron and has not had any difficulties uptil now; however, this was not the case when using soldering irons, which are directly operated from the power line.

The conductor lanes should be tinned slightly beforehand, and during the soldering process one should allow the solder to flow up to the ceramic case. Colophonium that has been dissolved in spirit should be used as flux. After carrying out the soldering process, remove the residual flux with the aid of spirit. Of course, the PC-board should be through-contacted with the aid of thin foil at the positions marked "X", or contacted around the edge of the board. Special attention must be paid to the through-contacting of the source.

The following should be noted regarding construction of the mixer: The mixer diodes should be soldered into place in a plate or cardboard box, since they are so small that it is virtually impossible to find them if they should drop onto the floor! This cautionary measure saved a lot of the author's diodes!

4.3. Determining the Constructional Values

Base material: RT/duroid 5870
$E_r = 2.35$
$d = 0.79$ mm

Transistor: CFY 11 (Siemens)

Selected operating point: $I_{DS} = 10$ mA
$V_{DS} = 3$ V

The associated S-parameters for 10 GHz are:
$S_{11} = 0.6 \quad +110°$
$S_{22} = 0.36 \quad -102°$

The consideration of S_{12} and S_{21} would lead to too complicated calculations and would also prerequire that the board was realized with very high accuracy according to the calculated values. The prototype drawings of the author were prepared in a scale of 1:1 on transparent foil, which means that the best accuracy is in the order of ±0.2 mm.

The series impedances are now determined according to (6):

$Z_{ES} = 18.7 + j\,32.2\ \Omega$
$Z_{AS} = 34 - j\,27.5\ \Omega$

We refer to the parallel impedances when considering the matching circuits. These are as follows according to (6):

$Z_{Ep} = 74\ \Omega \parallel j\,43\ \Omega$
$Z_{Ap} = 56\ \Omega \parallel -j\,69.5\ \Omega$

4.3.1. Matching the Amplifier Input to $Z_{in} = 50\ \Omega$

The real component is matched with the aid of a series λ/4-line whose impedance is:

$$Z_0 = \sqrt{Z_E \times Z_{Ep}} = \sqrt{50\ \Omega \times 74\ \Omega} = 61\ \Omega$$

This line is designated as L 1 in the circuit diagram.

The dimensions of L 1 are:

Conductor lane length: $= \lambda_0/4 \times V_p$
$= 5.1$ mm

with: $\lambda_0 = 29.1$ mm
$V_p = 0.7$

where $V_p = 1/\sqrt{E_{eff}}$ and E_{eff} can be calculated as follows according to an equation given in (7):

with: w = conductor lane width
h = thickness of dielectric

According to the line equations (5), the amount of the input impedance X corresponds to the impedance Z of the line for a line length of λ/8.

It is thus $|X| = Z$, and is, of course, valid also for
$|X| = \lambda/8 + n \times \lambda/2$
with: $n = 0, 1, 2, \ldots$

An open λ/8-line will have a capacitive reactive input impedance; a short-circuited line, on the other hand, will possess an inductive one. The amount corresponds to the impedance Z of the line. It is thus – within the range of possible conductor lane widths – feasible to use other PC-board material such as epoxy-glass fiber or PTFE, and to form inductances and capacitances with them. On the other hand, the use of concentrated components is no longer possible due to the wave propagation since their dimensions cannot be neglected with respect to wavelength. (Nearly all capacitors do not represent capacitances at frequencies in excess of 2 to 3 GHz, due to their high inductivity!)

The inductive reactive component at the input of the transistor of 43 Ω can be compensated for with an open line of $\lambda/8$, having an impedance of $Z_L = 43\ \Omega$.

For reasons of balance, the line of $Z = 43\ \Omega$ is formed by two parallel-connected lines of twice the impedance:

$$2 \times Z_L = 86\ \Omega$$

The conductor lane width is 0.85 mm, and the length is $l = 2.6$ mm after taking the velocity factor into consideration. These conductor lanes are designated C4 and C4' in the circuit diagram.

4.3.2. Output Matching

It is assumed that a load of 50 Ω is present at the output.

The real component of the transistor output impedance is 56 Ω, and therefore virtually corresponds to the load impedance. The low mismatch is acceptable, and no matching circuit is used.

It is only necessary to compensate for the capacitive component of the output impedance. A short-circuited $\lambda/8$-line is suitable for this. As has been seen, the $\lambda/8$-line is very short, which makes it extremely difficult to make defined short-circuits. Furthermore, one requires alignment possibilities, and V_{DS} should be fed in without additional components. All these demands must be taken into consideration during construction.

As previously mentioned, the impedance relationships are not changed if the line length is increased by a multiple of $\lambda/2$. It is therefore possible for the line to be 5/8 λ long and the short-circuit to be made at the end of a line using a low-impedance $\lambda/4$-choke having a low-impedance Z (5 to 10 Ω). Due to its surface area, it is also effective as a capacitance (C 7 in the circuit diagram). For this reason, the following is valid:

Line length $l = 2.6 \times 5\ (5/8\ \lambda!) = 13$ mm, which is designated L 2 in the circuit diagram.

The conductor lane width is 1 mm for the required impedance of $Z_L = 70\ \Omega$.

4.3.3. Blocking Capacitors C 1 and C 2

These capacitors are necessary to ensure that the operating voltages of the transistor are not short-circuited by the external connections, but should not block the operating frequency. Disk capacitors or chip capacitors of conventional construction are not suitable. Special capacitors have been available for some time now, but they are very expensive at low quantities. For this reason, blocking capacitors are to be home-made types:

The conductor lane is disconnected at input and output and the cut width should amount to approx. 0.2 to 0.5 mm. A piece of metal foil corresponding to the width of the conductor lane is now soldered to one side of the cut conductor lane, and spaced approximately 3 mm over the other side. A piece of cellotape ($E_r \approx 10$, $d \approx 0.1$ mm) is used as dielectric (or similar insulating foil), and the configuration is fixed with nail varnish. The author has also used nail varnish with success as dielectric for such capacitances. Allow enough time to dry, and then check for any shortcircuit.

The following is valid for the capacitance:

$$C_{pF} = \frac{0.086 \times E_r \times F/\text{cm}^2}{d/\text{cm}}$$

this results in $E_r = 10$. $d = 0.01$ mm
$F = 0.06\ \text{cm}^2\ (2 \times 3\ \text{mm})$
$C \approx 5\ \text{pF} \approx 3\ \Omega/10\ \text{GHz}$

This value is completely sufficient for coupling.

If a probe is used at the input and output, a blocking capacitor will, of course, not be required.

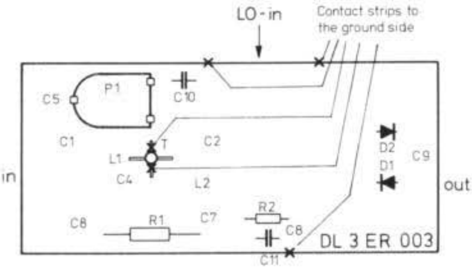


Fig. 16: Component locations on board DL 3 ER 003

4.3.4. RFC 1 and 50 Ω Lines

RFC 1 is a λ/4 choke with an impedance Z_L = 120 Ω.
Line length: l = 5.2 mm
Line width: w = 0.3 mm

Amplifier input and output, as well as mixer and oscillator input are designed for a real impedance of Z = 50 Ω. Conductor lane width w = 2.3 mm.

Figure 16 shows a drawing in a scale of 2:1 with the calculated conductor lane dimensions.

4.4. Connecting the Amplifier

A voltage of U_{DS} = + 3 V is set for the operating voltage. The voltage inverter will then provide approximately −2.8 V. Firstly check, whether the required currents can be supplied. One must take into consideration that the inverter must firstly run up, which means that the transistor is switched on via I_{DSS} (U_{GS} = 0). The current I_{DSS} amounts to approximately 50 mA and will not damage the transistor. After running up, the voltages should amount to U_{DS} = 3 V and U_{GS} = −2.8 V under load and should not change after being loaded by max. 30 mA or approx. 10 mA.

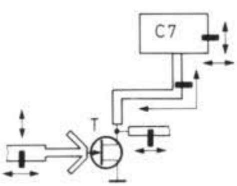


Fig. 17: Alignment aids on the 10 GHz amplifier

The amplifier remains disconnected during these preliminary checks. After connecting together, P 1 is now aligned so that the maximum gate bias voltage of approximately −2.8 V is connected to the gate. After switching on, the voltage drop across R 1 is measured at high impedance and the current I_{DS} ≈ 10 mA is selected. A variation of the current will show that the amplifier is oscillating, e. g. when the circuit is touched. However, no tendency to oscillation has been noticed with any prototypes manufactured by the author, when constructed carefully.

Note:
Gate bias voltages in excess of −5 V or over +0.5 V should be avoided. The gate-source path will be destroyed at voltages in excess of +0.7 V. In order to avoid the effects of electrostatic charge, it is important that P 1 is kept as low-impedance as possible.

4.4.1. Alignment Possibilities

In order to avoid too wide a bandwidth, alignment possibilities have been created to limit the bandwidth to that required for amateur applications. These are given in Figure 17. This is achieved by placing small metal plates of approximately 1.5 x 3 mm of thin metal foil onto the conductor lanes and shifting these in both axial directions to obtain the lowest noise figure, or highest gain (virtually identical). These possibilities are shown in **Figure 17**. Not all of this will be required.

It is advisable to stick the small metal plates to a thin insulating pin and then find the best adjustment. After this, the metal plate is soldered to the determined position. Of course, it is very important to avoid any shortcircuits between conductor lanes and ground.

The adjustment of the small metal plates is virtually independent of the adjustments on the alignment screws in the waveguide when a probe-coupling is used. On the other hand, further experiments can bring some improvements when carrying out changes on the waveguide side.

Of course, one can solve matching problems very easily with the aid of a network analyzer. However, there is no use giving such measuring methods when only a few (professional) amateurs have such equipment available to them. As can be seen in the measuring results, very usable results can be obtained even with simple means.

Results:
Noise figure $NF_{DSB} \approx 3$ dB
Local oscillator suppression ≈ 30 dB
with: IF = 144 MHz
NF_{IF} = 1.5 dB
P_{Osc} = 3 mW at 10.368 GHz
f_{in} = 10.224 GHz

It was not possible for the author to carry out the gain measurement. However, it can be assumed to be in the order of 5 to 6 dB according to the specifications of the transistors and the results of the experiments.

4.5. Measuring Results of the Integrated Amplifier/Mixer

The integrated amplifier/mixer only improves the noise figure slightly over the already good mixer characteristics. An improvement is only possible by adding an image-frequency filter between amplifier and mixer (2). The advantages are, however, in the suppression of the oscillator frequency and in the reduction of the effect of sensitivity fluctuations of the mixer, e. g. due to too low an oscillator power.

4.6. Measuring Results of the Amplifier with Image-Frequency Filter in front of the Mixer

The amplifier was built up according to the construction details given in Figure 14 and 15 and was combined with a waveguide filter as described in Section 3, Figure 11, as well as a mixer provided with a probe-coupling in the waveguide, as shown in Section 1, Figure 6. The measuring system remained unchanged. The noise figure improved, as was to be expected:

$NF_{SSB} \approx 3.5$ dB

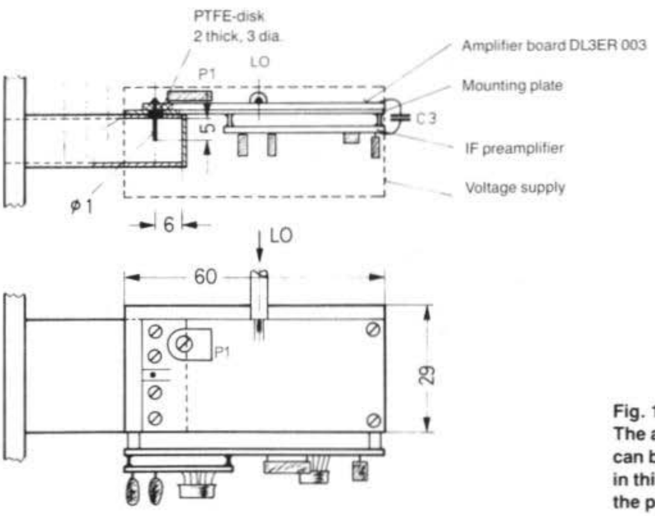


Fig. 18: The amplifier and power supply boards can be mounted onto the waveguide in this manner, which also solves the probe coupling

The suppression of the local oscillator frequency remained unchanged.

The gain of the amplifier on its own was measured to be approximately 5 to 6 dB as previously estimated.

4.6.1. Constructional Notes

The board shown in Figure 15 has now been shortened to 38 mm. The rest of the hybrid mixer, but not the printed capacitances, are removed up to the bend in the line, approximately 5 mm behind the blocking capacitor cut. Of course, one can remove the non-required conductor lanes before etching, using a cleaning fluid; or one can etch it twice after covering the upper and lower side correspondingly.

4.7. Instructions for Mounting onto the Waveguide

4.7.1. Integrated Amplifier/Mixer

The installation is made similar to Figure 6, and is shown in **Figures 18 and 19.**

The amplifier is mounted onto the waveguide with the aid of a 0.8 mm thick brass mounting plate. The threading for the mounting (M 1.4) is cut into the waveguide. Attention should only be paid that the screws do not protrude into the center of the waveguide; their protruding into the edge of the waveguide does not cause too much interference if it is only by 1 or 2 mm. The IF-preamplifier is mounted below the mounting plate, and is connected directly to the mixer lowpass filter via an approximately 680 pF capacitor. The voltage supply is mounted on the narrow side of the waveguide. The oscillator injection is made via a coaxial cable using a 50 Ω line as shown in Figure 5.

4.7.2. The Amplifier on its own

In order to construct an individual amplifier for experiments in receive and transmit applications, a board DL3ER 003 was constructed without mixer. It is screwed onto a piece of wave-

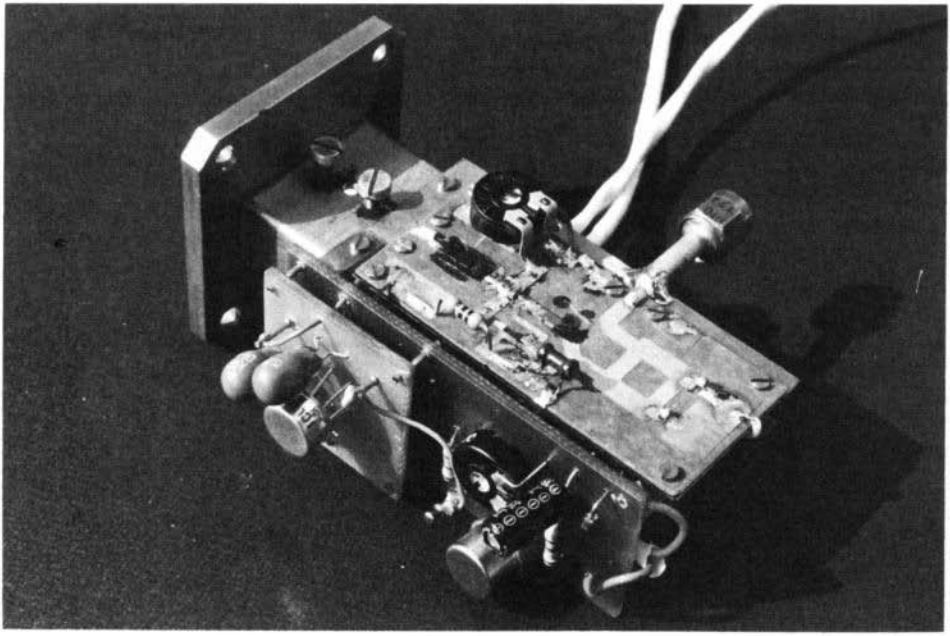


Fig. 19: Photograph of the author's prototype of the system shown in Figure 18

guide using a mounting plate of 0.8 mm brass plate (Figure 20). This waveguide possesses two panels to ensure that the probe pins for input and output of the amplifier are sufficiently decoupled. The waveguide is long enough to allow three matching screws, each, at the input and output of the amplifier, as well as flanges at each end (Figure 21). The voltage supply is to be found on the opposite side of the waveguide to the amplifier. Connection and alignment have already been described.

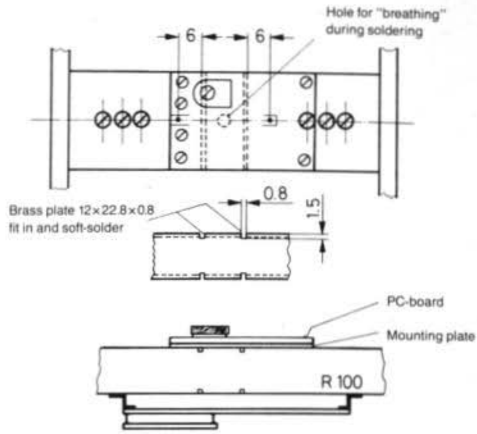


Fig. 20: Mounting the amplifier with its voltage supply onto the waveguide

5. VOLTAGE SUPPLY

The GaAs-FET amplifier equipped with a CFY 11 requires a voltage U_{DS} = +3 V as well as a variable negative gate bias voltage of between 0 and −2 V for setting the drain current between 10 and 15 mA. In order to avoid any electrostatic charge at the gate, which could destroy the GaAs-FET, it is important that the gate-source path is at low-impedance with respect to DC-current. The trimmer potentiometer for adjustment should therefore not be greater than 2.5 kΩ.

Fundamentally speaking, both voltages could be provided from batteries whose charge condition must then be monitored continuously. It is better

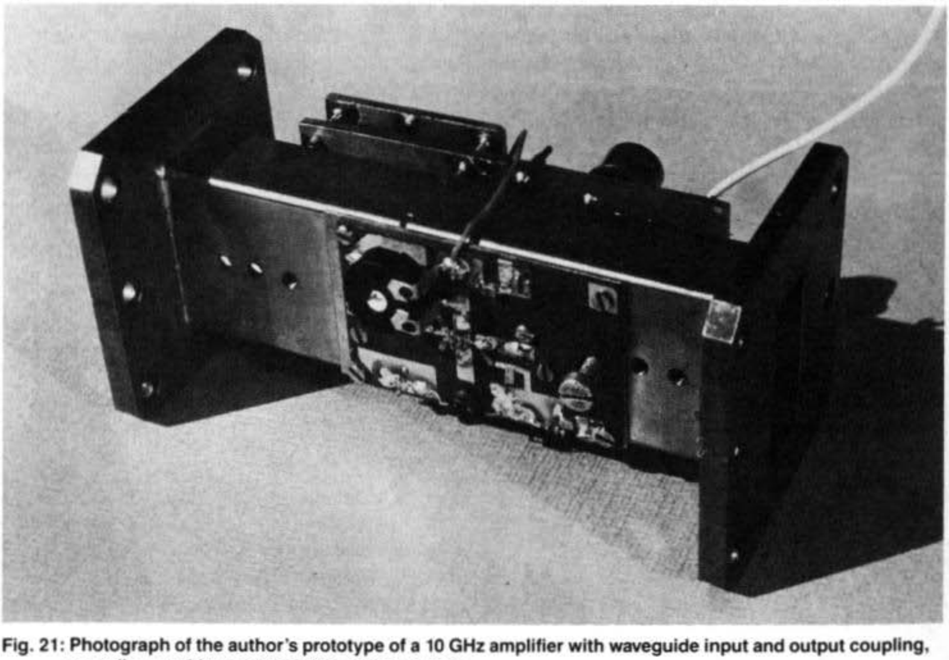


Fig. 21: Photograph of the author's prototype of a 10 GHz amplifier with waveguide input and output coupling, as well as positive and negative voltage supply

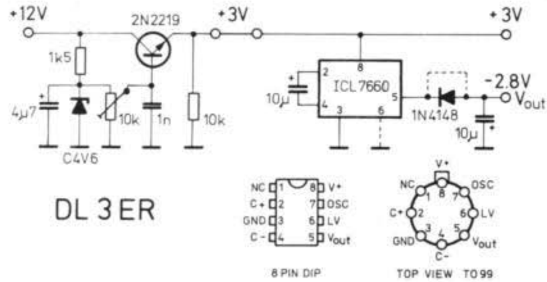


Fig. 22:
Circuit of the ICL 7660 CPA for generating a negative voltage from a positive input voltage between 1.5 and 10 V

for the operating voltages, however, to be obtained from the normal 12 V supply.

Negative voltages – even at low-power levels as required for bias voltages – could only be obtained so far from a positive supply voltage with some extent of components and room. This problem can now be solved easily using a monolythic C-MOS voltage converter such as the ICL 7660, manufactured by INTERSIL. This circuit can be used to drive the low-impedance voltage divider to obtain the required gate voltage (8). **Figure 22** shows the simple application circuit diagram and **Figure 23** shows a board for our application. The one-off price of approximately DM 10.— for the IC 7660 is well worthwile. In order to universally use the inverter, it was built up as a separate module on a 25 mm x 25 mm large epoxy board. This is later soldered onto the 3 V voltage supply board using four solder pins having a spacing of approximately 5 mm (**Figure 24**).

The following must be noted:
At input voltages lower than 3.5 V, connection LV (pin 6) of the ICL 7660 should be connected to ground; in the case of higher voltages, it remains disconnected.

Diode D_x is only required at input voltages in excess of 6.5 V. At lower input voltages, it will not be required or it can be short-circuited. The integrated board allows a compact construction with the CFY 11 amplifier directly connected to the waveguide (Figure 25). The width of the board therefore amounts to 25 mm as for all modules.

6. REFERENCES

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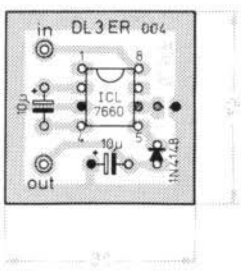

Fig. 23: The DIP line version of the ICL 7660 was used for bias voltage generation for the 10 GHz amplifier. These are accommodated on PC-board DL3ER 004

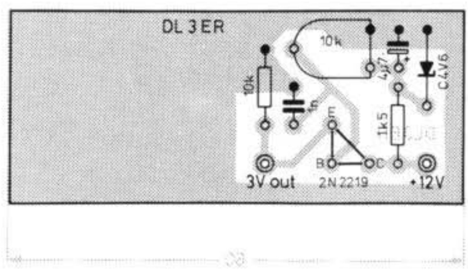

Fig. 24: PC-board for the 3 V supply including the mounting surface for the inverter shown in Figure 23.

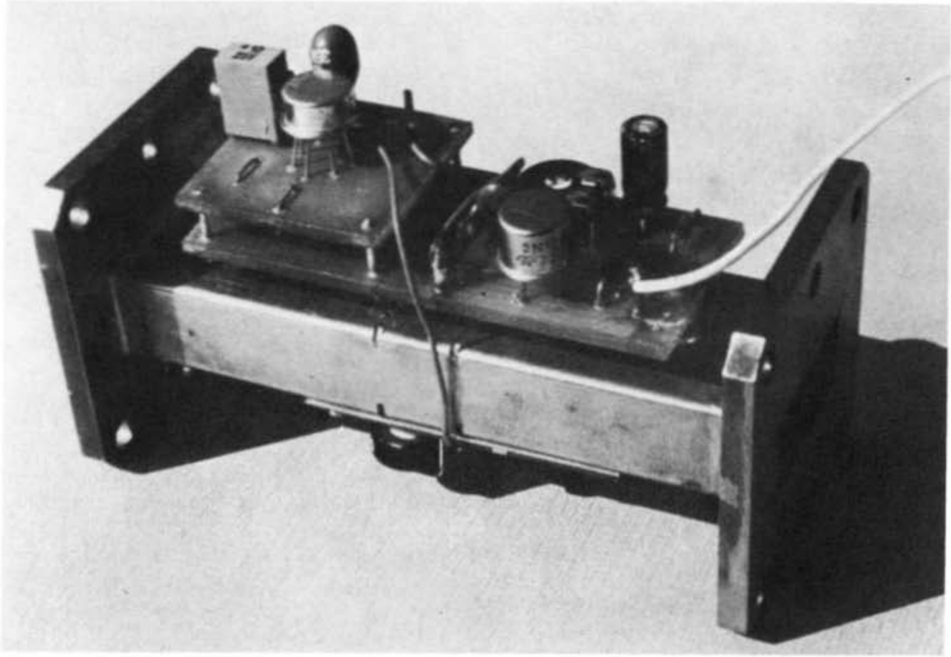

Fig. 25: Voltage supply as mounted onto the waveguide

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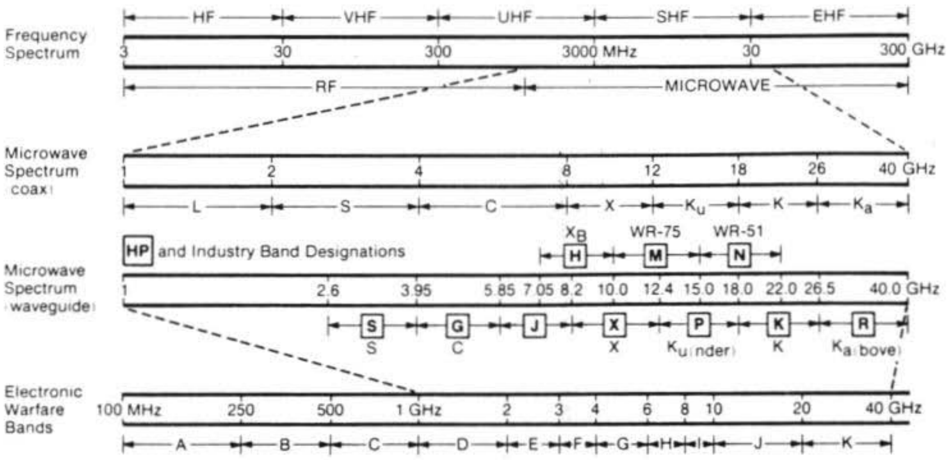
Editors

Designation of the Microwave Bands and Waveguide Specifications

Hewlett Packard has given us their kind permission to reprint an illustration and a table, which will interest all microwave enthusiasts. The first illustration shows the limits and designations of the various microwave bands, and the large table gives the standard specifications of the rectangular waveguides. In addition to giving the four most common designations (IEC in Europe) one will also find the JAN-designations of chokes and standard flanges, as well as the inner and outer dimensions of the waveguides, their cutoff frequencies, and their theoretical loss values at the upper and lower cutoff frequencies for the TE_{10} mode in dB/100 ft for brass/aluminium (upper row) and silver (lower row), as well as finally the maximum continuous power level at the two cutoff frequencies. Since these levels are very high – for instance 250 kW at 10 GHz – they should not worry us very much.

wr



HP Band Designation	Frequency Range TE_{10} Mode (GHz)	Band Designations					Material B-Brass A-Alum. S-Silver	JAN[2] Flange Designation		Waveguide Dimensions						Nom. Wall Thickness mm (in.)	Cutoff Frequency (GHz)	Theoretical Attenuation Low to High Frequency[3] Brass/Alum/Silver dB/100 ft	Theoretical Attenuation Low to High Frequency[3] Brass/Alum/Silver dB/100 Meters	Theoretical[4] CW Power Low to High Frequency Megawatts (Kilowatts)
		IEC R-	EIA WR-	British WG-	JAN[1] RG-	Other Common Usage		Choke UG-	Cover UG-	Inside Width cm (in.)	Inside Height cm (in.)	Inside Tol μm (mils)	Outside Width cm (in.)	Outside Height cm (in.)	Outside Tol μm (mils)					
	1.12 - 1.70	14	650	6	69 103	L	B A		417B 418B	16.510 (6.50)	8.255 (3.25)	±12.7 ±5	16.916 (6.66)	8.661 (3.41)	±12.7 (±5)	2.03 (0.080)	0.908	0.412 - 0.272 0.269 - 0.178	1.353 - 0.894 0.883 - 0.584	11.8 - 17.1
	1.45 - 2.20	18	510	7			B A			12.954 (5.10)	6.477 (2.55)	±12.7 ±5	13.360 (5.26)	6.883 (2.71)	±12.7 (±5)	2.03 (0.080)	1.16	0.574 - 0.390 0.374 - 0.255	1.883 - 1.280 1.229 - 0.836	7.5 - 10.6
	1.70 - 2.60	22	430	8	104 105	LS,R	B A		435B 437B	10.922 (4.3)	5.461 (2.15)	±12.7 ±5	11.328 (4.46)	5.867 (2.31)	±12.7 (±5)	2.03 (0.080)	1.375	0.759 - 0.504 0.496 - 0.329	2.492 - 1.655 1.626 - 1.080	5.2 - 7.5
	2.20 - 3.30	26	340	9A	112 113		B A		553A 554A	8.636 (3.40)	4.318 (1.70)	±12.7 ±5	9.042 (3.56)	4.724 (1.86)	±12.7 (±5)	2.03 (0.080)	1.735	1.030 - 0.716 0.673 - 0.468	3.382 - 2.352 2.207 - 1.535	3.4 - 4.71
S	**2.60 - 3.95**	**32**	**284**	**10**	**48 75**		**B A**	**54 585A**	**53 584**	**7.214 (2.84)**	**3.404 (1.34)**	**±12.7 ±5**	**7.620 (3.00)**	**3.810 (1.50)**	**±12.7 (±5)**	**2.03 (0.080)**	**2.080**	**1.435 - 0.982 0.937 - 0.642**	**4.711 - 3.225 3.074 - 2.105**	**2.18 - 3.1**
	3.30 - 4.90	40	229	11A	— —		B A		CMR229 —	5.817 (2.29)	2.908 (1.145)	±12.7 ±5	6.142 (2.418)	3.233 (1.273)	±12.7 (±5)	1.63 (0.064)	2.59	1.828 - 1.296 1.194 - 0.846	6.002 - 4.255 3.917 - 2.777	1.56 - 2.14
G	**3.95 - 5.85**	**48**	**187**	**12**	**49 95**	**C,H**	**B A**	**148C 406B**	**149A 407**	**4.755 (1.872)**	**2.215 (0.872)**	**±12.7 ±5**	**5.080 (2.00)**	**2.540 (1.00)**	**±12.7 (±5)**	**1.63 (0.064)**	**3.16**	**2.695 - 1.869 1.760 - 1.220**	**8.849 - 6.134 5.774 - 4.003**	**(941 - 1317)**
C	4.90 - 7.05	58	159	13	— —	C	B A		CMR159 —	4.039 (1.59)	2.019 (0.759)	±10.2 ±4	4.364 (1.718)	2.344 (0.923)	±10.2 (±4)	1.63 (0.064)	3.71	3.091 - 2.324 2.019 - 1.518	10.15 - 7.630 6.622 - 4.980	(754 - 983)
J	**5.85 - 8.20**	**70**	**137**	**14**	**50 106**	**XN,C,G**	**B A**	**343B 440B**	**344 441**	**3.484 (1.372)**	**1.580 (0.622)**	**±10.2 ±4**	**3.810 (1.50)**	**1.905 (0.750)**	**±10.2 (±4)**	**1.63 (0.064)**	**4.29**	**3.821 - 3.018 2.496 - 1.971**	**12.54 - 9.907 8.187 - 6.465**	**(554 - 696)**
H	**7.05 - 10.00**	**84**	**112**	**15**	**51 68**	**XB,W**	**B A**	**52B 137B**	**51 138**	**2.850 (1.122)**	**1.262 (0.497)**	**±10.2 ±4**	**3.175 (1.25)**	**1.588 (0.625)**	**±10.2 (±4)**	**1.63 (0.064)**	**5.26**	**5.355 - 4.161 3.497 - 2.717**	**17.58 - 13.66 11.47 - 8.913**	**(355 - 454)**
	7.00 - 11.00	—	102	—	— —		B A			2.591 (1.02)	1.295 (0.510)	±7.6 ±3	2.845 (1.12)	1.549 (0.610)	±7.6 (±3)	1.27 (0.050)	6.50	6.939 - 4.360 4.532 - 2.848	22.78 - 14.31 14.87 - 9.34	(280 - 424)
X	**8.20 - 12.40**	**100**	**90**	**16**	**52 67**		**B A**	**40B 136B**	**39 135**	**2.286 (0.90)**	**1.016 (0.40)**	**±7.6 ±3**	**2.540 (1.00)**	**1.270 (0.50)**	**±7.6 (±3)**	**1.27 (0.050)**	**6.56**	**8.362 - 5.784 5.461 - 3.778**	**27.45 - 18.99 17.91 - 12.39**	**(206 - 293)**
M	**10.00 - 15.00**	**120**	**75**	**17**	**— —**		**B A**			**1.905 (0.75)**	**0.953 (0.375)**	**±7.6 ±3**	**2.159 (0.850)**	**1.207 (0.475)**	**±7.6 (±3)**	**1.27 (0.050)**	**7.88**	**9.893 - 6.909 6.461 - 4.512**	**32.48 - 22.68 21.19 - 14.80**	**(166 - 229)**
P	**12.40 - 18.00**	**140**	**62**	**18**	**91 — 107**	**KU,Y,U**	**B A S**	**541A — —**	**419 — —**	**1.580 (0.622)**	**0.790 (0.311)**	**±6.4 ±2.5**	**1.783 (0.702)**	**0.993 (0.391)**	**±7.6 (±3)**	**1.02 (0.040)**	**9.49**	**12.46 - 0.162 8.141 - 5.984 6.165 - 4.531**	**40.92 - 30.08 26.71 - 19.63 20.22 - 14.87**	**(119 - 157)**
N	**15.00 - 22.00**	**180**	**51**	**19**	**— —**		**B A S**			**1.295 (0.510)**	**0.648 (0.255)**	**±6.4 ±2.5**	**1.499 (0.590)**	**0.851 (0.335)**	**±7.6 (±3)**	**1.02 (0.040)**	**11.6**	**17.02 - 12.33 11.12 - 8.054 8.418 - 6.099**	**55.88 - 40.49 36.47 - 26.42 27.62 - 20.01**	**(79 - 106)**
K	**18.00 - 26.50**	**220**	**42**	**20**	**53 121 66**		**B A S**	**596A 598A —**	**595 (425)[5] 597 —**	**1.067 (0.420)**	**0.432 (0.170)**	**±5.1 ±2**	**1.270 (0.500)**	**0.635 (0.250)**	**±7.6 (±3)**	**1.02 (0.040)**	**14.1**	**26.86 - 19.58 17.41 - 12.79 13.18 - 9.684**	**87.51 - 64.28 57.11 - 41.95 43.25 - 31.77**	**(43 - 58)**
	22.00 - 33.00	260	34	21	— — —		B A S		1530	0.864 (0.340)	0.432 (0.170)	±5.1 ±2	1.067 (0.420)	0.635 (0.250)	±7.6 (±3)	1.02 (0.040)	17.3	32.58 - 22.66 21.27 - 14.80 16.11 - 11.20	106.94 - 74.37 69.79 - 48.54 52.86 - 36.76	(34 - 47)
R	**26.50 - 40.00**	**320**	**28**	**22**	**— — 96**	**V,KA,U**	**B A S**	**600A**	**599 (381)[5] — —**	**0.711 (0.280)**	**0.356 (0.140)**	**±3.8 ±1.5**	**0.914 (0.360)**	**0.559 (0.220)**	**±5.1 (±2)**	**1.02 (0.040)**	**21.1**	**44.29 - 30.33 28.92 - 19.81 21.9 - 15.00**	**145.4 - 99.57 94.88 - 64.98 71.85 - 49.21**	**(23 - 32)**
	33.00 - 50.00	400	22	23	— 97	Q	B S		383 —	0.569 (0.224)	0.284 (0.112)	±2.5 ±1	0.772 (0.304)	0.488 (0.192)	±5.1 (±2)	1.02 (0.040)	26.35	30.84 - 20.96	101.2 - 67.78	(14 - 20)
	40.00 - 60.00	500	19	24	— —		B S			0.478 (0.188)	0.2388 (0.094)	±2.5 ±1	0.681 (0.268)	0.442 (0.174)	±5.1 (±2)	1.02 (0.040)	31.4	38.79 - 27.21	127.3 - 89.25	(10 - 14)
V	50.00 - 75.00	620	15	25	— 98	M	B S		385 —	0.3759 (0.148)	0.1879 (0.074)	±2.5 ±1	0.579 (0.228)	0.391 (0.154)	±5.1 (±2)	1.02 (0.040)	39.9	57.30 - 39.15	188.0 - 128.4	(6 - 9)
	60.00 - 90.00	740	12	26	— 99	E	B S		387 —	0.3099 (0.122)	0.1549 (0.061)	±1.3 ±0.5	0.5130 (0.202)	0.3581 (0.141)	±5.1 (±2)	1.02 (0.040)	48.4	78.33 - 52.51	256.9 - 172.3	(4 - 6)
	75.00 - 110.00	900	10	27	— —					0.2540 (0.100)	0.1270 (0.050)	±1.3 ±0.5	0.4572 (0.180)	0.3302 (0.130)	±5.1 (±2)	1.02 (0.040)	59.0	100.5 - 70.71	329.7 - 231.9	(3 - 4)

Abbreviations
IEC—International Electrotechnical Commission
JAN—Joint Army Navy
EIA—Electronic Industry Association

[1] For more information refer to U.S. Military Specification, MIL W 85, Waveguide, Rigid, Rectangular.
[2] For more information refer to U.S. Military Specification, MIL-F-3922, Flanges, Waveguide Cover.
[3] Attenuation computations: Rectangular guide, TE_{10} mode. Resistivities: Brass (65-35) 6.63×10^{-6} Ω cm; Aluminum, 2.83×10^{-6} Ω/cm; Silver, 1.62×10^{-6} Ω cm.
[4] CW Power computations: Breakdown strength of air taken at 15,000 volts per centimeter. Safety factor of approximately 2 at sea level is assumed.
[5] HP instrumentation flanges mate with rectangular cover flanges noted. Flange adapters are available to mate with UG-425/U and UG-381/U. Specify 11515A (K-Band, 18.0 - 26.5 GHz) or 11516A (R-Band, 26.5 - 40.0 GHz).

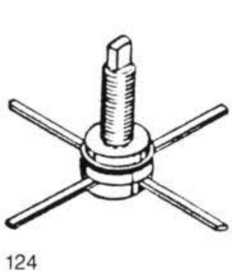
BRIEFLY SPEAKING...

New Transistors for UHF-Transmitters

Motorola now offers a new range of transistors for transmit applications in the UHF-range. They are very interesting due to their low noise, high-linearity, and high gain characteristics. The following preliminary specifications are given in the data sheets:

MRF 571:
U_{CEO} = 10 V, $I_{C\ max.}$ = 70 mA
f_T = 7 GHz at 25 mA,
NF = 1.2 dB
(at 10 mA and 500 MHz).
S-parameter from 0.2 to 2 GHz.
Case: 4 connection plastic case.

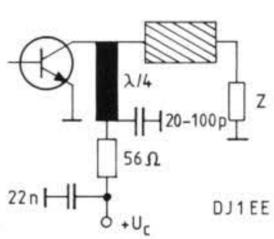
MRF 587:
U_{CEO} = 20 V, $I_{C\ max.}$ = 200 mA
f_T = 6 GHz at 90 mA,
NF = 2.7 dB
(at 60 mA and 500 MHz).
S-parameter between 0.1 and 1 GHz.
Case: Ceramic case with screw mount (stud).



MRF 597:
U_{CEO} = 20 V, $I_{C\ max.}$ = 250 mA,
f_T = 6 GHz at 150 mA,
NF = 2.8 dB
at 100 mA and 500 MHz,
S-parameter from 0.1 to 1 GHz,
Case: ceramic case with screw mount (stud).

No special amateur applications have been worked out for these transistors yet, however, the impedances indicate that types MRF 587 and MRF 597 could be suitable for use in the 1296 MHz linear amplifier described by DCØDA in VHF COMMUNICATIONS, edition 1/1979.

Motorola/DB3TB



Circuit Tip

Using chokes in UHF-stages

Since the gain of Microwave transistors increases by approximately 6 dB/octave on decreasing frequency, it is advisable to provide a low-impedance load in the voltage lines for lower frequencies. As can be seen in the circuit diagram, a real-resistor is used in conjunction with a bypass capacitor for lower frequencies subsequent to the UHF-choke. These measures can also be carried out for the base supply.

DJ 1 EE

GaAs-FETs

We have heard from Texas Instruments that the low-noise GaAs dual-gate MESFET **S3030** mentioned several times in VHF COMMUNICATIONS was only manufactured at laboratory level. Due to technical problems it was necessary for them to increase the price at the end of 1982. The publishers still have a small stock of these components which are getting more and more difficult to obtain. The actual price is DM 35.00.

The same is valid for the power FETs **P8002**, which are available for DM 9.80, each, for quantities of 1–9.

Line-of-Sight Communications
VHF COMMUNICATIONS 4/81, page 239

A printing error in this article from OE3HSC led to a completely incorrect result. The equation at the end of the first column should have a square-root symbol:

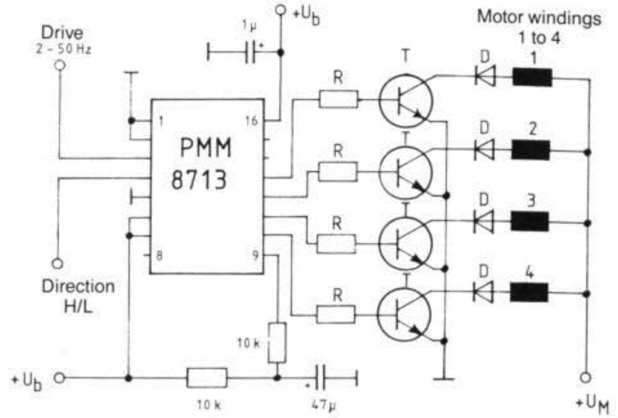
$$\cos\frac{\varphi_1}{2} = \sqrt{\frac{s\,[s - (r + h_1)]}{A \times (r + h_2)}}$$

Also, in the second column, line 4, it should read b' (and not b)

Furthermore, another square-root symbol was missing in the equation on page 241, second column:

$$a \approx 548 \times \sqrt{\frac{b'\,(b - b)}{[b' + (b - b')] \times f}}$$

HB 9 MMM



A minimum of 700 mW at 11 GHz . . .

The Impatt-diode type **ND8011-5G** generates a minimum of 700 mW at 11 GHz. This diode operates at a voltage of 85 V, where it draws approximately 140 mA. The price is in the order of DM 150.00.

Stepmotor for the DC 3 NT FAX-machine

The fax-machine described by DC3NT in **VHF COMMUNICATIONS, edition 1/81** can also be operated using step motors. These are more powerful, and are more accurate than synchronous motors, since step motors make more steps, for instance, 360 ÷ 1.8 = 200 per revolution.

The SANYO integrated circuit **PMM 8713** can be used for driving the step motor. They only cost approximately DM 30.00 at present. This IC is especially designed for driving the SANYO step motor **103-775-6**, which has a step angle of 1.8° and whose four coils require 2.25 V at 1.5 A. However, step motors manufactured by Philips will also work in conjunction with the above IC.

The circuit shown in the **diagram** is required twice so that one motor can be used for the drum rotation, and the other for the stylus deflection. This means that the reduction drive is no longer required. It is also possible to delete the FAX motor drivers (DC3NT 006).

Components:

T: NPN-Darlington transistors such as BD 433, BD 675

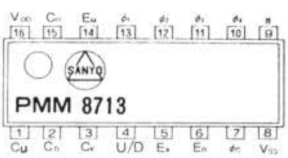
D: 1 N 4007

R: With U_{op} = 5 V: 100 Ω, 0.5 W
With U_{op} = 15 V: 500 Ω, 1 W

The operating voltage of the intergrated circuit can be between 5 V and 15 V. The value of the resistor R should be selected according to the component table.

Pin 3 is provided with the input signal: At least 3.5 V for 5 V operation, or at least 11 V for 15 V operation. The operation of the circuit can be checked with the aid of an audio frequency generator.

Martin Mulder, PA Ø



PIN NO.

1 Cu	Input pulse, UP clock	
2 CD	Input pulse, DOWN clock	
3 CK	Input pulse, clock	
4 U/D	Change-over of rotation direction "0" DOWN, "1" UP	
5 EA, 6 EB	Exitation-mode change over	
7 φc	3, 4 phase-change	
8 V_{SS}	(GND)	
9 R̄	Reset	
10 φ4	Output	4 phase
11 φ3	Output	3 phase, 4 phase
12 φ2	Output	3 phase, 4 phase
13 φ1	Output	3 phase, 4 phase
14 EM	Excitation monitor	
15 CO	Input pulse monitor	
16 V_{DD}	(+4 ~ +18V)	

MATERIAL PRICE LIST OF EQUIPMENT

described in Edition 2/83 of VHF COMMUNICATIONS

Mini SSB-Transceiver for the 2 m band			Art. No.	**Ed. 1 + 2/83**
PC-boards	DC 6 HL 010 + DC 6 HL 011	double-coated, with through contacts as above	6771 6772	DM 49.00
Parts	DC 6 HL 010 + DC 6 HL 011	4 FETs, 2 DG-MOS-FETs, 3 transistors, 1 ring-mixer IE-500, 4 linear ICs, 1 C-MOS IC, 20 diodes, 1 SSB crystal-filter with side-band crystals, 8 coils ready wound, 3 mini chokes, 2 toroid cores, silvered and insulated wire, 2 spindel trimmers, 1 relay, 15 feed-through and 65 ceram. disc. caps., 12 tantalum electrolytics, 2 round trimmer potentiometers, 78 resistors, 4 PTFE-feedthroughs, 1 tinned-metal case	6773	DM 462.00
Kit	**DC 6 HL 010 + 011, with above parts, complete**		**6774**	**DM 498.00**

DJ 3 RV	**Versatile IF-Module**		**Editions 4/81; 2/82; 3/82; 4/82; 1/83; 2/83**		
PC-board	DJ 3 RV 001a	double-coated, drilled		6729	DM 28.—
PC-board	DJ 3 RV 001b	double-coated, drilled		6730	DM 28.—
PC-board	DJ 3 RV 002	double-coated, drilled		6749	DM 28.—
PC-board	DJ 3 RV 003	double-coated, drilled		6746	DM 28.—
PC-board	DJ 3 RV 004	double-coated, drilled		6748	DM 28.—
PC-board	DJ 3 RV 005	single-coated, drilled		6747	DM 18.—
P 8002	Power-FETs		packets of 10	9069	DM 89.—
BFQ 69	UHF transistor			9577	DM 8.50
Tinned-metal case		74 × 148 × 30		9501	DM 6.50
Toroid core	R6,3K1			9159	DM 2.00
Coil set	D41 – 2165	orange		9166	DM 2.50

Monolithic Crystal Filters from KVG
for the DJ3RV IF-Module (for instance)

XF-909	6800	DM 31.—	XFM-9B02	6809	DM 148.—
XF-910	6801	DM 38.—	XFM-9S01	6810	DM 148.—
XF-914	6802	DM 46.—	XFM-9S02	6811	DM 148.—
XFM-9A	6803	DM 118.—	XFM-9S03	6812	DM 148.—
XFM-9B	6804	DM 136.—	XFM-9S04	6813	DM 148.—
XFM-9C	6805	DM 121.—	XFM-9S05	6814	DM 148.—
XFM-9D	6806	DM 121.—	XFM-9S06	6815	DM 148.—
XFM-9E	6807	DM 121.—	XFM-9S07	6816	DM 148.—
XFM-9B01	6808	DM 148.—	XFM-9S08	6817	DM 212.—

For Technical Data see rear cover page of VHF COMMUNICATIONS

UKWberichte Terry D. Bittan · Jahnstr. 14 · Postfach 80 · D-8523 Baiersdorf
Tel. West Germany 9133-855. For Representatives see cover page 2

A home-made automatic noise-figure measuring system

			Art. No.	Ed. 1 + 2/83
1. Noise source				
Parts	Noise source	1 metal case, 1 N connector, 1 BNC socket, 2 transistors, 2 diodes, 1 chip capacitor, 1 disc cap., 2 carbon- and 4 metal film resistors, 1 RF choke	6750	DM 35.00
2. Receive converter				
PC-board	DK10F 034	single coated, with printed component location plan	6442	DM 12.00
Parts	RMG E.K.	3 transistors, 1 crystal filter 10.7/30, 3 coil formers with core, 1 Neosid coil, 2 RF chokes, 1 ferrite bead, 1 m each of 0.8 and 0.12 mm dia. as well as 1 mm dia. silver plated wire, 2 foil trimmers, 3 feed-through and 24 ceram. disc capacitors, 23 resistors, 1 N connector, 1 metal case	6751	DM 105.00
Kit	**Receive converter, complete with above parts**		**6752**	**DM 115.00**
3. Indication electronics/Reference voltage generator				
PC-board	RMG 01	single coated, drilled, with component location plan	6753	DM 31.50
Parts	RMG 01	9 OpAmps, 1 temp. compensated Z-diode, 12 switching diodes, 9 ceramic and 2 tantalum capacitors, 18 trimmer potentiometers, 44 carbon and 15 metal-film resistors	6754	DM 65.00
Kit	**Indication electronics/Reference voltage generator, complete**		**6755**	**DM 95.00**
4. Control module				
PC-board	RMG 02	Double coated with through-contacts	6756	DM 46.00
Parts	RMG 02	4 transistors, 19 switching and 2 Z-diodes, 6 FET-OpAmps, 2 OpAmps, 2 C-MOS ICs, 19 ceram. disc. caps., 5 tantalum and 3 aluminium electrolytic caps., 3 foil caps., 6 trimmer potentiometers, 40 carbon resistors	6757	DM 120.00
Kit	**Control module, complete with above parts**		**6758**	**DM 165.00**
5. Mixer and variable amplifier				
PC-board	RMG 03	single coated, drilled, with component location plan	6759	DM 23.00
Parts	RMG 03	1 ring mixer, 8 transistors, 2 Z-diodes, 1 coil kit, 1 m wire 0.3 mm diam. 3 RF chokes, 12 ceram. disc caps., 6 tantalum and 5 aluminium electrolytic caps., 4 feed-through caps., 1 trimmer potentiometer, 19 resistors, 1 metal case	6760	DM 130.00
Kit	**Mixer and variable amplifier, complete**		**6761**	**DM 150.00**
6. Dual crystal oscillator			Art. No.	**Ed. 1 + 2/83**
PC-board	RMG 04	single coated, drilled, with component location plan	6762	DM 23.00
Parts	RMG 04	5 transistors, 3 Schottky-diodes, 1 precision voltage regulator, 3 coil kits, 1 coil former with core, 1 two-hole core, 1 m wire each: 0.12 mm dia., 0.3 mm dia., 0.8 mm dia. silver plated, 7 RF chokes, 2 foil trimmers, 22 ceramic disc caps, 2 feed-through caps., 1 tantalum electrol. cap., 13 resistors, 1 crystal each: 66.7 MHz and 10.72 MHz, 1 metal case	6763	DM 206.00
Kit	**Dual crystal oscillator, complete**		**6764**	**DM 225.00**
7. Remaining parts for the noise-measuring system				
Parts	RMG E1	2 each: 31-pole connectors, male and female, 1 potentiometer 5 kΩ/10 turns, 2 switching- and 2 LEDs (red), 1 toggle switch	6765	DM 75.00
Parts	RMG E2	1 mains transformer 220 V/2 x 15 V/2 A, 2 bridge rectifiers, 1 PC-board DK10F 028, 2 electrolytic caps. 1000 μF/40 V	6766	DM 67.00
Kit	**Automatic Noise-figure measuring system, all parts from 1 to 7**		**6767**	**DM 899.00**