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VHF COMMUNICATIONS

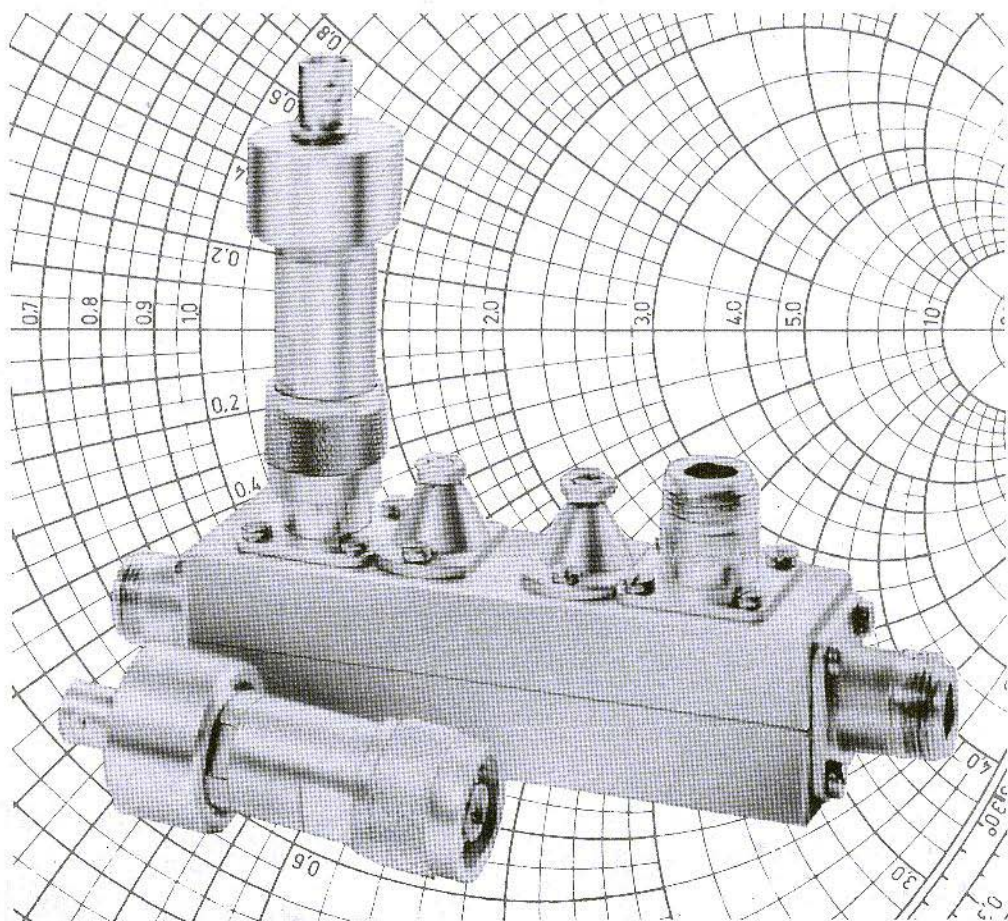
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ESPECIALLY COVERING VHF, UHF AND MICROWAVES

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A PUBLICATION FOR THE RADIO AMATEUR ESPECIALLY COVERING VHF, UHF AND MICROWAVES VOLUME NO. 6 SPRING EDITION 1/1974

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AMSAT have just announced that the start of OSCAR 7 will not take place in March 1974 as planned but will be delayed until the summer.

The next editions of VHF COMMUNICATIONS will contain some really outstanding designs such as :

A linear transverter 2-m/70-cm; a new phase-locked oscillator; a 400 channel synthesizer with 10 kHz channel spacing from 144 to 148 MHz; a foxhunt (DF) receiver with five programmable channels, as well as many more interesting designs, and articles.

PRECISION REFLECTOMETER FOR 0 TO 2300 MHz

by H. Tiefenthaler, OE 5 THL and B. Roessle, DJ 1 JZ

A precision reflectometer is to be described that can be used within the frequency range up to approximately 2400 MHz. The directivity and coupling attenuation are in the order of 28-42 dB over the whole range. These values allow the reflectometer to be used for precision measurements, whereas most of the conventional reflectometers available on the amateur market are only suitable for monitoring purposes.

1. EXPLANATION OF THE TERMINOLOGY

The following definitions are used in microwave and measuring technology. They are to be given here together with a short description.

1.1. DIRECTIONAL COUPLERS

Directional couplers are installed into the feeder line and couple out either the forward or reflected wave which is available at the output. Figure 1a indicates the principle of a directional coupler. A drawing of a directional coupler is given in Figure 1b. The main line consists of a coaxial line of the required impedance Z to which a secondary line is used as coupler. This coupling line is terminated with R at one end and the RF voltage at the other end is rectified and indicated. The rectification and measuring system can be separate from the directional coupler; in this case, the secondary line is connected to a coaxial connector.

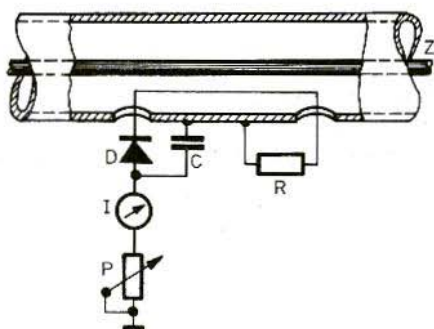


Fig. 1b: Construction of a directional coupler

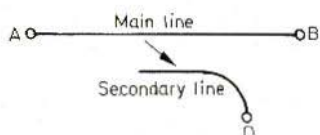


Fig. 1a: Principle of a directional coupler

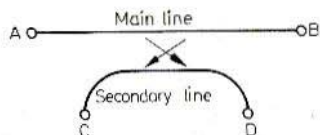


Fig. 1c: Principle of a reflectometer

1.2. REFLECTOMETER

Reflectometers are units that allow both the forward and reflected wave to be observed by coupling out the appropriate voltages without adversely affecting the line. Such a reflectometer can be constructed using two directional couplers. Reflectometers are either equipped with two separate outputs or a changeover switch and one output. Figure 1c shows the principle of a reflectometer.

1.3. DIRECTIVITY

If a directional coupler or reflectometer is connected between a transmitter and consumer so that the reflected energy is indicated, no indication should be present if the matching is correct. In practice, there is always a small indication since the directional couplers are not able to differentiate infinitely between forward and reflected waves. The measure of the quality of a directional coupler is its differentiation between forward and reflected energy which is termed directivity. The higher the directivity, the lower will be the measuring errors.

For amateur measurements, a minimum directivity of approximately 20 dB is classed as satisfactory. At these values, the measuring error is within acceptable limits. Home-made directional couplers and reflectometers, as well as commercially available reflectometers for the amateur mostly exhibit a directivity of only 10 - 20 dB. Such units allow a standing-wave ratio (SWR) of 1:1 to be "measured" although it is actually 1.8:1.

The easiest way of checking the operation of a directional coupler or reflectometer, is to connect a professional terminating resistor and see whether the reflected wave indication returns to zero.

1.4. COUPLING ATTENUATION

The secondary line (lines) of the directional coupler (reflectometer) couples out a small portion of the energy passing along the cable. The amount of energy coupled out depends on its mechanical size and degree of coupling. The ratio between the energy in the main line and the decoupled energy is the coupling attenuation. This attenuation which is also given in dB, is frequency-dependent since the mechanical dimensions of the secondary line will increase with respect to wavelength on increasing the frequency.

The coupling attenuation is therefore dependent on the construction and on the dimensions of the directional coupler. It determines the voltage value at the rectifier circuit. If the rectifier circuit is not an integral part of the unit and if the coupling attenuation is accurately known, it is possible for power levels in the kW-range to be measured with low-power Wattmeters. The actual power is then increased by the value of the coupling attenuation.

2. MECHANICAL CONSTRUCTION

Figures 2 and 3 show drawings of the 50 Ω reflectometer designed by OE 5 THL. A disadvantage of this design was the difficulty in constructing the secondary lines. For this reason, DJ 1 JZ reconstructed the reflectometer. The main body now consists of two halves which can be screwed together after mounting the secondary lines. At the same time, it was possible to slightly reduce the dimensions and to accommodate the terminating resistors in cone-shaped caps. In addition to this, the demodulator heads were designed to accommodate the wellknown diode series 1 N 21. Figures 4 and 5 show a prototype of this reflectometer with demodulators. This version of the reflectometer can also not be constructed on the workbench, however, it does allow those persons who have connections to a mechanical workshop to construct a precision measuring unit, in contrast to the normal SWR indicators. Further information on diodes

OE 5 THL

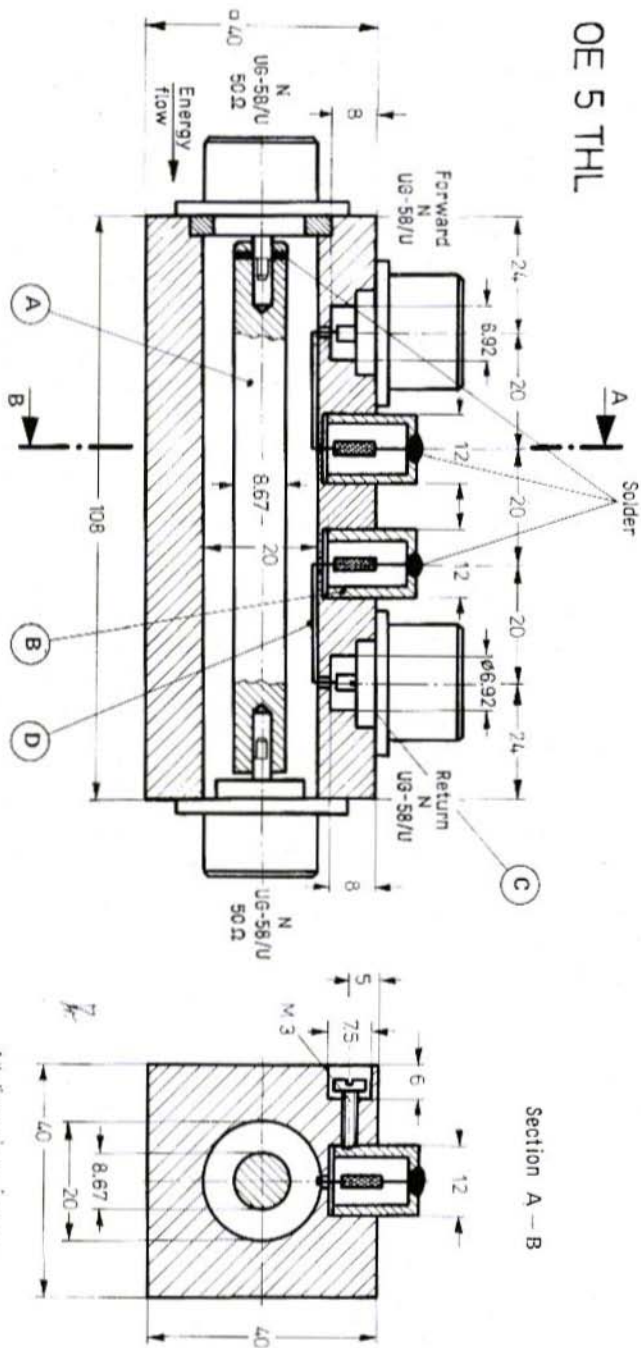


Fig. 2: 50 Ohm reflectometer for VHF and UHF designed by OE 5 THL

and detector probes will be given later. Attention must be made that no impedance jumps are present between the connectors and the main line, or between the secondary lines and their terminating resistors. These are decisive for a high directivity. Any non-homogeneous effects at these points will approximate a low-pass filter in series with the terminating resistors. This will mean that the lines are not terminated truly resistively, but mismatched with complex impedances. According to (1) improvements can be made by correct selection of the shape (bending of the line, large ratio of the length of the coupling link to the connection length) and by compensation. These have been used, where possible, in the described reflectometer.

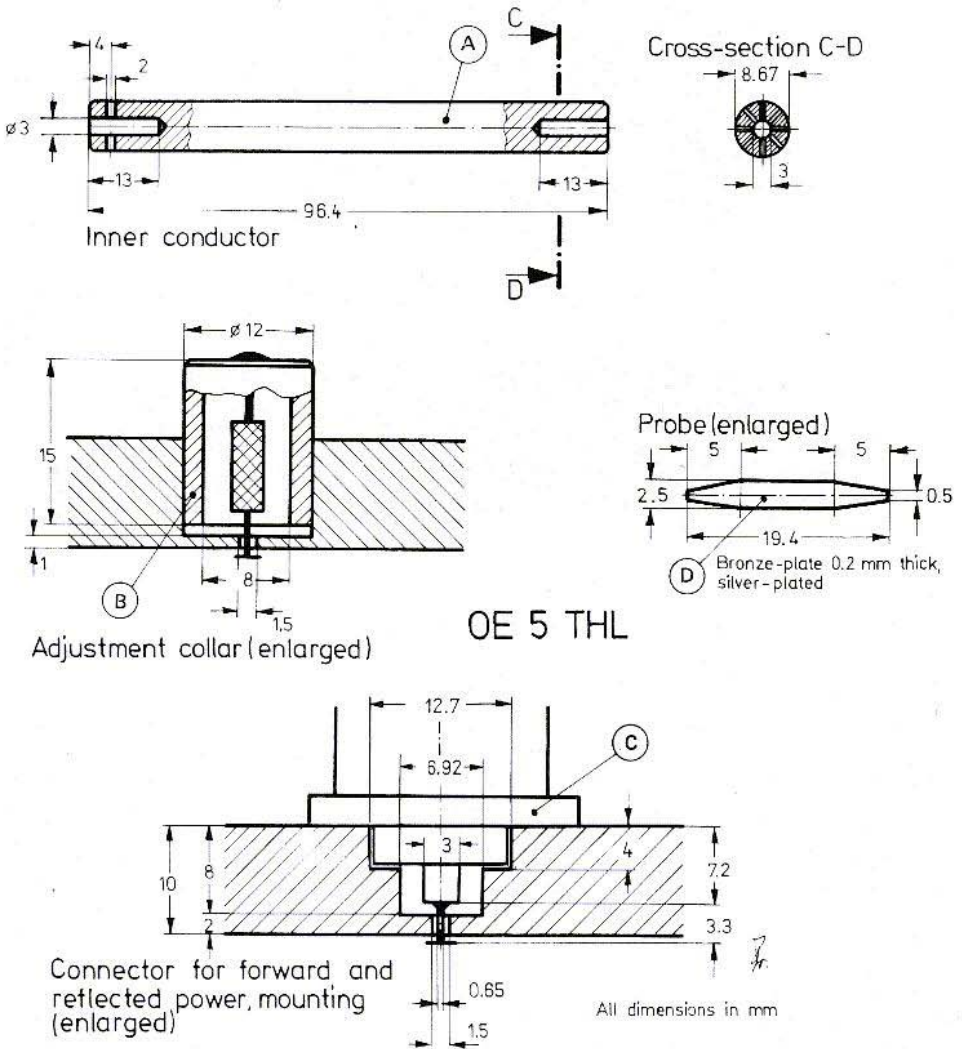


Fig. 3: Detailed drawings of the reflectometer designed by OE 5 THL

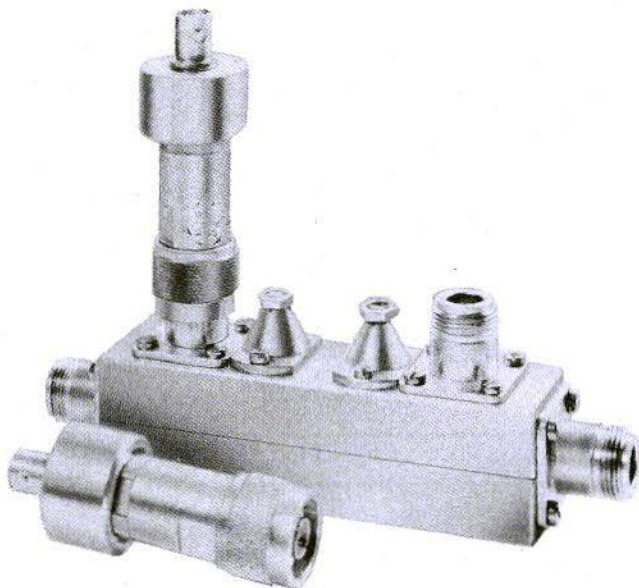


Fig. 4: 50 Ohm reflectometer designed by DJ 1 JZ with detector probes

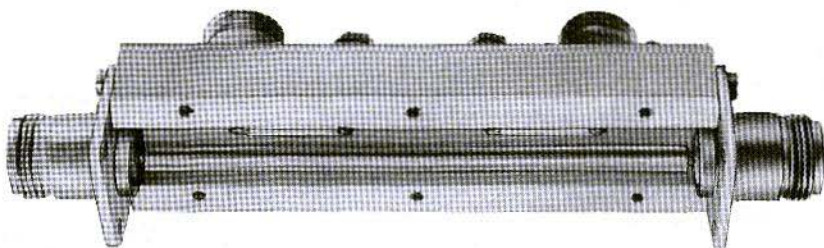


Fig. 5: Lower view of the open reflectometer

2.1. THE REFLECTOMETER

Figure 6 shows a sectional drawing of one half of the reflectometer reconstructed by DJ 1 JZ. The other half is exactly identical. The main line "3" will be seen in the main body ("1" and "2"). The ring "7" centers the type N coaxial socket in the inner chamber of the main body of the reflectometer. In order to compensate for the effect of the unavoidable jump in the diameter between the coaxial connector and the main line, a small cut-out is provided between the connector and the inner conductor. The inner conductor is formed by the center pin of the connector in this 1.44 mm wide cut-out at each end of the reflectometer.

The secondary line "6" is only 0.4 mm from the edge of the inner conductor. In this manner, it is possible to obtain a high value of coupling attenuation and a very low effect on the field of the main line, which has a favourable effect on the standing wave ratio. The secondary line is connected between a shortened pin of a N-connector and fed as center conductor to the terminating resistor "5". Part "5" increases the cross-section of the conductor in a low reflection

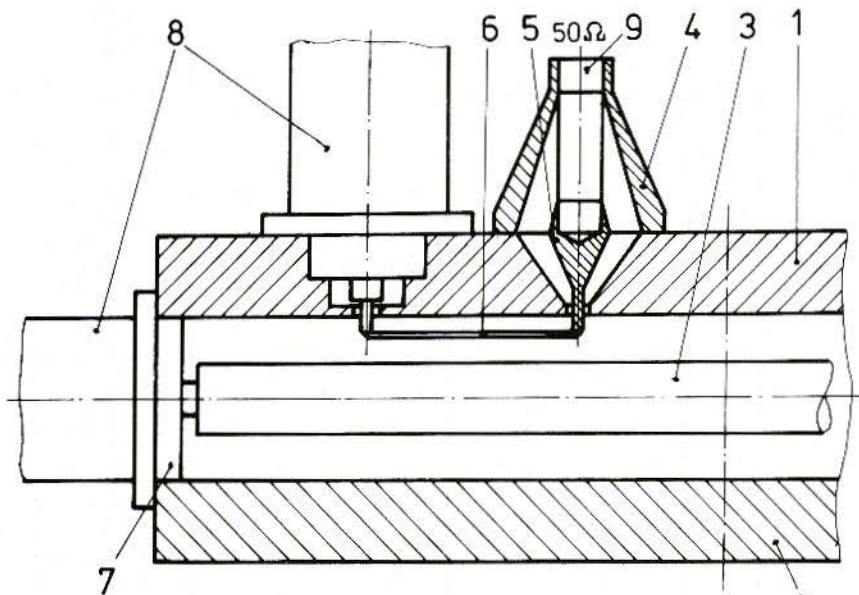


Fig. 6: Sectional drawing of the reflectometer

DJ 1 JZ

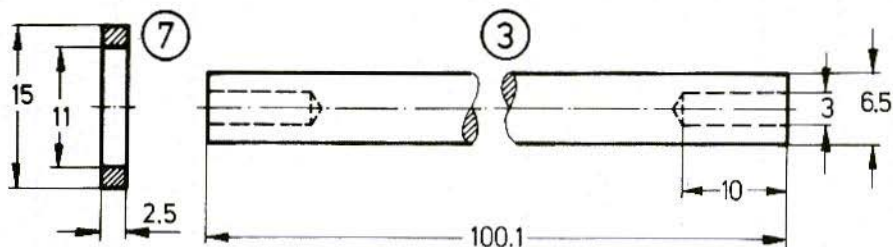


Fig. 8: Inner conductor and intermediate ring

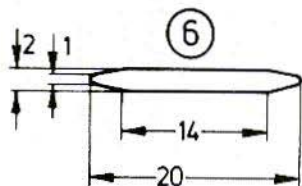


Fig. 9: Secondary line

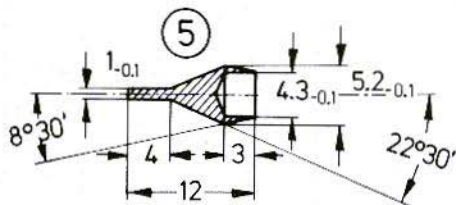
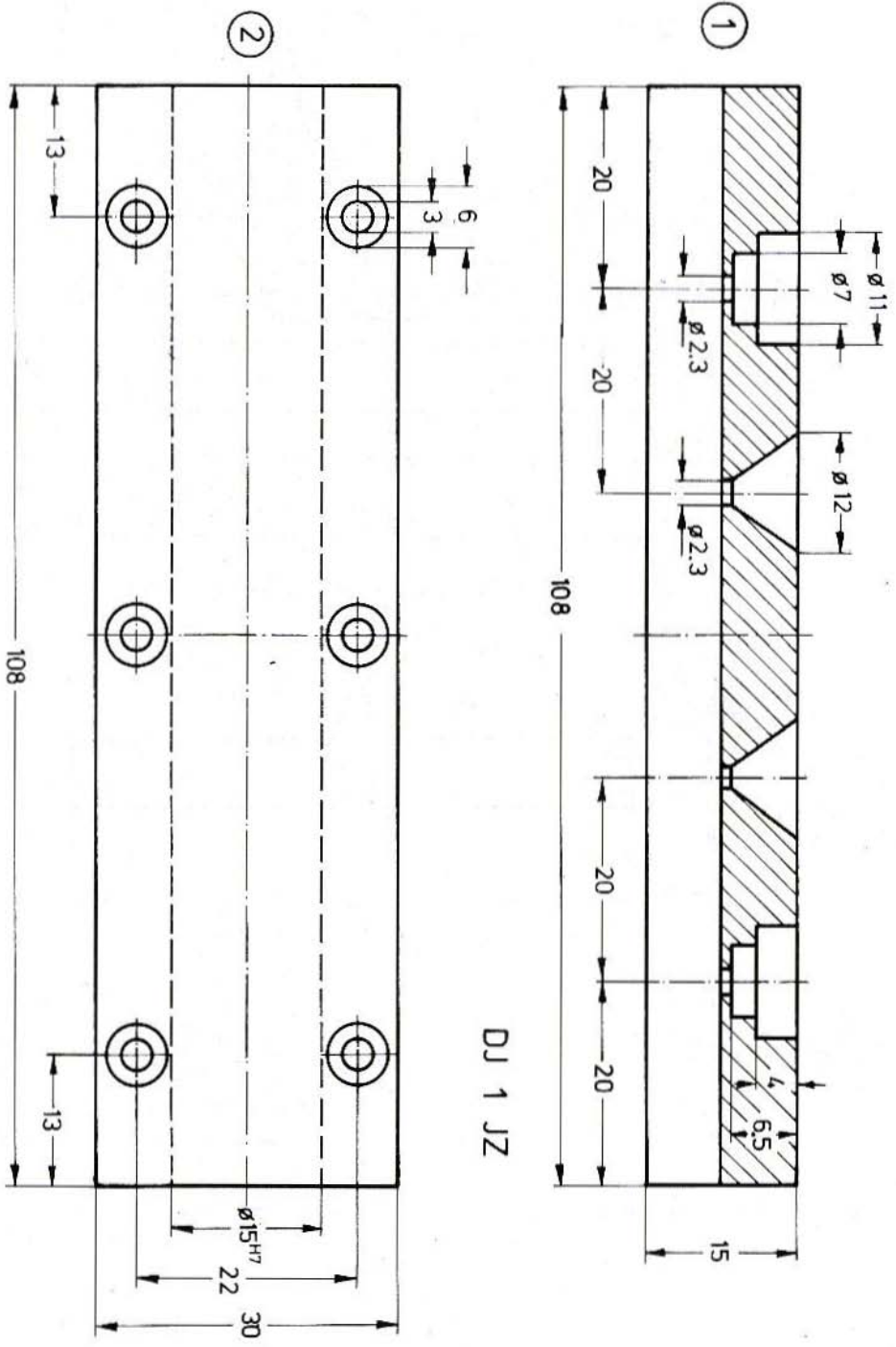


Fig. 10: Cone-shaped inner conductor for the terminating resistor



DJ 1 JZ

Fig. 7 : The two halves of the reflectometer block

DJ 1 JZ

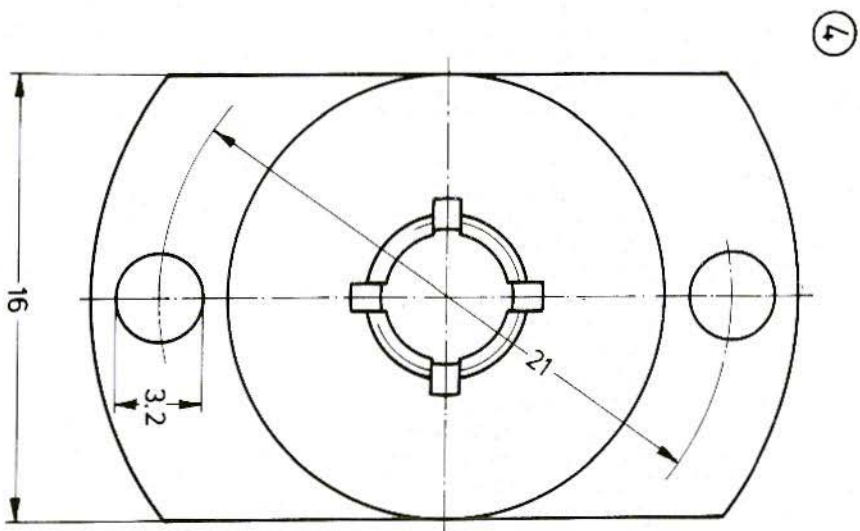
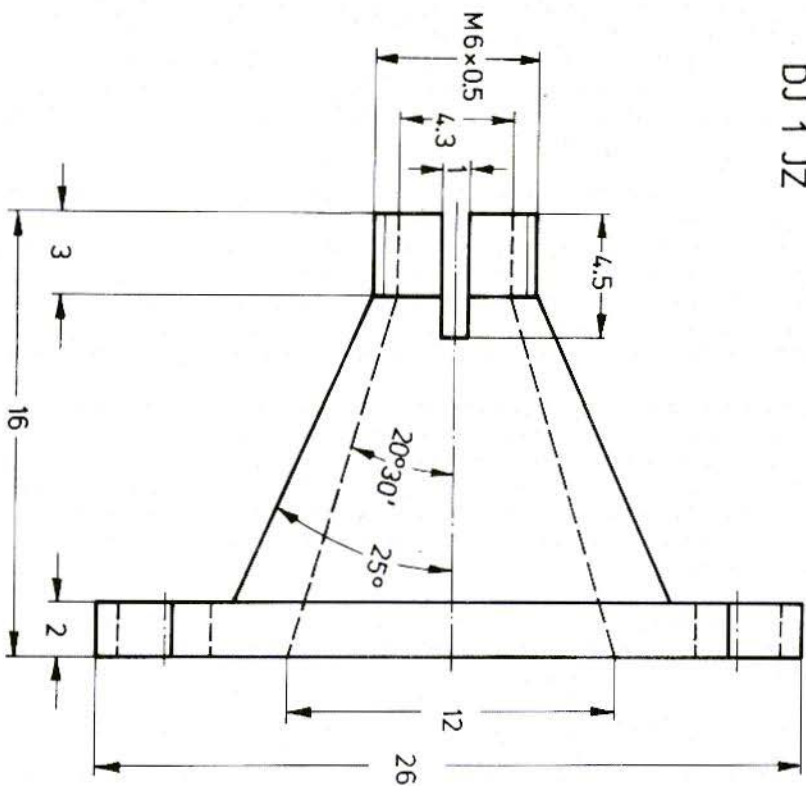


Fig. 11: Cone-shaped cover for terminating resistor, side and top view

manner to the diameter of the terminating resistor. It is in the form of a cone in a similar manner to the surrounding cutout in the main body. Another cone-shaped cap (part "4") further adjusts the cross-section up to the ground connection at the other end of the resistor. The upper end of part "4" is cut and provided with an external thread. A matching nut seals the cap and resistor together.

The dimensions of the main body of the reflectometer (part "1" and "2") are given in Figure 7. Two brass blocks of 15 mm x 30 mm x 110 mm long are required. The wide sides of these blocks are screwed together and a hole is drilled in a longitudinal direction from one end to the other. The resulting hole is brought to the correct diameter with the aid of a reamer. In addition to this, it is important that the surface is smooth. The holes for the two coaxial connectors and for the two terminating resistors are also given in Figure 7.

Figure 8 shows the inner conductor and intermediate ring of the main line. The two rings (part "7") are soldered onto the rear side of the coaxial connectors. The exact length and diameter as well as a smooth surface are important for the inner conductor (part "3"). The center pins of the coaxial connectors are soldered into the ends of the inner conductor. In order to ensure that the spacings are correct, it is necessary for the parts to be installed in one half of the main body.

Figure 9 shows the secondary line constructed from thin metal plates. Two pieces are required. It is also necessary to make two pieces each of part "4" and part "5" (Fig. 10 and 11).

2.1.1. PARTS LIST FOR THE REFLECTOMETER

Part	Number	Designation	Dimensions	Material
1	1	Main body, lower part	15 x 30 x 120 mm	brass
2	1	Main body, upper part	15 x 30 x 120 mm	brass
3	1	Inner conductor of the main line	6.5 dia. x 100 mm	brass
4	2	Cap for the terminating resistor	26 dia. x 16 mm	brass
5	2	Inner conductor for terminating resistor	6 dia. x 15 mm	brass
6	2	Secondary line	0.5 x 2 x 20 mm	brass
7	2	Intermediate ring	15 dia. x 4 mm	brass
8	4	Coaxial connector type N		UG-58/U
9	2	Terminating resistors 0.25 W without caps, without connection leads non inductive. Length 14.6 mm; diameter of the contacts 4.32 mm	3.5 Ω \pm 1%	
	20	Cylinder-headed screws	M 3 x 6 mm	
	6	Cylinder-headed screws	M 3 x 50 mm	
	2	Hexagonal nuts	M 6 x 0.5 mm	

2.2. DETECTOR PROBES

Figure 12 gives a cross-section of one of the two detector probes. It is built into a coaxial connector type N which has not been shown. The center pin of the coaxial connector is extended by part "16" (Fig. 13) and the center pin of a diode of the 1 N 21 series is inserted into a cutout at the upper end of this part. The thick end of the diode is pressed onto a disc (part "13", Figure 15) with the aid of a spring (part "12", Figure 14). This disc forms a UHF bypass capacitor of several tens of pF together with the insulating disc (part "14", Figure 15) and the case. The spring conducts the rectified voltage to the center pin of a coaxial connector type BNC (part "17", Figure 12). Three or four bypass capacitors connected around the connector bypass all VHF frequencies from the center pin to the case (part "10", Figure 15) onto which the connector is mounted and which seals the case (part "11", Figure 15).

The spring (part "12") can also be made as a spring made from approximately 6 mm wide bronze plate that is bent in the shape of a "U".

The case (part "11") fits into the side of a N-connector and will be held in place after insertion. The extension of the inner conductor (part "16") is soldered to the center pin of the coaxial connector. The BNC-connector is screwed to the cover (part "10").

2.2.1. PARTS LIST FOR THE TWO DETECTOR PROBES

Part	Number	Designation	Dimensions	Material
10	2	Cover	26 dia. x 5 mm	brass
11	2	Case	26 dia. x 40 mm	brass
12	2	Contact spring	0.7 dia. x approx. 50 mm	bronze
13	2	Disc	22 dia. x 1.5 mm	brass
14	2	Insulating disc	23 mm dia. x 0.05	PTFE
15	2	Diodes (paired) 1 N 21 or similar		
16	2	Inner conductor-extension	3 dia. x 20 mm	brass
17	2	BNC-connector for single-hole mounting or with square flange		
	6-8	Ceramic disc capacitors of 1 nF (value uncritical)		

3. MEASURED VALUES

The following values were measured by R.Griek, DK 2 VF on the prototype of the described reflectometer:

	145 MHz	435 MHz	1250 MHz	2300 MHz
Directivity	27 dB	22 dB	28 dB	20 dB
Coupling attenuation	42 dB	33 dB	25 dB	33 dB
Standing wave ratio	1.01	1.05	1.1	1.15

DJ 1 JZ

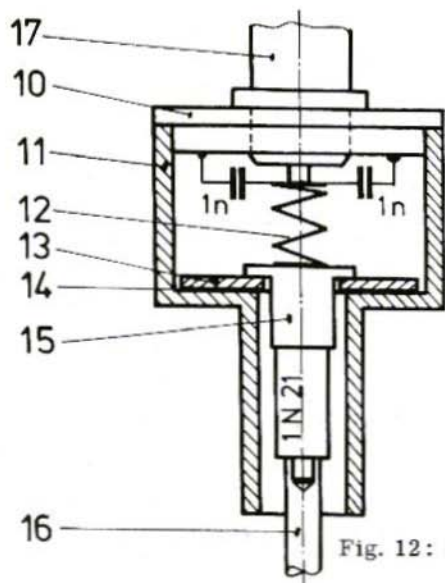


Fig. 12: Sectional drawing of a detector probe

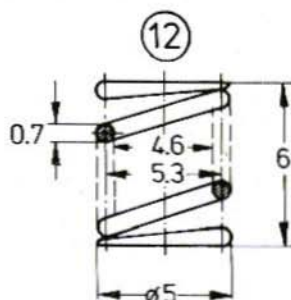


Fig. 14: Contact spring in detector

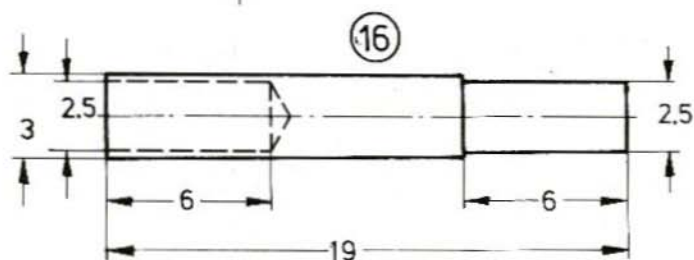


Fig. 13: Inner conductor extension for the detector

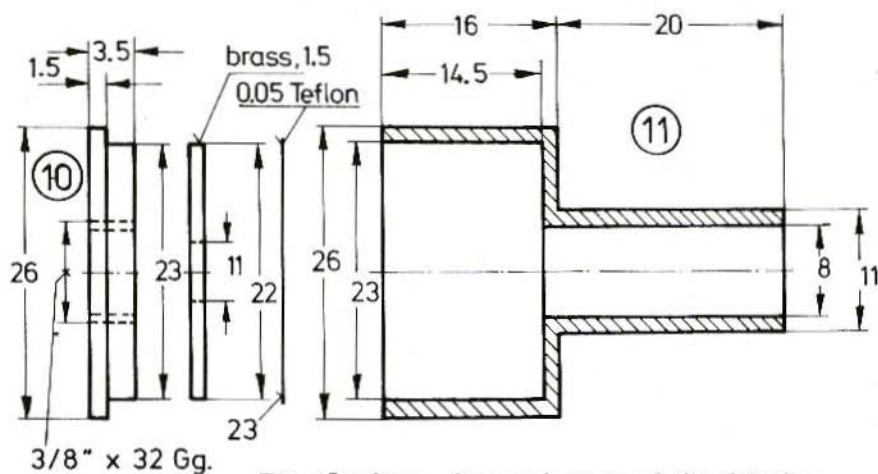


Fig. 15: Case, disc and cover of the detector

4. FURTHER DETAILS

Due to the large surfaces involved, it is not absolutely necessary to silver-plate the reflectometer. However, it is favourable to at least silver-plate the inner conductor of the main line, the secondary lines and the inner conductor to the terminating resistor. It is also favourable to silver-plate the extension of the inner conductor and the disc of the detector probes.

4.1. CHECKING THE OPERATION OF THE REFLECTOMETER

After construction, the reflectometer is firstly checked without demodulator probes. Even if no measuring equipment is available, it is absolutely necessary for the coupling attenuation of both directional couplers to be aligned to the same value with the aid of an uncalibrated power-meter. This is done by terminating the reflectometer with 50Ω (good terminating resistor or long coaxial cable with at least 20 dB attenuation and a less accurate resistor). After this, a transmitter is connected and a portion of the forward power corresponding to the coupling attenuation is taken from the connector nearest to the transmitter and indicated on the power-meter. If the indicated value is higher after reconnecting the reflectometer in the opposite direction, it will be necessary for the secondary line to be placed nearer to the outer conductor and vice versa.

A receiver with external attenuator for 50Ω is very suitable for power indication. The S-meter of the receiver is then brought to a certain indication with the aid of the attenuator. This has the advantage that all measured values are read off on the attenuator so that all problems encountered with non-linear characteristics of the demodulator circuits are avoided.

It is possible to measure the coupling attenuation with such a measuring system or with a calibrated power-meter by alternate measurement on the main and secondary line and for both directional couplers to be adjusted for the values given in Section 3. If the power-meter is sensitive enough and the terminating resistor sufficiently accurate, it is also possible to measure the directivity. The directivity is the ratio of the powers measured at the secondary connector in the forward and reflected wave direction and is given in dB. All measurements should be made at the highest possible frequency (at least 435 MHz), since the effect of the adjustment measures can be seen most clearly at such frequencies.

4.2. MEASUREMENTS WITH THE REFLECTOMETER

After the coupling attenuation has been measured in the frequency range of interest, it is possible for higher power levels to be measured on a mW-meter. A coupling attenuation of, for instance 30 dB means that 100 mW will be present at the forward power connector when a power of 100 W is present on the main line. The measuring results will be very accurate if a thermo-couple power-meter or receiver and calibrated attenuator is used. Attention should be paid that the maximum permissible power for the terminating resistors of the secondary lines is not exceeded. It is possible to accurately determine the standing wave ratio from the power relationships between the forward and reflected power levels. When measurements are made using demodulators, the measuring results are not very reliable due to the non-linear characteristics of the diodes.

4.3. MEASUREMENTS WITH DETECTOR PROBES

If the RF voltages from the directional coupler or reflectometer are rectified and indicated as a DC current, it is necessary for the characteristics of the diodes to be considered during evaluation of the indicated values.

4.3.1. DIODES

The main types of diodes differ in the shape and steepness of their I/U characteristics and in their threshold voltage. Figure 16 shows a comparison between the following diodes in the form of a graph:

- Point-contact diode (1 N 21 for silicon, or AA 138 for germanium)
- Schottky-diode (e.g. BAX 25 or hp 2800)
- Silicon-junction diode (e.g. 1 N 914)

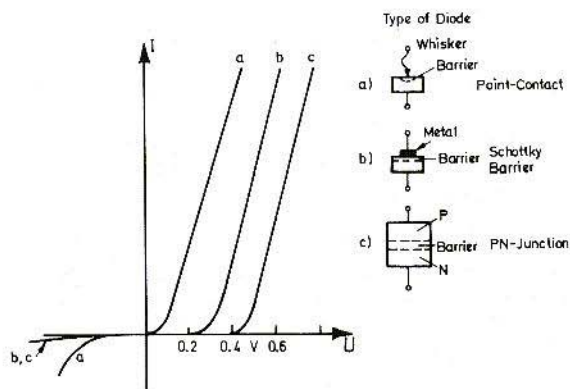


Fig. 16:

Characteristic curves of

- Point-contact diode
- Schottky diode
- Silicon junction diode

These characteristics were discussed in (2). With RF voltages in excess of 1 V, the DC-current is proportional to the RF voltage in all cases. However, 1 V is already the maximum permissible voltage for silicon point-contact diodes of the 1 N 21 diode series and only RF voltages in the range of 10 mV to 1 V will appear at the secondary connectors of precision directional couplers. The characteristic curves in the range below 1 V which is important for the required application can be evaluated better when given in a logarithmic scale. This is shown in Figure 17 for a germanium point-contact diode and in Figure 18 for a Schottky-diode. The Schottky-diode is operated with a bias current of 20 μA in an indicator circuit with an impedance of 5 $\text{k}\Omega$. The bias current reduces the diode losses and thus increases the sensitivity.

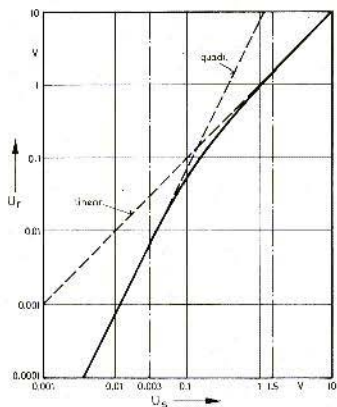


Fig. 17:
Logarithmic scale of the forward characteristic of a germanium point-contact diode designating the three different ranges of the characteristics

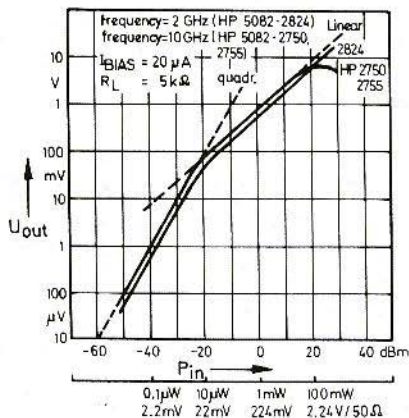


Fig. 18:
Logarithmic scale of the forward voltage range below 1 V of a Schottky diode with bias current. The three, different characteristic ranges are marked

A rough orientation for applications in detector probes of directional couplers or reflectometers is given in the following table in order to allow selection of the most suitable diode:

Characteristic	Silicon point-contact diode	Germanium point contact diode	Schottky-diode
Sensitivity:	approx. equal for all types, however the Schottky-diode requires a bias current.		
Frequency range:	Up to over 30 GHz	Up to the lower GHz-range	Up to over 10 GHz
Reproduceability for exchange or pairing:	poor	moderate	very good
High power capability:	poor	moderate	good
Capability of handling shock and vibration:	poor	poor	very good

If the detector probes are to be equipped with silicon point-contact diodes (e.g. 1 N 21) it is necessary for the two diodes to be selected to have the same characteristics. For amateur measurements, it is sufficient for two types to be selected that have the same current characteristics at two different power levels. Schottky diodes do not need to be selected. However, they must be provided with a bias current of $20 \mu\text{A}$ (12 V via $600 \text{ k}\Omega$) so that the lowest

RF voltages are also indicated. The indicator circuit (series connection of dropper resistor and meter) should possess an impedance of $5\text{ k}\Omega$. The following relationships exist independent of whether point-contact or Schottky diodes are used:

RF voltage at the diode	RF voltage DC current $I_{DC} \sim U_{RF}^2$	RF power DC current $I_{DC} \sim P_{RF}$	DC current in an indicator circuit with $R = 5\text{ k}\Omega$	Appropriate forward power at $50\ \Omega$ with a coupling attenuation of:		
				20 dB	30 dB	40 dB
less than approx. 30 mV	square	linear	less than approx. $7\ \mu\text{A}$	Less than 1.8 mW	Less than 18 mW	Less than 189 mW
approx. 30 mV to approx. 100 mV	uncertain relationship	uncertain relationship	approx. $7\ \mu\text{A}$ to $20\ \mu\text{A}$	approx. 1.8 mW to 20 mW	approx. 18 mW to 200 mW	approx. 180 mW to 2 W
approx. 100 mV to 1 V	linear $I_{DC} \sim U_{RF}$	square $I_{DC} \sim P_{RF}$	approx. $20\ \mu\text{A}$ to $200\ \mu\text{A}$	approx. 20 mW to 2 W	approx. 200 mW to 20 W	approx. 2 W to 200 W
over 1 V (not permissible for silicon point-contact diode)	ditto	ditto	greater than $200\ \mu\text{A}$	$>2\ \text{W}$	$>20\ \text{W}$	$>200\ \text{W}$

4.3.2. POWER MEASUREMENTS

The scale of a μA -meter can be interpolated and marked for power values if the following information is followed: It is necessary to at least lay down a calibration point. It is, for instance, possible to calibrate a full scale deflection of $200\ \mu\text{A}$ and to interpolate the power scale quadratically down to $20\ \mu\text{A}$. An interpolation cannot be used in the range below $20\ \mu\text{A}$. An idea of the forward power value at the various coupling attenuation of the directional couplers are given in the last column of the above table.

4.3.3. MEASUREMENT OF IMPEDANCE MATCHING

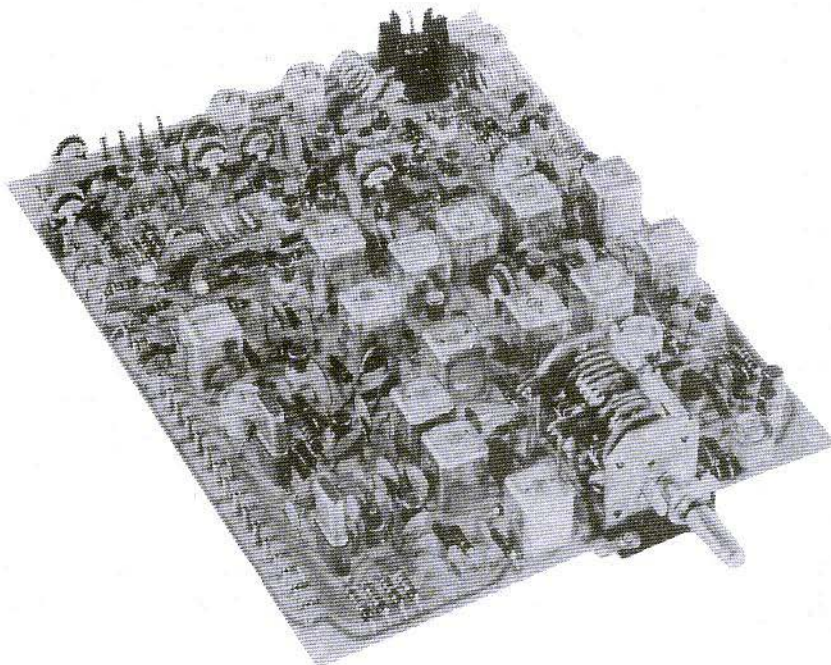
The standing wave ratio is calculated from the voltages of the forward and reflected power. Since the indicated DC-currents are in a linear relationship to the RF voltage down to approximately 100 mV, impedance matching measurements can be carried out without problems down to this lower limit. This means that the reflected power must correspond to at least 20 mW, 200 mW or 2 W according to the coupling attenuation. This corresponds to a DC current indication of approximately $20\ \mu\text{A}$ in a $5\text{ k}\Omega$ indicator circuit. With indications of less than $20\ \mu\text{A}$, it is not possible to assume a linear relationship. It is more reliable to measure the standing wave ratio from the power ratios in the method given in Section 4.2.

5. REFERENCES

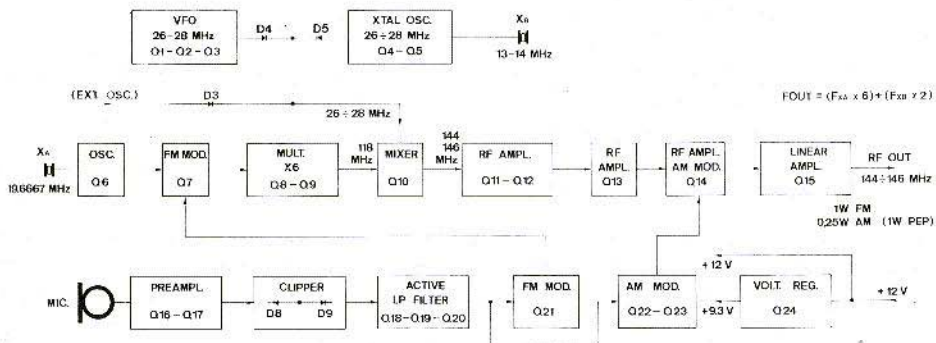
- (1) A.Kraus: Der technische Richtkoppler aus gekoppelten Leitungen Rhode und Schwarz Mitteilungen 21/1967, Pages 297-306
- (2) A.G.van Nie: Low Level Properties of Microwave Crystal Detectors Philips Electronic measuring and microwave notes 1970/1, Pages 1-9
- (3) R.Griek: Stripline Reflectometers for VHF and UHF VHF COMMUNICATIONS 3 (1971), Edition 2, Pages 89-92



New AM/FM 2 m Transmitter Module AT 222



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- 12 VDC operation
- Matching linear amplifier for 8 W output available



SIMPLE DIGITAL VOLTMETER

by K. Wilk, DC 6 YF

A digital voltmeter (DVM) is to be described whose analog-digital converter operates according to the sawtooth-method which was described as the most favourable method for constructors in (1). All complicated logic circuits have been avoided. The basic digital voltmeter module is suitable for workshop use and allows measurement of DC voltages in the range of 9.99 V, 99.9 V and 999 V. The separate construction of the analog digital converter and indicator unit allows different indicator tubes such as Nixies or 7-segment displays to be used.

1. MODULES OF THE DIGITAL VOLTMETER

The digital voltmeter consists of the following modules:

- Analog-digital converter
- Indicator module
- Power supply.

The operation of an analog-digital converter operating according to the sawtooth method has already been described in (1). Further details are given in the circuit description. The indicator module allows the output signals of the analog-digital converter to be indicated. The power supply provides the required operating voltages to the various modules of the digital voltmeter.

2. ANALOG-DIGITAL CONVERTER DC 6 YF 005

The analog-digital converter converts the DC-voltage in the range of 0 V to 9.99 V into a digital signal in BCD-code that is available in three decades of four connections each.

2.1. CIRCUIT DESCRIPTION

The circuit diagram is given in Figure 1; Figure 2 gives the pulse diagram of the analog-digital converter. The converter consists of an analog and digital portion. The main elements of the analog portion consists of operational amplifiers which operate from ± 15 V. These form the following groups:

- Input amplifier with the integrated circuit I 501
- Sawtooth generator with integrated circuit I 502
- Comparators with integrated circuit I 503
- Clock-generator with integrated circuit I 504

The digital portion is built up with TTL-circuits which are fed with an operating voltage of +5 V. The individual groups of the digital portion are as follows:

- Signal evaluation with I 505
- Counter with I 506, I 507, I 508
- Storage with I 509, I 510, I 511

Transistors T 501 to T 504 operate as level converters. They are used for matching the output voltage of the analog portion which is in the order of ± 14 V to the input level of the TTL-circuits of 0/5 V.

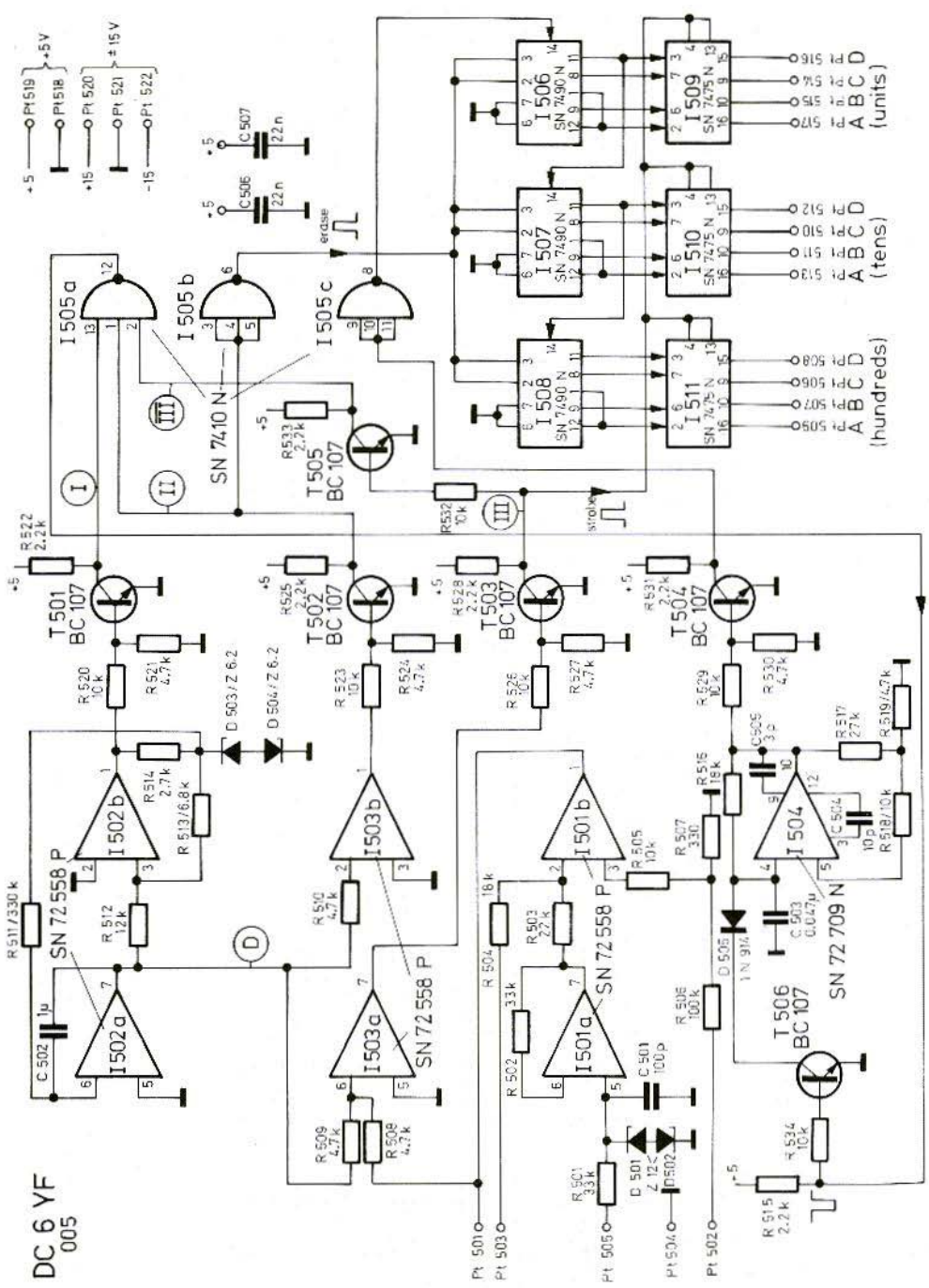


Fig. 1: Circuit diagram of the analog-digital converter of the digital voltmeter

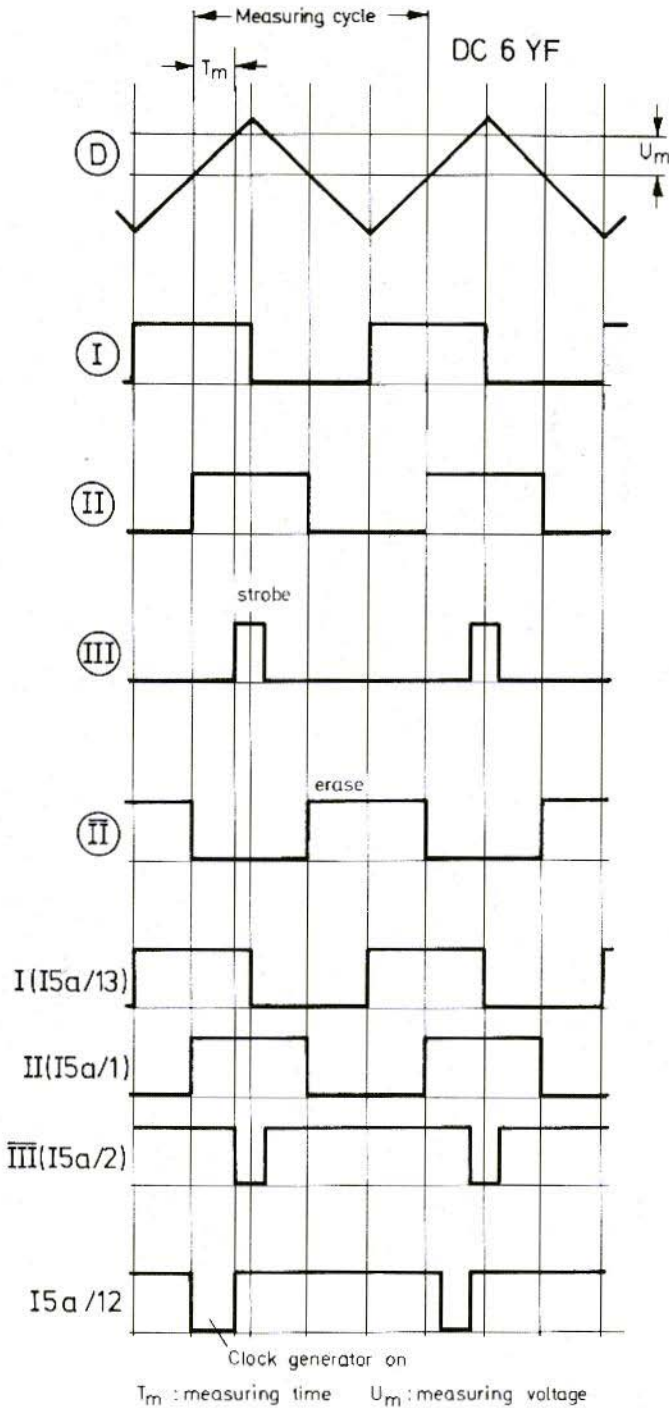


Fig. 2: Pulse diagram of the analog-digital converter

The input amplifier has two stages. It has been designed for input voltages of 0 V to 10 V. The first stage (I 501a) forms an impedance converter with an input impedance of several M Ω . The second stage (I 501b) is connected as an inverting amplifier with a gain figure of approximately one. Gain and zero point can be corrected within limits using external resistors connected to points Pt 501, Pt 502, Pt 503.

The sawtooth generator with I 502 consists of an integrator (I 502a) and an electronic switch (I 502b) whose rise and fall characteristics are not identical. The output voltage of the integrator rises and falls linearly with time. On obtaining a given voltage value dependent on the connection of I 502b, the electronic switch will change polarity. The previously increasing (or decreasing) output voltage of the integrator will now fall (or rise). The sawtooth signal (D) and the synchronized squarewave signal (\bar{I}) is taken from the sawtooth generator (the marking above the roman number indicating the pulse train designates that the signal is inverted).

The comparators (I 503) will obtain positive (or negative) output polarity when a negative (or positive) voltage is present at the inverting input. I 503a compares the voltage to be measured with the sawtooth voltage, and I 503b compares them with zero potential. The time taken between the positive voltage jumps of signals II and III is proportional to the voltage to be measured. This corresponds to a voltage-time conversion.

The clock-generator (I 504) consists of a multivibrator using an operational amplifier. Its output frequency is extremely independent of temperature and operating voltage fluctuations. The generator will operate when transistor T 6 is blocked, that is when the base of T 6 is connected to logic 0 via the evaluation circuit I 505a. The generator is only switched on during the measuring period that is proportional to the input voltage.

In the most simplified form, a free-running clock-generator is used with a subsequent gate circuit. The disadvantage of this is that a number of pulses differing by one can pass the gate according to the phase position of clock-generator and the control signal for the gate. This effect is called blocking error and will cause the last digit of the read-out to jump. This error is avoided in the described circuit since the clock-generator commences oscillation with a defined phase position at the commencement of each measuring period.

In the signal evaluation circuit with I 505, the measuring period is obtained by comparing pulse trains II and \bar{III} . This is possible when both signals are fed to a NAND-gate. In order to assure that no start signal is given to the clock generator by a falling or rising portion of the sawtooth voltage, signal I is used additionally for blanking. The triple NAND-gate I 505a is therefore fed with signals: I, II, and \bar{III} .

The clock-pulses are fed to the counter chain via inverter I 505c. This inverter provides the required steep pulses for driving the counter.

The contents of the counter is erased before commencement of each measuring cycle. This means that it is reset to 000 and that the subsequent count recommences from 0. Suitable pulses are provided by pulse train II, which are fed via I 505b and fed to the reset inputs of the counter circuits as an inverted II signal.

The counter chain equipped with integrated circuits I 506, I 507 and I 508 provide the result of the count in BCD-code to the storage comprising integrated circuits I 509, I 510 and I 511. These storage circuits are provided to ensure a stationary indication. The storage must be provided with strobe signals after each count (obtained from pulse train III).

After evaluation of the signal from the analog portion, the following processes are made in the given order during one measuring cycle: Count-strobe transfer - reset. The duration of a measuring cycle corresponds to the dimensioning of the sawtooth and clock-generator: 2.5 s.

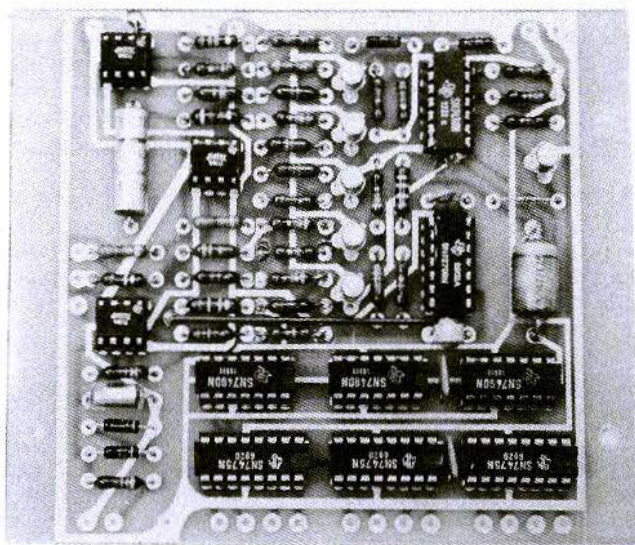
Outputs: The signal present at the outputs of the storage is the measuring result to be indicated. Four connections are available (a, b, c, d) for each digit (units, tens, hundreds) according to BCD-code.

2.2. MECHANICAL CONSTRUCTION

The analog-digital converter is accommodated on a double-coated PC-board whose dimensions are 100 mm by 120 mm (Fig. 3). The component locations are given in Figure 4.

The connection points are as follows:

Pt 501	Gain correction resistor		Pt 518	Power supply 0	
Pt 502	Zero-point correction voltage		Pt 519	Power supply + 5 V	
Pt 503	Gain correction resistor		Pt 520	Power supply + 15 V	
Pt 504	Input 0		Pt 521	Power supply 0	
Pt 505	Measuring voltage input		Pt 522	Power supply - 15 V	
Pt 506 C	} Output Pt 507 B } hundreds Pt 508 D } Pt 509 A }	Pt 510 C	} Output Pt 511 B } tens Pt 512 D } Pt 513 A }	Pt 514 C	} Output Pt 515 B } units Pt 516 D } Pt 517 A }



- 22 - Fig. 5: Prototype of the analog-digital converter DC 6 YF 005

Figure 5 shows a photograph of the author's prototype. One bridge must be made with insulated wire. The resistors should possess a slight spacing from the PC-board so that they do not short out any conductor lanes. It is advisable to use sockets for the integrated circuits.

2.3. COMPONENT DETAILS

The integrated circuits used by the author are manufactured by Texas Instruments, however, equivalent types manufactured by other manufacturers can be used.

T 501 - T 506: BC 107, BC 108 or similar silicon AF transistor.

I 501, I 502, I 503: SN 72558 P (dual-operational amplifier)

I 504: SN 72709 N (operational amplifier)

I 505: SN 7410 N (triple NAND-gate)

I 506, I 507, I 508: SN 7490 N (decimal counter)

I 509, I 510, I 511: SN 7475 N (quadruple-storage)

D 501, D 502: BZY 85/C 12 or similar 12 V zener diode

D 503, D 504: BZY 85/C6V2 or similar 6.2 V zener diode

D 505: 1 N 914, 1 N 4148 or similar silicon diode.

C 501: 100 pF styroflex capacitor (12.5 mm spacing)

C 502: 1 μ F/50 V plastic foil capacitor, max. 25 mm long

C 503: 47 nF/50 V plastic foil capacitor, max. 20 mm long

C 504: 10 pF ceramic disc capacitor, 5 mm spacing

C 505: 3 pF ceramic disc capacitor, 5 mm spacing

A spacing of 12.5 mm is available for all resistors.

2.4. ACCURACY

The deviations with respect to linearity and long-term stability were surprising good when compared to a professional unit (Hewlett-Packard). The linearity deviations were less than 0.5% and the deviation of the indication four hours after calibration were also less than 0.5% with a constant ambient temperature. The digital voltmeter was allowed the usual warm-up period of 20 minutes. The given deviations referred to the maximum value of 9.99 V.

2.5. POWER SUPPLY

The analog-digital converter requires the following operating voltages and currents:

+ 5 V at approx. 200 mA

+ 15 V at approx. 40 mA

- 15 V at approx. 40 mA

These voltages should be stabilized: The operating voltage for the digital integrated circuits should not exceed the limits 4.75 V and 5.25 V. The stability of a simple transistor-stabilized power supply is sufficient for the analog portion (+ 15 V) of this digital voltmeter.

3. INDICATOR MODULE USING NIXIE-TUBES DC 6 YF 006

The indicator-module provides a digital read-out of the output signals from the analog-digital converter. It possesses a separate channel for units, tens and hundreds.

3.1. CIRCUIT

The circuit diagram is given in Figure 6. It mainly consists of Nixie-tubes type ZM 1330 and the appropriate decoder-driver circuits SN 74141 N and power supply for the Nixie-tubes.

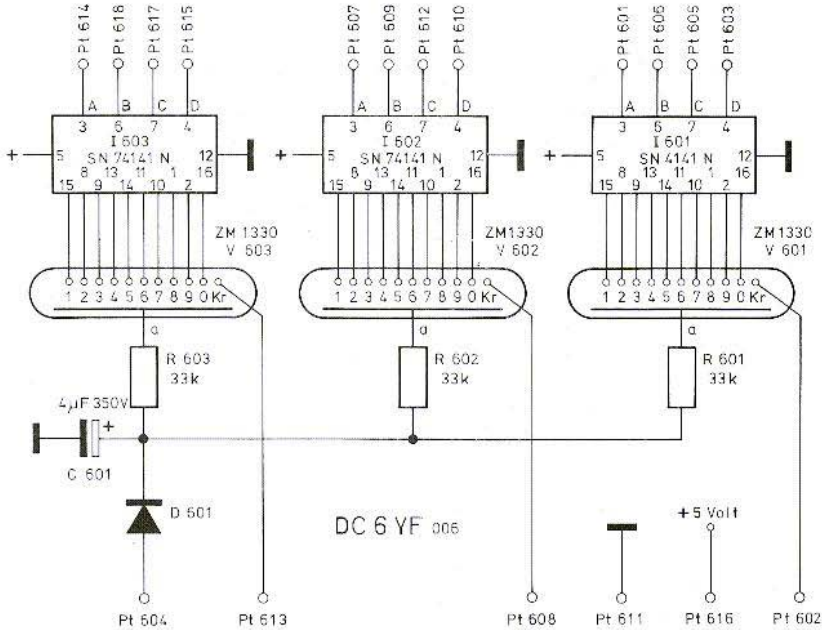


Fig. 6: Circuit diagram of the indicator module

3.2. MECHANICAL CONSTRUCTION

The PC-board used for this module is single-coated and possesses the same dimensions as that of the analog-digital converter. Figures 7 and 8 give the component locations and show a photograph of a prototype. Three short bridges are required. The connection points are as follows:

Pt 601: Input A, units
 Pt 602: Decimal point, units
 Pt 603: Input D, units
 Pt 604: Power supply 170 V AC
 Pt 605: Input C, units
 Pt 606: Input B, units
 Pt 607: Input A, tens
 Pt 608: Decimal point, tens
 Pt 609: Input B, tens

Pt 610: Input D, tens
 Pt 611: Power supply 0
 Pt 612: Input C, tens
 Pt 613: Decimal point, hundreds
 Pt 614: Input A, hundreds
 Pt 615: Input D, hundreds
 Pt 616: Power supply, + 5 V
 Pt 617: Input C, hundreds
 Pt 618: Input B, hundreds

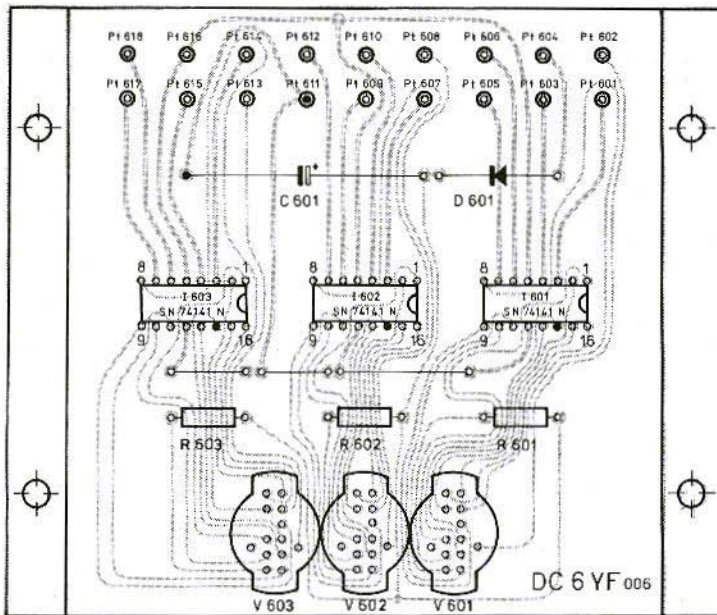


Fig. 7: Component locations on PC-board DC 6 YF 006

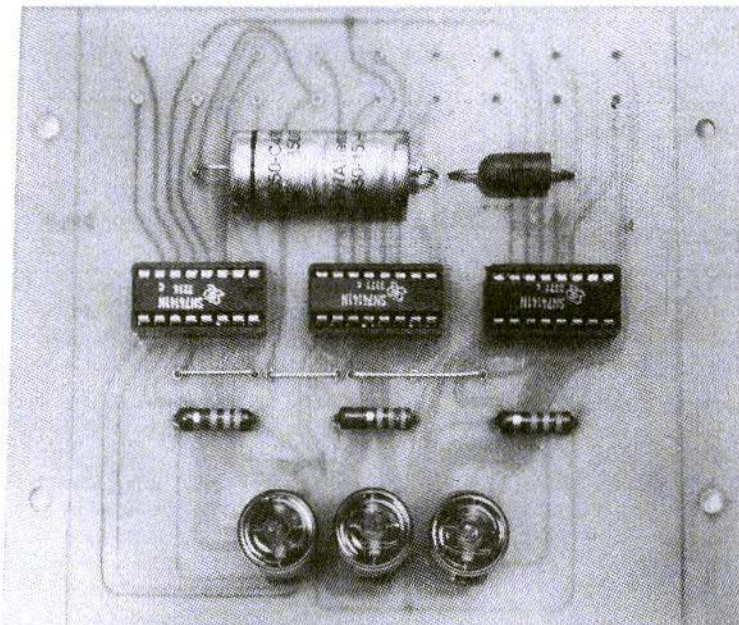


Fig. 8: Prototype of the indicator module DC 6 YF 006

3.3. POWER SUPPLY

The indicator module requires +5 V (at approximately 50 mA) for the TTL-circuits and approximately 170 V AC at max. 30 mA for the Nixie-tubes. A rectifier and filter capacitor for this voltage are to be found on the PC-board of the indicator module.

3.4. COMPONENT DETAILS

I 601, I 602, I 603: SN 74 141 N

V 601, V 602, V 603: Nixie tubes ZM 1330 (Siemens), 5870 S (ITT)

D 601: 1 N 4007 or similar silicon diode for min. 600 V

C 601: 8 μ F/250 V or more, max. 40 mm long

Three resistors of approximately 33 k Ω , max. 12.5 mm long.

4. COMPLETE DIGITAL VOLTMETER

4.1. THE COMPLETE CIRCUIT DIAGRAM

The complete block diagram is given in Figure 9. The following components are required in addition to the printed circuit boards for the analog-digital converter, indicator module and power supply:

Power transformer,

An input voltage divider for extending the 0 - 9.99 V range of the analog-digital converter to 99.9 V and 999 V.

A calibration voltage source; the author used an extremely stable, temperature-compensated zener diode, type BZX 52 (AEG-Telefunken) as calibration voltage source. The voltage of this diode (8.4 \pm 0.4 V) possesses a temperature coefficient of only $\pm 5 \times 10^{-5}/^{\circ}\text{C}$ at an operating current of $I_z = 10$ mA. If another diode is used, it is necessary to alter the resistors. The adjustment resistor is selected so that a clear indication, e.g. 300, is provided for calibration. If a normal zener diode is used, greater temperature deviations must be expected. The required three-pole switch allows either the measuring voltage, 0 V for calibrating the zero point with R 1, or the calibration voltage for calibration of the gain with R 3 to be connected to the input of the analog-digital converter.

Three power supply modules DC 6 YF 003 provide + 15 V and - 15 V as well as + 5 V. In the case of the 5 V board, only half of the dual-power supply is used and the other half of the board can be used for mounting a heat sink for the small power transistor, (e.g. 2 N 3054). The dimensioning of the power supplies was described in (2). Of course, other similar or better power supplies can be used.

The switch of the input voltage divider also switches the decimal point of the Nixie tubes. It is then not necessary for the switch positions to be marked.

4.2. INTERCONNECTION

Before interconnection, the power supply modules should be checked separately and adjusted so that no overvoltages or incorrect polarity is fed to the other modules.

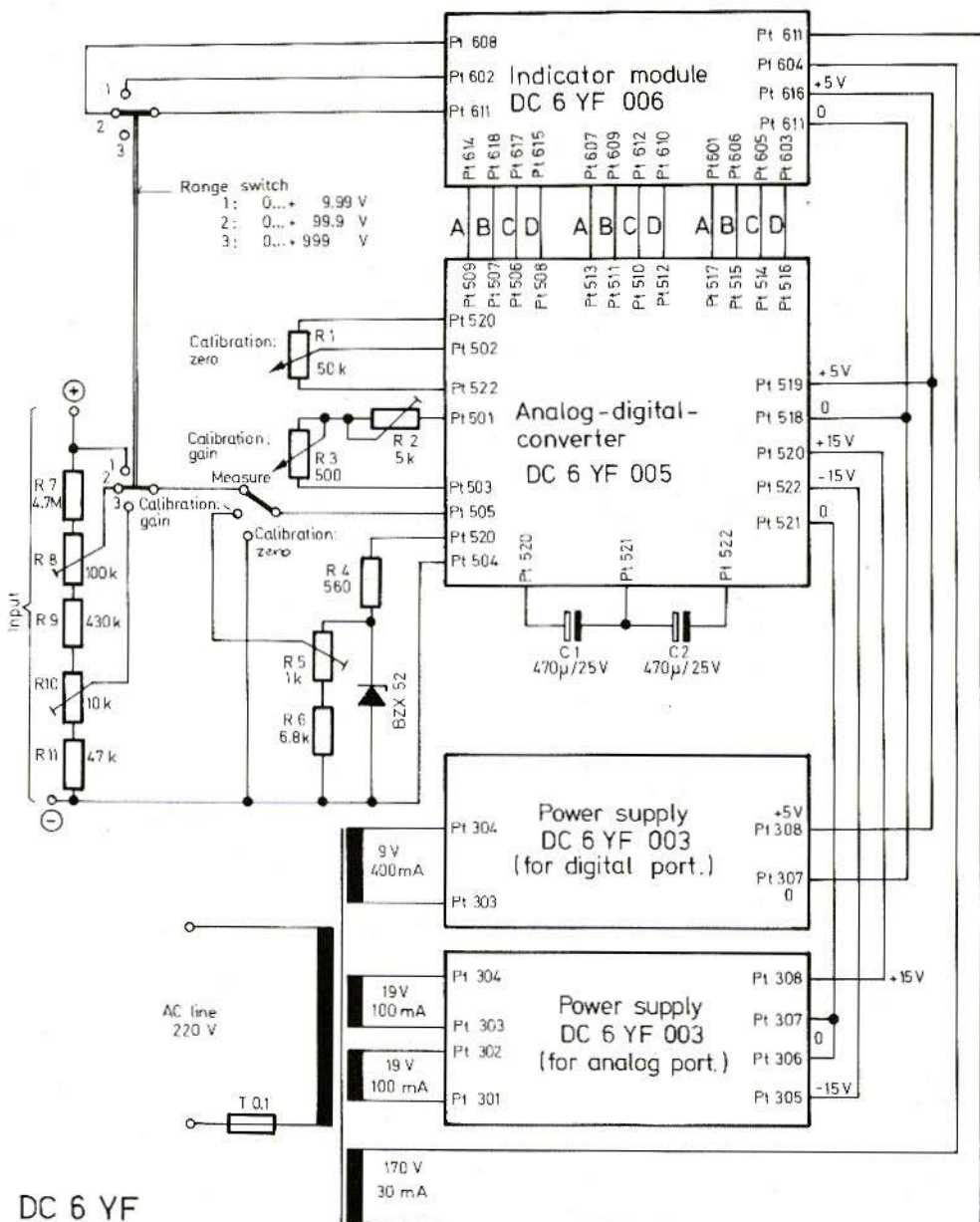


Fig. 9: Complete block diagram of the three-digit digital-voltmeter

If there is no immediate operation after interconnection, and connection of the measuring voltage in correct polarity, it is advisable to check the pulse trains on an oscilloscope at the positions given in the circuit diagram.

Adjust resistors R 1, R 2, R 3, R 5, R 8, and R 10 as follows:

R 1: Should be adjusted in the "calibrate 0-point" so that the indication 000 is just obtained from a higher value.

R 2: Is adjusted in the center position of R 3 so that the correct calibration source is indicated (e.g. 800).

R 3: Is used for gain adjustment during the calibration process.

R 5: Is the voltage selector of the calibration voltage source which is set to the required value (e.g. 800).

R 8 and R 10: Are part of the input voltage divider and are used to adjust the voltage division factor to exactly 10 or 100.

4.3. THE CALIBRATION PROCESS

The correction resistors R 1 and R 3 are mounted on the front panel. The adjustment of these controls must be checked at regular intervals when using the digital voltmeter and corrected where necessary. This calibration process must be made in the order R 1 to R 3.

4.4. INFORMATION TO THE MECHANICAL CONSTRUCTION

The individual boards of the digital voltmeter can be mounted one above the other since their dimensions and mounting holes coincide. The complete DVM is accommodated in a metal case.

Suggestions:

Holes on the rear panel for:

AC-line connection

Fuse

Other switches

Holes on the front panel for:

Switch, measure-calibrate

Calibrate: zero (R 1)

Calibrate: gain (R 3)

Input voltage selector

5. REFERENCES

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VHF COMMUNICATIONS 5 (1973), Edition 4, Pages 203-207

(2) K.Wilk: TV-Pattern Generator

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TRANSISTORIZED LINEAR AMPLIFIER FOR 70 cm

by G. Freytag, DJ 3 SC

Two versions of a three-stage linear amplifier are to be described that are suitable for increasing the power output of, for instance, a 2 m/70 cm transverter or low power transmitter. UHF power transistors manufactured by CTC are used. The output power is either 10 W or 18 W at an operating voltage of 13.5 V in the SSB mode. A large number of these linear amplifiers have been tested under practical conditions for some considerable time.

The illustrations mainly give details of the 10 W version; however, the higher power output is mainly only realized by using a different transistor complement. The two linear amplifier modules have the following specifications:

10 W Amplifier

$$P_{in} \approx 0.15 \text{ W}$$

$$P_{out} \approx 10 \text{ W}$$

$$\text{Total efficiency } \eta = 50\%$$

$$\text{Operating voltage } U_b = 11 \text{ V to } 13.5 \text{ V}$$

18 W Amplifier

$$P_{in} \approx 0.8 \text{ W}$$

$$P_{out} \approx 18 \text{ W}$$

1. CIRCUIT DETAILS

A circuit for a linear amplifier (Fig. 1) was designed around the information given by the manufacturers (CTC) in (1). The required quiescent current of transistors T 1 to T 3 is obtained with a base bias voltage using the relatively low impedance voltage dividers (R 1 in series with R 2 etc.). A voltage of approximately 7 V is required that is stabilized with a power zener diode so that stable operating conditions are guaranteed even if the battery voltage drops, for instance, during portable operation.

Inductances L 1 to L 4 in the matching networks of the transistors comprise straight conductor lanes on the printed circuit board. Capacitors C 9 and C 10 have only been provided as a safety measure to protect transistors T 2 and T 3 in case trimmer capacitor C 6 or C 7 is accidentally shorted out. Capacitors C 9 and C 10 as well as C 11 to C 16 are ceramic bypass capacitors without connection leads or chip capacitors which are placed in a 1 mm wide slot in the PC-boards and soldered on both sides to the appropriate conductor lane.

2. CONSTRUCTION

The linear amplifier circuit is accommodated on a single-coated epoxy PC-board and the components are located on the conductor lane side. Cut-outs should be made at connection points Pt 1 and Pt 2 of the PC-board for mounting the BNC sockets. Holes of 9.5 mm diameter are required for transistors T 1 to T 3. Slots of 1 mm by 10 mm are required to accommodate the chip capacitors C 9 to C 16. The dimensions of the PC-board are 210 mm by 75 mm.

The components can now be mounted on the PC-board with the exception of the transistors and the resistors of the base voltage divider R 1, R 4 and R 7 which are installed in that order. The transistors are subsequently screwed onto the heat sink. A prototype of the linear amplifier is shown in Figure 3, however, three different ferrite chokes are used than described in Section 3. The com-

DJ 3 SC
001

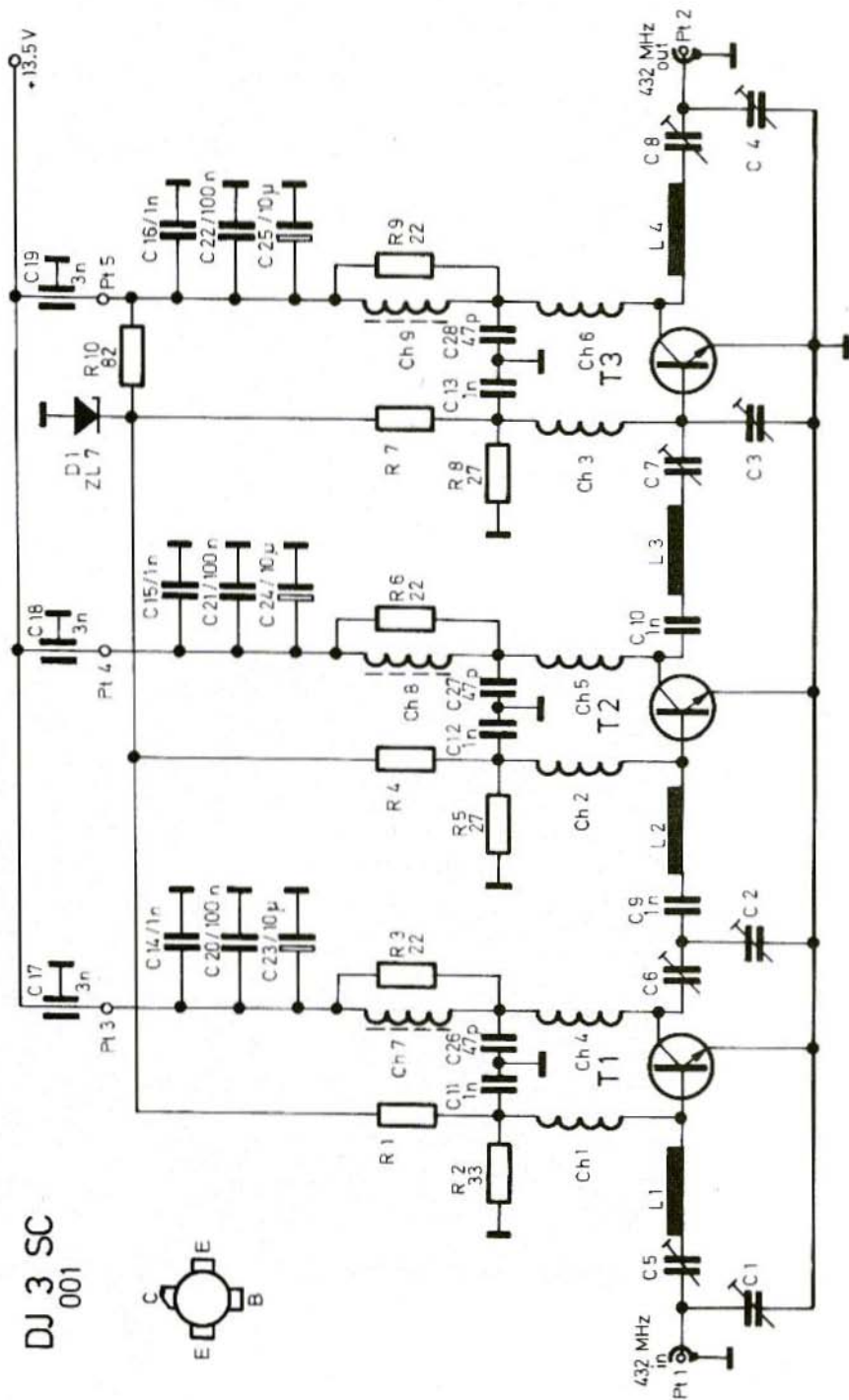
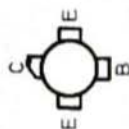


Fig. 1: Three-stage transistor linear amplifier for 70 cm

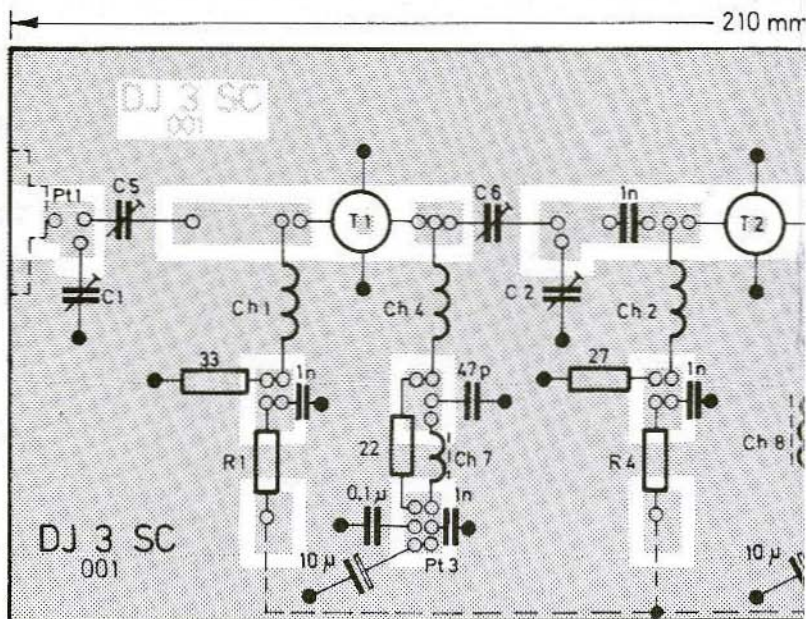


Fig. 2: Component location

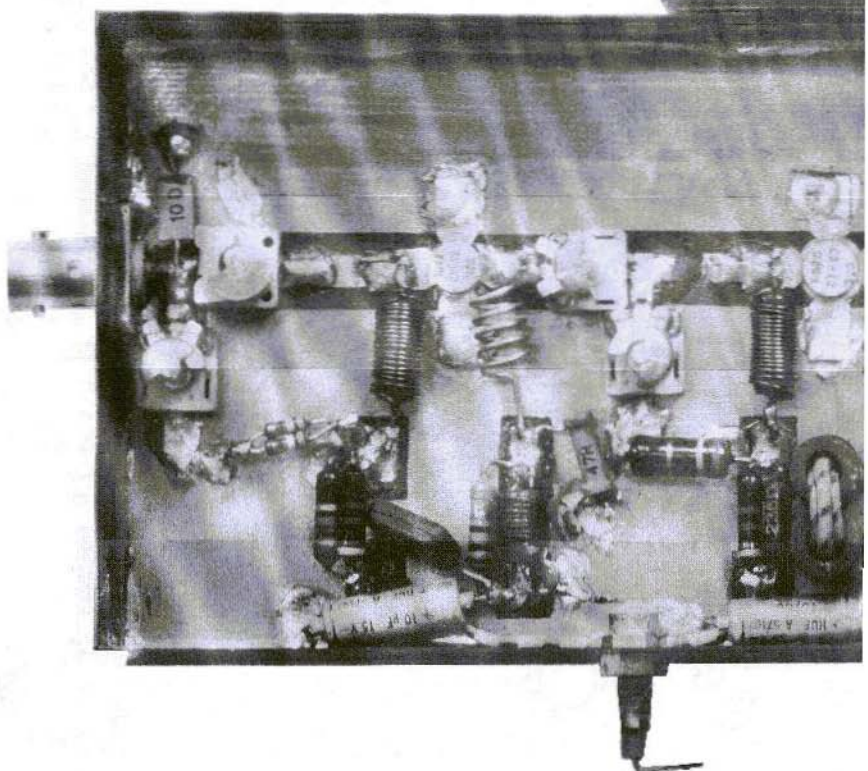
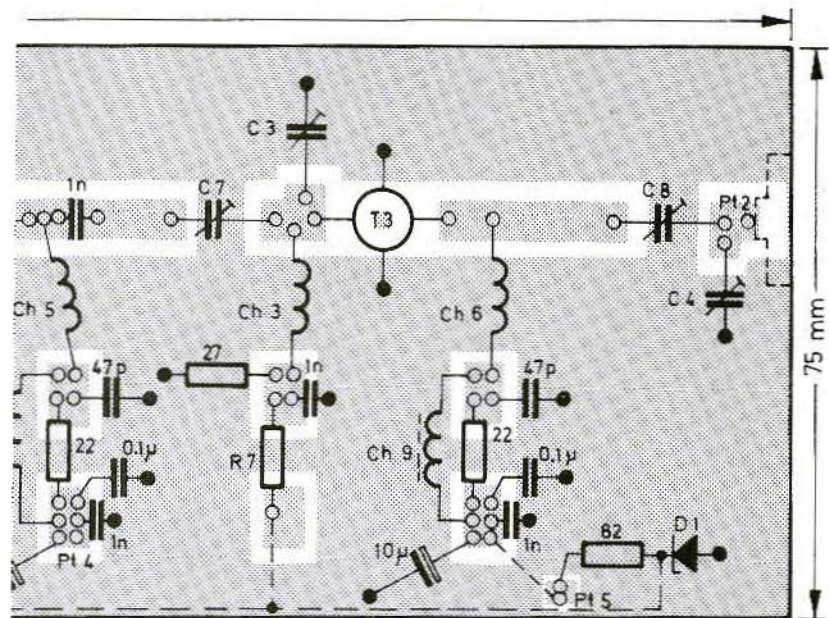
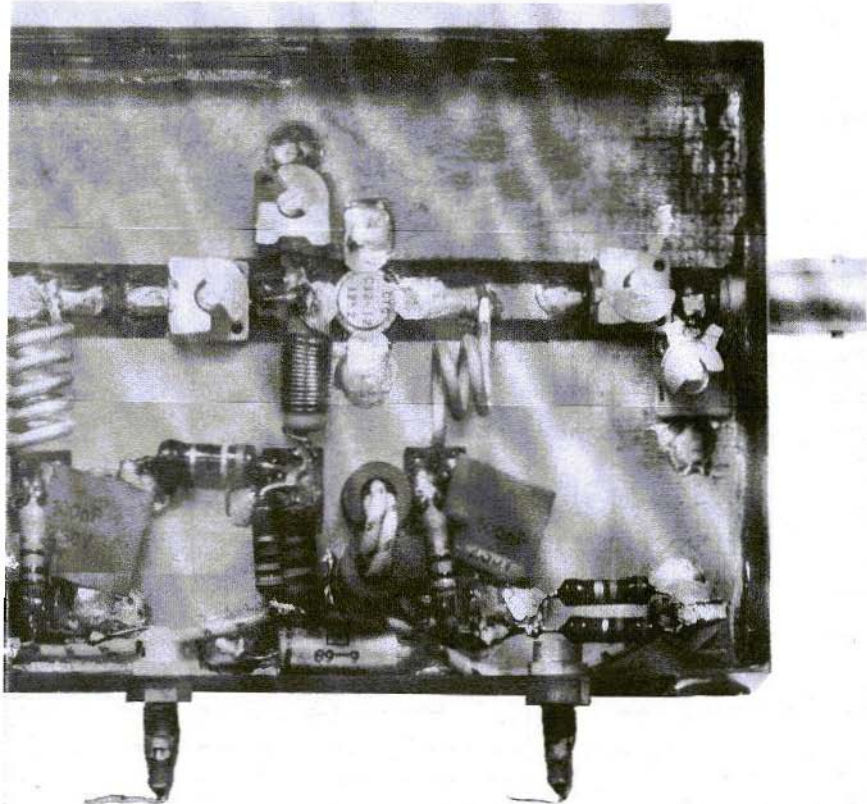


Fig. 3: Prototype of the 10



ons on PC-board DJ 3 SC 001



W linear amplifier for 70 cm

ponents can be seen clearly. At first, the four stripline inductances appear to be normal solder points. The feedthrough capacitors C 17 to C 19 are located below and are connected to soldering points Pt 3 to Pt 5.

To ensure stable operation of the linear amplifier, the PC-board is enclosed in a metal frame constructed from a 0.6 mm thick and 45 mm high metal plate which is soldered to the edge of the PC-board before mounting the components. The required parts A to D are given in Figure 4. The same parts are required for both amplifiers.

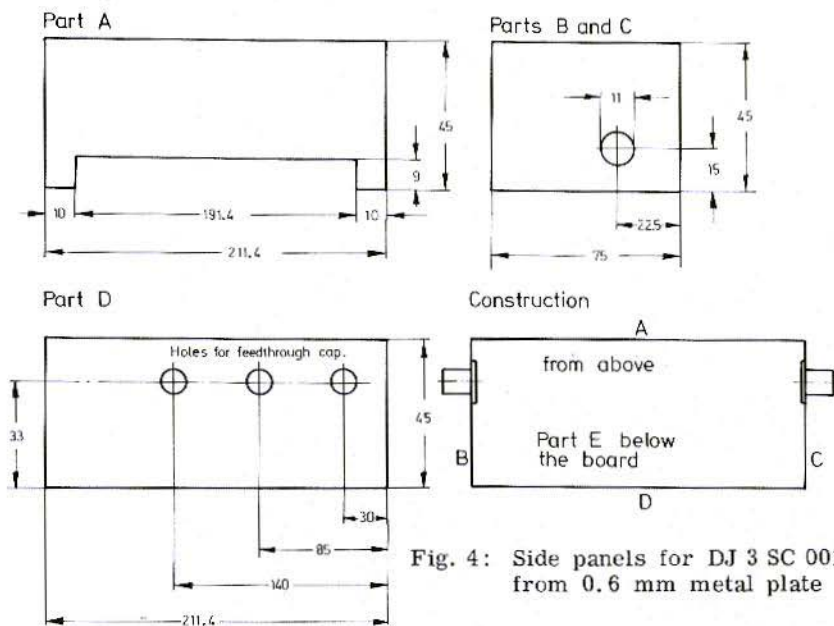


Fig. 4: Side panels for DJ 3 SC 001 from 0.6 mm metal plate

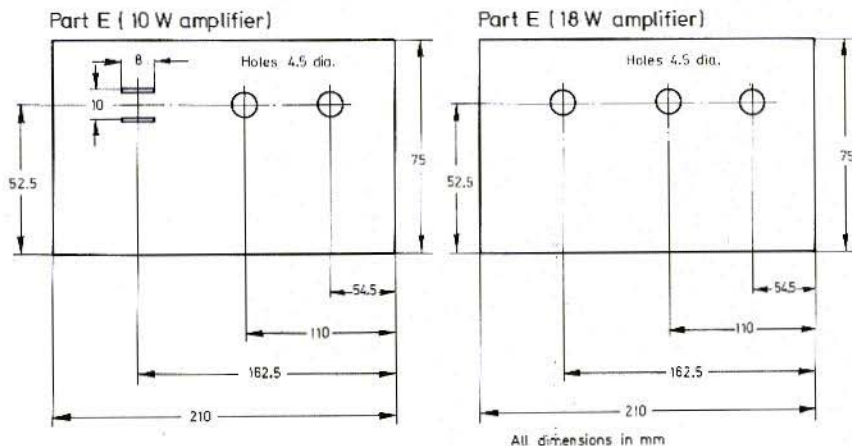


Fig. 5: Base plate from 1 mm brass plate

In order to completely screen the amplifier, if required, a further metal plate (Fig. 5) is mounted 2.5 mm below and parallel to the PC-board. This plate also helps to cool the transistors. In order to ensure that this base plate can be mounted with the correct spacing, it is necessary for the bypass capacitors not to protrude more than 1.5 mm from the PC-board.

The mounting is assisted if the PC-board and metal plate are glued together to form one unit with the aid of relatively large-area spacer pieces made from 2.5 mm PC-board material. After this, the PC-board and metal plate can be soldered to the metal frame.

With this construction, the case of the transistors type C 3 - 12, C 12 - 12 and C 25 - 12 are mounted on the metal plate (part E) whereas the connection leads are connected to the board and do not possess any mechanical stress. Attention should be paid when soldering the already glued unit that the heat sink constructed from an aluminum bracket is well fitted to the metal plate (part E) and the metal frame (part A). This is shown in Figure 6.

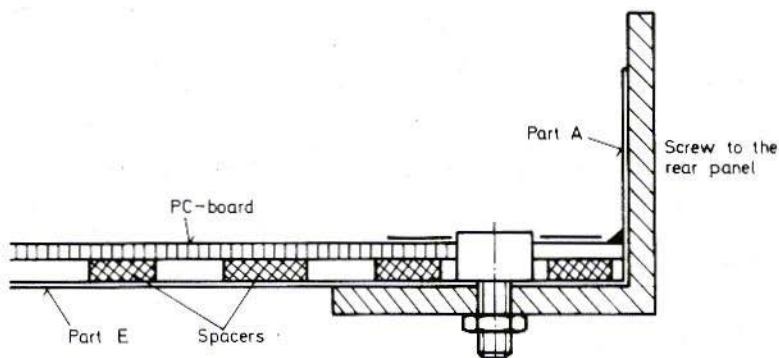


Fig. 6: Cross-section of the amplifier DJ 3 SC 001 with metal plates and heat sink

The heat dissipated from transistor types C 3 - 12 to C 25 - 12 is taken from their bolts and fed to the aluminum heat sink of 50 mm x 50 mm x 4 mm to the rear panel of the case. If this rear panel does not have to dissipate heat from any other sources, no further heat sink will be required with the 10 W version when used in the SSB mode.

A good contact to the metal plate below the PC-board is sufficient for cooling transistor type C 1 - 12. This transistor possesses a gold-plated disc on the lower side which can be soldered to a heat sink. This heat sink is made from a 6 mm wide, U-shaped copper plate approximately 0.5 mm thick. The two arms are then placed through slots in the metal plate (part E in Fig. 5) and are soldered to this plate after bending (see Fig. 7).

This means that the aluminum heatsink of the 10 W version need only be provided for the two transistors with bolts (approx. 120 mm).

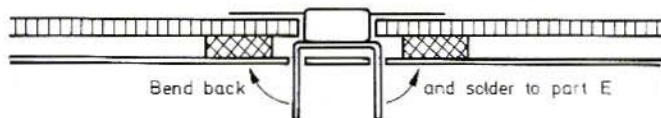


Fig. 7: Cooling of transistor type C 1 - 12

3. COMPONENTS

10 W Version

18 W Version

T 1: C 1 - 12

T 1: C 3 - 12

Manufacturer:

T 2: C 3 - 12

T 2: C 12 - 12

Communications

T 3: C 12 - 12

T 3: C 25 - 12

Transistor Corporation

D 1: ZL 7, BZY 92/C6V8 or similar 7 V/1 W zener diode.

C 1 - C 8: 6 to 30 pF air-spaced trimmer with two connection pins plastic foil trimmers of 2 - 22 pF are also suitable for C 1 - C 4.

C 9 - C 16: Approximately 1 nF ceramic bypass capacitors without connection leads; or chip capacitors.

C 17 - C 19: 3 nF feedthrough capacitors, value uncritical (attention should be paid that they are able to handle the DC current).

Ch 1 - Ch 3: 18 turns of 0.5 mm dia. (24 AWG) enamelled copper wire wound on a 1 W resistor of 6 mm dia., length 14 mm.

10 W - Amplifier

18 W - Amplifier

Ch 4: 5 turns of 1 mm dia. (18 AWG) silver-plated copper wire, inner diameter 6 mm, length 10 mm, self-supporting.

Ch 4: As Ch 5

Ch 5: As Ch 6

Ch 5: 5 turns of 2 mm dia. (12 AWG) silver-plated copper wire, inner diameter 6 mm, length 16 mm, self-supporting.

Ch 6: 1 turn of 2 mm dia. (12 AWG) silver-plated copper wire, inner diameter 6 mm, self-supp.

Ch 6: 2 turns of 2 mm dia. (12 AWG) silver-plated copper wire, inner diameter 6 mm, length 7 mm, self-supporting.

Ch 7: As Ch 8

Ch 8: As Ch 8

Ch 9: As Ch 8 but with 4 turns

Ch 7: Ferrite, wideband choke

Ch 8: 8 turns on ferrite toroid: outer diameter: 23 mm; inner dia.: 14 mm; height: 7 mm; $\mu_i > 2000$.

Ch 9: As Ch 8

R 1: Approx. 320 Ω (select required value)

R 4: } Approx. 250 Ω (select correct value)
R 7: }

4. ALIGNMENT

After the PC-board has been soldered onto the metal frame and all components with the exception of resistors R 1, R 4, and R 7 have been mounted, it is then possible for the quiescent current of the transistors to be adjusted. Measure the voltage at the zener diode. The operating voltage is then connected to only one of the stages and the value of resistor R 1 (or R 4 or R 7) is selected by carefully reducing the resistance value in small steps until the correct value is obtained.

The linearity of the amplifier increases with the quiescent current; however, there is a danger of instability at quiescent currents of over 30 mA. Sufficiently linear SSB quality can be obtained from approximately 5 mA per stage.

The RF alignment can be made most favourably when a long roll of coaxial cable (50 m) with a high attenuation is connected via a standing wave bridge (2), (3). The 50 Ω resistor at the end of the cable will only be loaded by a fraction of the output power and any reflection will have no effect at the transmitter end of the cable.

The trimmer should be brought approximately to their central position observing the current drain to the amplifier. This is followed by feeding approximately a quarter of the drive power to the input. No RF voltage will be present at the output at this point. Trimmer capacitors C 1 and C 5 should be firstly adjusted in an attempt to increase the current drain, which is then followed by adjustment of C 2 and C 6. Experience has shown, however, that a large increase of the output power is only to be observed when virtually all of the final positions of the trimmers have been obtained.

It is now possible for the drive power to be increased and the trimmers aligned for maximum output power.

5. RESULTS

A very large number of these linear amplifiers have been constructed in the meantime in Germany. Some of them have been in operation for more than one and a half years. Although the semiconductors used are not especially designed as linear transistors, the results are extremely satisfactory. The very good quality of the SSB signal is confirmed by all QSO partners. No increase of the signal spectrum or splatter could be heard, even by local stations.

6. REFERENCES

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Application notes from Communications Transistor Corporation, USA.
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VHF COMMUNICATIONS 3 (1971), Edition 2, Pages 89-92
- (3) H. Tiefenthaler and B. Roessle: Precision 50 Ω Reflectometer
for 0 - 2400 MHz
In this Edition of VHF COMMUNICATIONS

ANTENNA NOTEBOOK

by T. Bittan, G 3 JVQ / DJ Ø BQ

1. SWITCHING THE POLARISATION OF CROSSED YAGIS

The interconnection of a crossed Yagi antenna for clockwise circular polarisation was described in (1). It was also recommended that clockwise circular polarisation be standardized for all amateur communications on the VHF, UHF and Microwave bands.

However, an originally clockwise circular polarisation will be inverted into anticlockwise polarisation in the case of direct mirror-like reflections on mountains, the Moon etc. Furthermore, the signal of a clockwise circular polarised antenna will be received as an anticlockwise signal when the transmit antenna is facing away from the receive station. The above details, as well as the fact that the OSCAR 7 satellite will be transmitting either clockwise or anticlockwise circular, or elliptical polarisation according to its position in space, indicate that it is advisable to switch the circular polarisation. Two methods are to be described: The first method allows the circular polarisation to be switched between clockwise and anticlockwise circular polarisation and only requires one coaxial relay. The second more sophisticated method allows vertical, horizontal, clockwise and anticlockwise polarisation to be selected, and uses a total of four coaxial relays.

1.1. SIMPLE SWITCHING UNIT FOR CLOCKWISE AND ANTICLOCKWISE POLARISATION

The circuit of this simple switching unit is given in Figure 1. When using the normal phasing cable for circular polarisation in conjunction with one of the MOONBOUNCER antennas, the longer arm of the phasing cable is connected to the rearmost dipole of the crossed Yagi. In order to achieve anticlockwise circular polarisation, it is only necessary to add an electrical half wave of coaxial feeder to the shorter arm of the phasing line (foremost dipole). This can be achieved in the most simple manner by shorting out this extra halfwave line when anticlockwise circular polarisation is not required. This is shown in Figure 1 where the switching is carried out by relay Rel. 1.

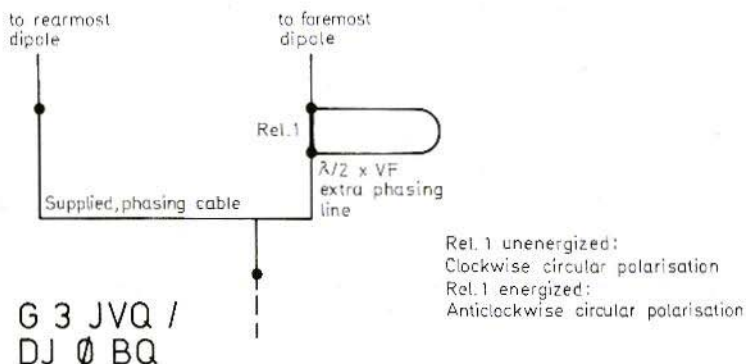
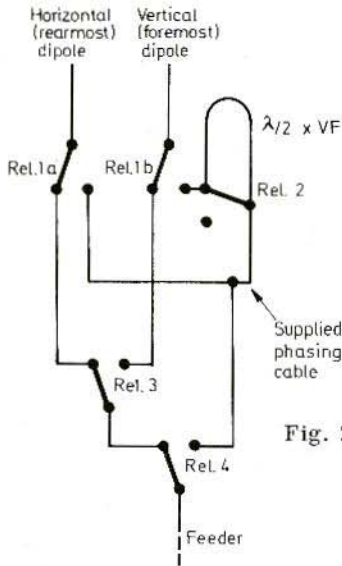


Fig. 1: Circuit of a switch unit for clockwise and anticlockwise polarisation



The following polarisations will result:
 Horizontal: No relays energized
 Vertical: Relay Rel. 3 energized
 Clockwise circular: Relays 1 Rel. 1 and 4 energized
 Anticlockwise circular: Relays Rel. 1, 4 and 2 energized

Fig. 2: Switching unit for all polarisation modes

1.2. SWITCHING UNIT FOR HORIZONTAL, VERTICAL, CLOCKWISE AND ANTICLOCKWISE CIRCULAR POLARISATION

The circuit diagram of this switching unit is given in Figure 2. Horizontal polarisation is present at the output of the switching unit when no relays are energized. In order to switch to vertical polarisation, it is only necessary to energize relay Rel. 3. Circular polarisation is obtained by energizing relays Rel. 1 and Rel. 4. The crossed Yagi should be mounted so that the rearmost dipole is in the horizontal plane. If this is the case, clockwise circular polarisation will be available when only relays Rel. 1 and Rel. 4 are energized. Anticlockwise circular polarisation can be achieved by additionally energizing relay Rel. 2.

2. REQUIRED RELAYS AND CABLES

In the case of the relay Rel. 1 in Figure 1 and Rel. 2 in Figure 2, it is necessary for these to be taken into consideration in calculation of the electrical $\lambda/4$ and $\lambda/2$ wavelengths.

Prerequisite is that both antenna feeders are of exactly the same length electrically upto the output of relay Rel. 1a and 1b. In the case of Rel. 1 in Figure 1 and Rel. 2 in Figure 2, it is important that these are taken into consideration in calculating the electrical $\lambda/4$ and $\lambda/2$ wavelength of the phasing cables. It should be remembered that any additional phase shift of more than 90° or 180° will cause a deterioration of the circularity of the polarisation which will appear in the form of an intrusion or cutout in the circular pattern. Further details regarding the testing of the circularity will be given later.

With the exception of the phasing line itself and the additional $\lambda/2$ phasing cable, all other cables are uncritical in length and should be of the same impedance as the antenna in question. All relays except Rel. 1 are of the single pole changeover type. Relay Rel. 1 is a double pole changeover type. All relays should be capable of handling the full output power of the transmitter.

The length of the extra $\lambda/2$ phasing cable given in Figures 2 and 2 can be calculated from the formula:

$$\lambda/2 \times VF$$

Where $\lambda/2$ is a mechanical halfwave and VF the velocity factor of the cable in question. As was given in (2), a velocity factor of 0.66 is valid for coaxial cables with a solid dielectric and 0.85 for foam and semi-airspaced cables. This results in a mechanical length of 68.65 cm (27.02") for cables with solid dielectrics, or 88.40 cm (34.80") for semi-airspaced and foam dielectric cables.

2.1. POSSIBLE VARIATIONS

Of course, the above switching unit can also be used for groups of crossed Yagi antennas if all the vertical and all the horizontal antennas are stacked in the conventional manner with suitable stacking cables, and fed to the switching unit with equal lengths of cable. In this case, the same is valid as for switching an individual crossed Yagi.

If the equal length feeders are fed down to the shack, it will be possible to switch polarisation using switches instead of relays. This would reduce the cost of such a switching unit considerably.

3. CHECKING THE CIRCULARITY OF THE CIRCULAR POLARISATION

This is a problem that many amateurs have passed on to the author. It is, of course, not always possible to achieve a truly circular pattern due to small variations of the velocity factor of the coaxial cable used in the phasing cable. The supplied phasing cable virtually always offers completely satisfactory circular polarisation. However, it should be noted that any phasing cable is only really absolutely correct at one frequency and slight phase differences will be present at other frequencies. Of course, this is rather observing the matter from a perfectionist point of view since the variations will only be in the order of tenths of a dB. Since the spacing between the two separate dipoles of the crossed Yagi is taken into consideration by the phasing cable, the phasing is also only truly correct when the antenna is connected for clockwise circular polarisation. In fact it will be noticed that this spacing of the dipoles and the compensation means that a truly circular polarisation is only provided in the forward direction. In the reverse direction, a phase error caused by the spacing of the dipole is added to an additional phase error caused by the compensation in the phasing line. This will be seen as an intrusion into the circularity when measured at the rear of the antenna, even when the signal is truly circular in the forward direction. This can amount to a phase error of 18° in the reverse direction. In the case where the phase line has been connected incorrectly so that anticlockwise circular polarisation results, the phase error will also be in the order of 18° . The above information is only specific for the MOON-BOUNCER range of antennas since it will vary with the spacing between the dipole elements and the compensation of the phasing line, where this taken into consideration.

The circularity of the circular polarisation can be measured simply using a receiver with an accurate S-meter or a good field-strength meter, in conjunction with a dipole or folded dipole antenna. The test antenna should be within the main lobe of the antenna under test and be clear of the ground and surrounding

effects. The test dipole is then rotated circularly in the same plane as the circular polarisation, i.e. slowly from horizontal to vertical and back to horizontal. If any intrusions into the circular pattern are observed in the form of a reduction in signal strength, this will mean that a phase error is present. This will usually be present at a position diagonal to the plane of the antennas. This obtains a maximum when the phase error amounts to 180° where a linear, diagonal polarisation will result with an intrusion of 15 to 25 dB in the opposite diagonal plane. The author is still experimenting in order to find out to what extent the position, width and depth of this intrusion can give information as to the actual phase error and this will be discussed in a later article.

The author already mentioned in (1) that it is advisable to mount a cross Yagi in the form of an "X" if only circular polarisation is to be used. However, if linear polarisation is also to be used, it is recommended that glass-fiber tubing be used; PVC tubing is normally not strong enough for such applications.

4. AVAILABLE PARTS

The publishers are willing to supply the required relays, cables, and case for such a switching unit if there is a demand. It is also possible that the publishers will be bringing out a ready-to-operate switching unit in conjunction with J-Beam. We have also arranged for 70 cm crossed Yagis to be made available by Spring 1974. Glass fiber tubing could also be supplied if there is a demand. Please write to your national representative.

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CALCULATION OF THE ELEVATION AND AZIMUTH ANGLES FOR ANTENNA CONTROL FOR MOONBOUNCE COMMUNICATIONS USING DATA FROM THE AIR ALMANACH

by P. Raichle, DJ 6 XV

It is necessary to track the orbit of the moon for radio communications using the Moon as reflector (EME). An optical tracking system cannot usually be used mainly due to clouds and bad weather which would not allow the Moon to be visible. However, it is possible to adjust the antenna array using the predicted Moon orbital data from the Air Almanach. This publication is used for aeronautical celestial navigation by plotting the positions of Sun, Moon or stars.

1. DESIGNATIONS AND MAGNITUDES

- δ = Declination (Deviation from celestial equator)
- GHA = Greenwich hour angle
- φ = Geographical latitude of EME station
- AZA = Azimuth angle of the antenna (required)
- ELW = Elevation angle of the antenna (required).

The declination (δ) of the moon (the angle between the Moon and the celestial equator measured along the meridian), and the GHA (the momentary angle between the Greenwich meridian and the Moon) designate the position of the Moon with respect to the Earth. Both these angles are given every ten minutes for one year in the Moon column of the Air Almanach. The angles commence at the centre of the Earth and pass through the Greenwich Meridian (0°), which means that they must be recalculated for the required location. It is then possible to direct an antenna or telescope to the Moon at 10 minute intervals.

The recalculation of the data and antenna tracking is not difficult if the antenna is parallactically mounted. A parallactic mounting is when one axis of the antenna runs parallel to the axis of the Earth. It is only necessary for the antenna to be directed to the Moon at the start of the EME-test, and rotated at a constant speed to compensate for the rotation of the Earth. However, due to the relatively small distance between the Moon and Earth when compared with other heavenly bodies, it is necessary to correct the setting fairly often. In addition to this, the parallactic mounting of large antenna arrays is extremely extensive and a disadvantage when the antenna is also to be used for terrestrial communication (along the Earth's surface), or for communication via artificial satellites.

This is the reason why an XY-mount is usually employed so that the antenna can be moved in the vertical and horizontal axis. Azimuth and elevation angles are necessary for tracking the moon, which can be calculated from data given in the Air Almanach.

2. METHOD OF CALCULATION

H. Götting, DL 3 XW calculated a table according to spherical geometry which allows him to establish the azimuth and elevation angles for his antenna and location from the Greenwich hour angle and declination data of the Air Almanach. The antenna can be easily tracked to the Moon during the EME-test when such a table is used. The calculation is made as follows:

$$\begin{aligned} \sin \text{ELA} &= \sin \varphi \times \sin \delta + \cos \varphi \times \cos \delta \times \cos \text{GHA} \\ \text{ELA} &= \arcsin (\sin \varphi \times \sin \delta + \cos \varphi \times \cos \delta \times \cos \text{GHA}) \\ \sin \text{AZA} &= \frac{\cos \delta \times \sin \text{GHA}}{\cos \text{ELA}}; \quad \text{AZA} = \arcsin \frac{\cos \delta \times \sin \text{GHA}}{\cos \text{ELA}} \end{aligned}$$

The maximum values limit the range for which the table is valid. The Greenwich hour angle and declination are varied within these limits. Unfortunately this calculation is too time consuming and inaccurate when using a slide rule.

3. USING A COMPUTER

The use of a computer for exact calculation is, of course, very favourable. The author prepared a computer program in FORTRAN IV which is flexible enough so that the calculation can be made for any required location. In addition to this, it is possible to vary the angular range, the number of computed pairs and steps. In a computed example, the steps amounted to 10° , the GHA range was variable from 0° to 130° and the declination from -30° to $+30^\circ$.

Figure 1 shows the arrangement of the computer table. However, this table is only a demonstration printout for checking the computer program. The steps are far too great for practical operation, which will use a table with steps of 1° . This results in approximately 15000 pairs of azimuth and elevation values.

CONVERSION TABLE

Greenwich hour angle GHA		0°	10°	20°	30°	130°
- 30°	ELA	7.5829	7.1193	5.7453	3.5085			0.0
	AZA	0.0	8.7169	17.3192	25.7107			0.0
- 20°	ELA	17.5828	17.0632	15.5169	13.0207			0.0
	AZA	0.0	9.8277	19.4844	28.8321			0.0
- 10°	ELA	27.5828	26.9946	25.2652	22.4925			0.0
	AZA	0.0	11.0648	21.8668	32.2046			0.0
0°	ELA	37.5828	36.9159	34.9686	38.8838			0.0
	AZA	0.0	12.5440	24.6684	36.0747			0.0
+ 10°	ELA	47.5828	46.8134	44.5902	41.1312			0.0
	AZA	0.0	14.4701	28.3269	40.8239			0.0
+ 20°	ELA	57.5828	56.6639	54.0574	50.1198			0.0
	AZA	0.0	17.2727	33.1978	47.1187			0.0
+ 30°	ELA	67.5828	66.4064	63.1992	58.6132			3.2524
	AZA	0.0	22.0639	41.0636	56.2423			41.6453

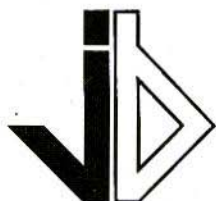
The process and application are relatively simple. The required values of declination and Greenwich hour angle are taken from the Air Almanac in ten minute intervals for the period in question. The table gives the azimuth and elevation values for the antenna at the intersection of both angular magnitudes for that particular time. It is only necessary for them to be transferred to accurate angular scales on the antenna axes. Intermediate values can be interpolated.

4. CALCULATION DATA

Interested parties can receive such a computer list from the author. For this the author requires the geographical position of the antenna location with an accuracy of one tenth of a second so that the accuracy is sufficiently great. Furthermore the period for which the calculation is to be valid is also required. The step width between two computations should be approximately 1° .

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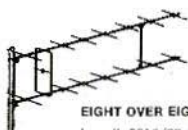


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NOTES AND MODIFICATIONS

1. MINIATURE AM/FM/CW TRANSMITTER DJ 8 PG 001

Two critical components have been found during construction of this transmitter:

It is hardly possible to obtain the required inductivity of the oscillator inductance L 201 when using the small 4 mm coilformer. It is advisable to wind the same number of turns on a 5 mm coilformer and to use enamelled copper wire in order to avoid short circuits.

The inductance of the emitter choke Ch 201 will not be sufficient with all ferrite cores. In such cases, the oscillator will be short circuited for RF-voltages and will not oscillate. The most suitable choke for this purposes is a 5 mm long ferrite bead through which four or five turns of enamelled copper wire have been wound.

The ease of oscillation and thus the output power of the transmitter can be improved considerably when a capacitor of approximately 10 pF is connected between the base of T 201 and ground. An output power of 1 mW into 60 Ω was measured at an operating voltage of 9 V.

We would like to point out once again the error in the component location plan which mentioned in an earlier edition: It is the collector of transistor T 205 that is grounded not the emitter and the positive operating voltage is grounded.

2. IMPROVEMENT OF THE AGC IN THE DC 6 HL TRANSCEIVER

Although the AGC range of the SSB transceiver amounts to 120 dB it has been noticed that extremely strong signals cause a certain amount of pumping. This is caused by the two time constants of the AGC circuit. With weaker signals, C 153 (2.2 μF) is charged with a time constant of

$$t = R \times C = 10^3 \times 2 \times 10^{-6} = 2 \text{ ms}$$

via R 138 and R 139 = 1 kΩ, which provides the desired rapid increase of the control voltage. With strong signals, capacitor C 157 (22 μF) is charged additionally via the diode chain D 113 to D 118, i.e. with ten times the time constant. This means that the control voltages reacts too slowly. The rectifier comprising D 106 and D 107 reduces this effect but is not able to suppress it. The removal or changing the value of C 157 will cause other disadvantages. A far better AGC can be obtained if the Plessey IC SL 621 is used.

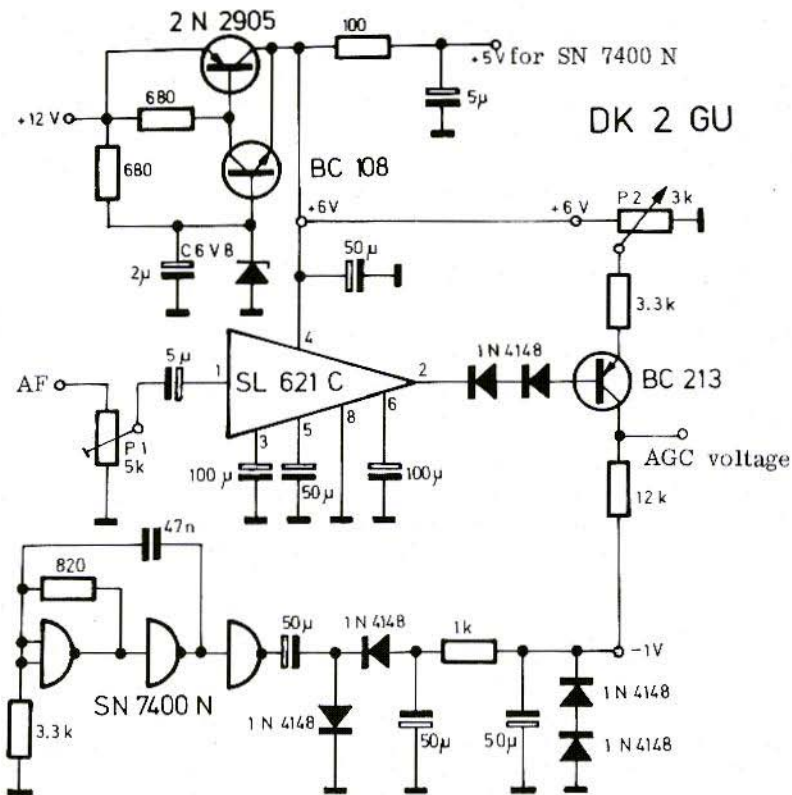
The circuit consists of three parts:

AGC voltage generator with level converter (centre);
DC voltage converter for - 1 V (below) and
a voltage stabilizer in order to provide the SL 621 with
an operating voltage of 6 V with the required low impedance.

Since the circuit does not possess any special features, it is not necessary to explain this further here. Further details regarding the operation of the SL 621 have already been given in VHF COMMUNICATIONS.

Installation of the recommended AGC circuit in the DC 6 HL transceiver:

Remove C 146 (2.2 μ F). Replace C 145 with a 2.2 μ F capacitor. The AF voltage for generating the AGC voltage is taken from this output. Depending on whether T 106 is controlled or not (see previous recommended modifications in VHF COMMUNICATIONS), it will be possible to remove other components from the main board. After connecting the new AGC circuit, the control voltage is adjusted to 2.2 V with the aid of potentiometer P 2. Potentiometer P 1 is rotated towards ground during this adjustment, and allows the threshold to be adjusted afterwards.



3. ATV TRANSMITTER DJ 4 LB

The stability of the video and sound IF (modules DJ 4 LB 001 and 002) are mainly dependent on capacitors C 106, C 218, C 219 and C 220: High quality ceramic disc capacitors with a defined temperature coefficient should be used.

Too high a residual carrier (more than 10%) can be caused by the PNP transistor T 104 when modulating the video IF signal. The current gain of this transistor should only be in the order of a several tens as is the case of the given transistor type BC 178 VI. The BC 178 B has a current gain of several hundred times.

Due to the extension of the series, diodes D 201 and D 202 (BZY 87) of module DJ 4 LB 002 are now designated BZY 87/0V7. They exhibit a steeper increase of current in the forward direction than conventional silicon diodes such as the 1 N 4148.

The output power of module DJ 4 LB 003 can be increased to 60 mW at 13 V or 90 mW at 18 V when a transistor BFR 90 is used in the output stage - soldered directly to the conductor lanes. The emitter resistor should then be 120 Ω . This modified output stage operates far more stably than the original BF 223 stage with 40 mW output.

If transistor T 407 of module DJ 4 LB 004 takes a quiescent current of considerably more than 25 mA (measureable as 0.25 V across R 424 = 10 Ω), it will be advisable to increase the value of R 422 to 1.2 k Ω or 1.5 k Ω . In order to ground the emitters of transistors T 405 to T 407 satisfactorily for RF-voltages, it is necessary for low-loss disc capacitors to be installed with short leads for C 415, C 420, C 422, C 423. All transistors handling UHF voltages should be mounted with short leads, a spacing of 4 mm to the board is sufficient except for the 2 N 3866 which should be spaced 1 mm.

4.1. INSTALLATION OF THE PC-BOARDS IN A CASE

It is advisable to mount the IF-output connectors of modules DJ 4 LB 001 and 002 on the longer sides of the TEKO-boxes in the vicinity of the appropriate pins on the PC-boards. These short connections should not be made with coaxial cable in order to avoid unwanted ground loops; normal wire is completely satisfactory.

If the cases of modules DJ 4 LB 003 and 004 are joined together so that their long sides are adjacent to another, it is possible for the local oscillator frequency to be fed from one module to the other through a hole in the two sides that are screwed together. This saves the use of coaxial connectors.

It is important for the stability of the mixer and amplifier of module DJ 4 LB 004 that the coaxial cable connected to the UHF output Pt 405 is fed to an adjacent UHF connector so that the outer conductor of the coaxial cable is grounded. If, for instance, all of the ATV modules are installed in a common, larger cabinet, it is not permissible for the coaxial cable to be passed through the side of the case in an insulated manner and fed to an undefined ground point, e. g. on the rear panel of the cabinet; it is very important that the coaxial cable is grounded to the screening box of module DJ 4 LB 004 on passing through the side of the box.

4.2. ALIGNMENT

Module DJ 4 LB 004 should be aligned with the maximum IF signal available from the video IF module. It is possible in this manner to obtain the largest, linear drive range of the amplifier. A new circuit for combining the sound and video IF signals is under test which provides an adjustable IF gain so that greater IF signals are available for the alignment.

4.3. NOTES

Any amateurs that do not possess a closed-circuit monitor can view their own signals on a conventional TV receiver by feeding the composite video signal from UHF demodulator DJ 4 LB 005, and using an additional circuit DC 6 YF 007 to be described in one of the next editions of VHF COMMUNICATIONS. In this case, connection Pt 504 of module DJ 4 LB 005 is connected to Pt 4 of the additional circuit DC 6 YF 007.

5. FREQUENCY COUNTER DJ 6 ZZ 004

The following two errors are present in the component location plan:

I 401 (SN 7400 N): This IC should be rotated by 180° so that the marker is on the right.

I 408 is an SN 7400 N (and not SN 7473).

6. CONNECTION OF CROSSED YAGIS FOR CIRCULAR POLARISATION

A method of connecting a crossed Yagi for clockwise circular polarisation was described in Edition 4/73 of VHF COMMUNICATIONS. In the case of one of the MOONBOUNCER range of antennas, it has been found that it is merely necessary to connect the longer arm of the phasing cable to the rearmost dipole. Further details and two switching units for switching the polarisation are given in this edition. The author would very much like to receive reports from other amateurs regarding their experience with this relatively new polarisation mode for VHF/UHF amateur communications. Upto now virtually all feedback has been extremely positive, but critical comments and negative reports are also very constructive.



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AMATEUR RADIO SATELLITE OSCAR 7

The main technical details regarding this satellite were given in (1). This article is to provide more detailed information about the satellite and is based on a paper presented at the ARRL Technical Symposium in September 1973, and information from AMSAT Deutschland.

OSCAR 7 is the second in the AMSAT-OSCAR-B series of long-life amateur spacecraft. It is built in an octahedral (8-sided solid) configuration, allowing sufficient surface area for enough solar cells to provide a positive power budget system. This means that unlike OSCAR 6, this spacecraft should not have to be commanded into recharge modes periodically. The main difference between this spacecraft and OSCAR 6 is that OSCAR 7 contains two repeaters and two auxiliary beacons, and both Morse code and teletype telemetry encoders.

The OSCAR 7 two-to-ten meter repeater has an output power of 2 watts PEP. This will make received signals somewhat stronger at the ground than those coming from OSCAR 6. The second repeater is the AMSAT Deutschland repeater which relays signals from 432 MHz to 145.9 MHz with an internal beacon on 145.98 MHz. The unit was designed and built by Dr. Karl Meinzer, DJ 4 ZC and Werner Haas, DJ 5 KQ. The two beacons consist of a Canadian-built 435.1 MHz beacon similar to the one flown on OSCAR 6, and a second auxiliary beacon at 2304 MHz developed by members of the San Bernardino Microwave Society.

Ground control of the spacecraft is achieved by means of command receivers in each repeater, redundant command decoders and an Experiment Control Logic subsystem.

Downlinked telemetry and stored message data are generated by the Morse code telemetry encoder, or the Codestore unit, these two systems being identical to those flown on OSCAR 6, and a new teletype telemetry encoder designed and built by Dr. Peter Hammer, VK 3 ZPI and Edwin Schoell, VK 3 BDS.

The Codestore, Morse code telemetry and teletype telemetry signals can be routed to any of the beacons in the spacecraft except the 2304 MHz beacon. The four beacons include two in the repeaters and two auxiliary transmitters in a similar manner to OSCAR 6. It is thus possible, for example, to receive Morse code on the 29.45 MHz beacon and teletype telemetry on the 435.1 MHz beacon at the same time (on two receivers).

The primary power source of the spacecraft consists of eight solar cell arrays supplying 2.2 Amps at 6.4 volts when illuminated by the sun. A Battery Charge Regulator converts the raw solar cell array output to a +14 V supply bus. This supply line charges the battery and supplies the spacecraft loads if the solar cell current is not sufficient to run the spacecraft (for example when the satellite is on the dark side of the earth). During these periods, the Nicad battery supplies the extra power. Two other redundant switching regulators supply the remaining voltages needed by the spacecraft modules.

1. MODES OF OPERATION

OSCAR 7 has four automatic modes of operation defined as follows:

Mode A:

AMSAT two-to-ten meter repeater

Input frequency passband between 145.85 and 145.95 MHz

Output frequency passband between 29.40 and 29.50 MHz

Power output is 2 W PEP

Downlink passband is not inverted from uplink passband

Linear Operation - SSB and CW are preferred modes

Telemetry beacon at 29.50 MHz (not same as OSCAR 6)

435.1 MHz and 2304 MHz beacons can be switched on by command.

Mode B:

AMSAT Deutschland Repeater

Input frequency passband between 432.125 and 432.175 MHz

Output frequency passband between 145.975 and 145.925 MHz

Power output (high power mode) is 14 W PEP

Downlink passband is inverted from uplink passband

Repeater is 45% efficient using envelope elimination and restoration technique

Linear Operation - SSB and CW are preferred modes

Repeater is commandable to 3.75 W (mode C)

Telemetry beacon at 145.980 MHz (200 mW)

2304 MHz beacon can be switched on by command.

Mode C:

Low power mode (3 W PEP) otherwise as mode B.

Mode D:

Recharge mode. 435.1 MHz and 2304 MHz can be switched on by command.

Each of these modes of operation may be overridden by ground command. In Mode D either the 435.1 MHz or the 2304 MHz beacon can be operated upon ground command, while none of the repeaters will be operating. It is also possible to have the 435.1 MHz auxiliary beacon operational by ground command while the spacecraft is operating in Mode A. The 2304 MHz beacon can be operated in any of the modes A through D.

The spacecraft will normally alternate between Modes A and B. An internal timer in the spacecraft generates a pulse every 24 hours which causes the satellite to switch between these two modes. The 24-hour timer will be set by ground command so that the mode change can be kept at approximately the same time each day. Thus, each repeater will be operational on alternate days.

The spacecraft contains automatic power supply monitoring circuitry, such that if the battery charge drops 60% below the full-charge value, the spacecraft will automatically switch to Mode C and reset the timer so as to stay in that mode for 24 hours. In Mode C, the AMSAT Deutschland repeater output power is reduced to 2.5 W PEP, and the battery drain should be reduced sufficiently to permit the battery to be recharged by the solar cell arrays.

The switch to Mode C takes place under low battery charge conditions when the spacecraft is operating in either Mode A or Mode B. If the battery charge recovers, the spacecraft will switch to Mode B at the next 24-hour pulse, and then continue normal operation.

If the battery power does not recover, but deteriorates even further so that the battery charge drops 70% below the full-charge value, the spacecraft will automatically switch to Mode D and reset the 24-hour timer. Both repeaters will then be switched off, but the 435.1 or 2304 MHz beacons can be switched on by ground command to allow telemetry to be received.

Modes C and D are actually expected to serve as backup operating modes for use if the spacecraft available power reserves are low. Normally, operation in these modes will not be required.

Each of the modes can be changed by ground command so as to turn any repeater or beacon on or off as required. This is done so that any failure of the automatic control circuits can be overcome by ground command.

2. INITIAL LAUNCH OPERATION

The spacecraft contains an initial condition reset circuit so that the antennas will deploy after separation from the launch vehicle and the spacecraft will power up in Mode D with the 435.1 MHz beacon on. No repeaters will be operational for at least the first day. It is expected that the repeaters will not be turned on until the spacecraft has stabilized electrically and thermally, as indicated by the telemetry data.

3. ORBIT AND TRACKING DATA

The expected orbit for OSCAR 7 is very similar to OSCAR 6. The orbit is expected to be sun-synchronous with an almost identical period and inclination. Thus, the same tracking procedures used for OSCAR 6 will be suitable for use with OSCAR 7.

OSCAR 7 is expected to be placed into orbit so that it is half an orbit ahead of or behind OSCAR 6. Currently, OSCAR 6 comes over daily at a time about 5 minutes earlier every 48 hours. If all goes well, OSCAR 7 is to be launched so that it will come over about 25 minutes earlier than OSCAR 6 did the day before, and similarly, OSCAR 6 will come over about 2.5 minutes earlier than OSCAR 7 did the day before. It is thus possible to expect that instead of three usable spacecraft passes about two hours apart each evening, there will be five or six passes (assuming OSCAR 6 is in operation) about sixty minutes apart.

The reference orbit data for OSCAR 7 will also be published in the same format as the OSCAR 6 data has been up to now, so as to enable each individual to plot his own orbital information.

4. GROUND EQUIPMENT REQUIREMENTS

In considering the ground equipment needed for OSCAR 7, each repeater or beacon will be discussed separately in terms of the ground equipment needed to operate with it.

4.1. AMSAT TWO-TO-TEN METER REPEATER

The two-to-ten meter repeater operates in a linear mode similar to the unit flown on OSCAR 6. As such, SSB and CW are the preferred operating modes. The repeater receives signals between 145.85 and 145.95 MHz and re-radiates them between 29.4 and 29.5 MHz. There is also a telemetry beacon on 29.50 MHz.

Note that these frequencies are different from those employed with OSCAR 6. They reflect comments received on the operational experience obtained with OSCAR 6. The repeater has an output power of 2 W PEP, so received ground signals should be stronger than with OSCAR 6.

The same equipment used to work through OSCAR 6 will be suitable for working through this repeater, namely a sensitive receiver, and preamplifier if possible, as well as a suitable ten-meter antenna. Since the spacecraft will again be using a linearly polarized ten-meter antenna, the ground station antenna should preferably be circularly polarized. Linearly polarized ten-meter receiving antennas can also be used, but at the sacrifice of some fading.

The transmitting equipment should be capable of putting out not more than 80-100 W of effective radiated power from the antenna. It is operationally preferable to use a transmitter with an output power of the order of 80-100 W and a simple ground plane or turnstile antenna than to use a lower powered transmitter and more directional antenna.

4.2. AMSAT DEUTSCHLAND 432 to 145.9 MHz REPEATER

The AMSAT Deutschland repeater is also a linear device. Again, CW and SSB (or controlled-carrier AM) are the preferred operating modes. The repeater has an input frequency passband between 432.125 MHz and 432.175 MHz, and an output frequency passband between 145.975 MHz and 145.925 MHz. The output passband is inverted. That is, upper-sideband signals transmitted to the spacecraft would be received on lower sideband.

The relationship between input and output frequencies is such that a received signal on 432.125 MHz would be relayed on 145.975 MHz, and similarly, a received signal on 432.175 MHz would be relayed on 145.925 MHz, i.e., tune up the band at 432 MHz and down the band at 146 MHz. This repeater also has a telemetry beacon on 145.980 MHz.

Any receiver with a good two-meter converter should be able to receive signals from this repeater, even with a simple antenna. Since the spacecraft antennas associated with this repeater are circularly polarised, linearly polarised antennas will be suitable for ground use. If linearly polarised, the receiving antenna for this repeater can be the same one used to work through the two-to-ten meter repeater.

On the transmitting side, the recommended effective radiated power output is of the order of 300-400 W. Thus, a 30 W transmitter will require an antenna with a gain of the order of 10-12 dB, but it would be preferable to obtain or even build a 300 W amplifier and use an omnidirectional antenna to reduce the antenna pointing accuracy requirements.

Though the spacecraft will have circularly polarised antennas for this repeater so that linear antennas at ground stations will work satisfactorily, it is important not to forget that circularly polarised ground station antennas can be expected to provide as much as 3 dB more signal, and this might be the difference between making or missing a contact. All circularly polarised antennas used with this repeater should be right hand circularly polarized (RHCP) in the

Northern Hemisphere and left-hand circularly polarized (LHCP) in the Southern Hemisphere.

Editorial Note: It is considered that the above is an over simplification of the polarisation problem since the canted turnstile antenna used on the satellite will not provide such a clear polarisation especially after passing over the north or south magnetic pole. In the opinion of the editors, it will take some time for the satellite to stabilize itself after passing the magnetic pole. Even after the satellite has stabilized itself, the polarisation will depend whether all four antenna rods can be seen by the receive antenna and whether the satellite is coming towards passing over, or has passed the station. It is considered that the satellite will provide a predominately horizontal or vertical polarized signal (elliptical polarisation), whereas true circular polarisation will only be provided when the canted turnstile is directly orientated to the ground station in the form of an "X". This means that a difference of upto approximately 10 dB could be provided between vertical and horizontal polarisation. Best antenna would therefore be a crossed Yagi that can be switched to vertical, horizontal, clockwise, and anticlockwise circular polarisation. Such a switching unit is to be described in this edition of VHF COMMUNICATIONS.

The simplest means of working over this repeater is to triple the output of a two meter transmitter to 70 cm in a varactor tripler and operate in the CW mode. If SSB is to be used, it will be necessary for a linear transverter to be used. Suitable transverters from 28 MHz and 144 MHz have been described in this magazine.

5. 435.1 MHz AUXILIARY BEACON

The Canadian 435.1 MHz beacon will usually be operating when the spacecraft is in Modes A or D. It will not operate while the spacecraft is in Modes B or C because of interference effects with the 432 MHz uplink of the AMSAT Deutschland repeater.

Extremely good signal levels were copied from the OSCAR 6 435.1 MHz beacon during the early months that it was operating. For receiving the signals, a receiver with any good converter and antenna will be suitable. Again, a circularly polarized antenna would be preferable. The converter should be fitted with a new crystal so as to cover 435.1 MHz instead of the more conventional 432 MHz.

Doppler shifts of the order of ± 10 kHz can be expected on the signals.

6. 2304 MHz S-BAND BEACON

The 2304 MHz beacon, built by members of the San Bernardino Microwave Society in California, will transmit a "HI" in Morse code followed by thirty seconds of continuous carrier for tracking purposes. The beacon contains an internal thirty-minute timer to ensure positive control which will shut down the beacon 30 minutes after it is commanded on. The 2304 MHz beacon can also be keyed with Morse code telemetry on ground command.

7. TELEMETRY

OSCAR 7 contains two separate telemetry encoders: a Morse code unit identical to that flown on OSCAR 6 and an 850 Hz shift teletype encoder designed and built in Australia.

7.1. MORSE CODE TELEMETRY

The Morse code telemetry format is identical to that of OSCAR 6. The format is arranged in six lines of four words. The first digit of each three-figure "word" is the line identifier. Each telemetry frame is separated from the next by the "III" identifier. The code speed, like OSCAR 6, is commandable between 10 and 20 WPM.

7.2. TELETYPE TELEMETRY

Sixty channels of data are monitored and encoded by the WIA-Project Australis teletype telemetry encoder. The data is formatted as ten words per line in six lines of data. Each data word contains five digits. The first two digits indicate the channel number, and the last three represent the encoded sensor data digits.

Between each data frame are two lines of digital data which provide information on the spacecraft clock and command register status.

The encoder has two operating modes. There is a stepping mode in which each channel is sampled in turn, and a single-channel "dwell" mode in which one channel is sampled continuously.

Samples of the printout are presented in Figure 1. Each line of data is followed by a carriage return, line feed and figures signal, so as to keep the printer in upper case.

The teletype data is transmitted from the spacecraft in Baudot code using 850 Hz shift. Signals will be frequency-shift keyed on 435.1 MHz and audio frequency shift keyed on 145.98 and 29.50 MHz. It may be necessary to be able to reverse the mark and space tones in the ground station terminal unit to receive the AFSK telemetry.

Doppler on the 435.1 MHz beacon will be of the order of +10 kHz for a pass directly overhead. Tests were conducted from WA 3 EWJ transmitting FSK RTTY through the two-to-ten meter repeater in OSCAR 6 during January 1973. It was found that the 5 kHz Doppler shift encountered there did not cause any appreciable errors. It was just necessary to keep retuning the receiver every few minutes. Thus, the tuning rate will just have to be increased to cope with the extra Doppler shift.

A better idea is to use a special IF with a 25 kHz bandwidth and a phase-lock loop teletype terminal unit using one of the phase-lock integrated circuits now available at low cost.

8. SUMMARY

This article has briefly described OSCAR 7, its projected orbit and the type of equipment needed to operate with it. A summary table of the frequencies of interest is presented below.

Beacons:

29.50 MHz	Mode A	Associated with the two-to-ten meter repeater.
145.98 MHz	Mode B, C	Associated with the 432 to 146 MHz repeater.

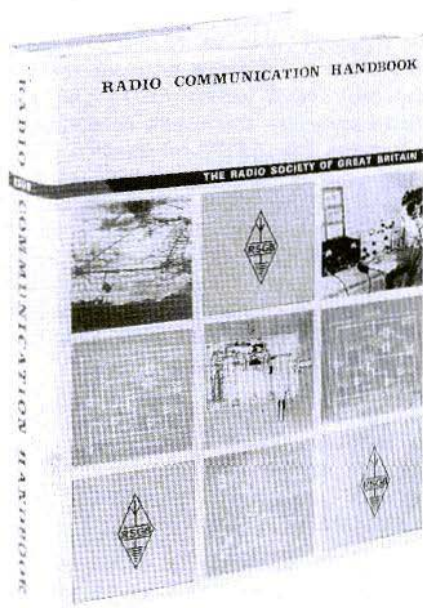
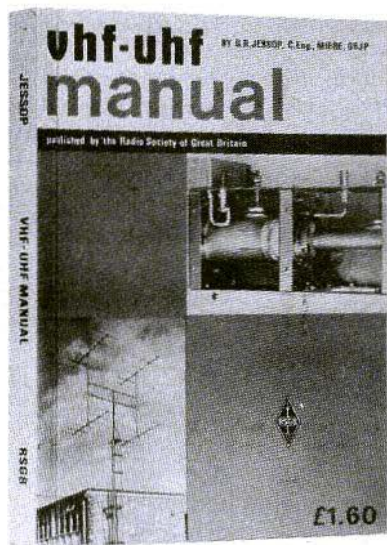
435.10 MHz	Mode A, D	Teletype, Morse code or Codestore keying.
2304 MHz	Mode A, B, C, D	CW tracking beacon and Morse code telemetry.

Repeaters:

Mode A	145.85 MHz to 145.95 MHz input 29.40 MHz to 29.50 MHz output (non-inverting passband)
Mode B, C	432.125 MHz to 432.175 MHz input 145.975 MHz to 145.925 MHz output (inverted passband)

9. REFERENCES

- (1) J.Kasser and J.King: OSCAR 7 and its Capabilities
ARRL Technical Symposium September 14th, 1973
- (2) P.Klein: Summary of AMSAT-OSCAR-B Spacecraft System
VHF COMMUNICATIONS 6 (1973), Edition 4, Pages 226-227
- (3) T.Bittan: Circular Polarisation on 2 Metres
VHF COMMUNICATIONS 5 (1973, Edition 2, Pages 104-109.



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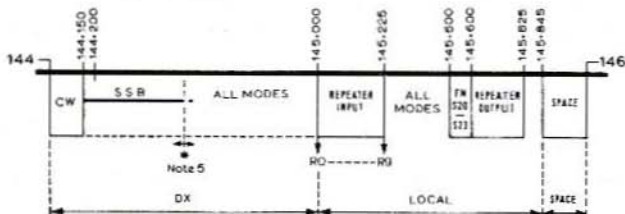
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NEW EUROPEAN BAND PLAN FOR THE VHF AND UHF BANDS

2m Band Plan

MHz	Allocation
144-000-144-010	E-M-E
144-100	Random ms
144-150	Centre frequency regional beacons
144-200	SSB calling
144-600	RTTY (dx)
145-000-145-225	Repeater input—R0 to R9
145-300	RTTY (local)
145-500	Mobile calling
145-500 (S20), 145-525 (S21)	FM simplex
145-550 (S22), 145-575 (S25)	FM simplex
145-600-145-825	Repeater output

MHz	Allocation
144-000-144-010	E-M-E
144-100	Random ms
144-150	Centre frequency regional beacons
144-200	SSB calling
144-600	RTTY (dx)
145-000-145-225	Repeater input—R0 to R9
145-300	RTTY (local)
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145-500 (S20), 145-525 (S21)	FM simplex
145-550 (S22), 145-575 (S25)	FM simplex
145-600-145-825	Repeater output



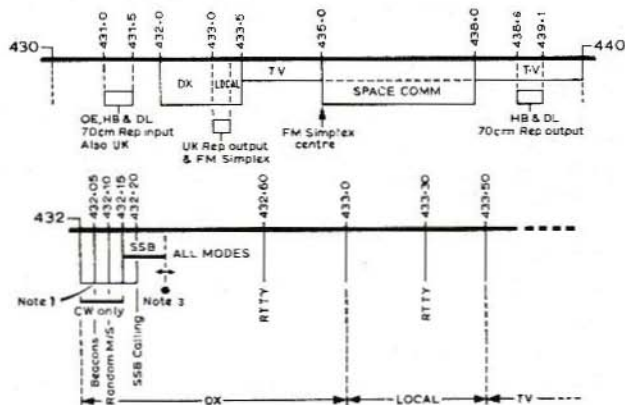
Notes

1. Established simplex frequencies on repeater output channels may be retained.
2. The segment 145-25-145-5MHz may be allocated, if desired, to fm channels.
3. No regional planning for low power beacons (erp of 5W or less).
4. Area coverage by regional beacons (erp of 50W or greater).
5. The upper limit of ssb is flexible.

70cm Band Plan

MHz	Allocation
432-000-432-010	E-M-E
432-100	Random ms
432-200	SSB calling
432-600	RTTY (dx)
433-300	RTTY (local)

MHz	Allocation
432-000-432-010	E-M-E
432-100	Random ms
432-200	SSB calling
432-600	RTTY (dx)
433-300	RTTY (local)



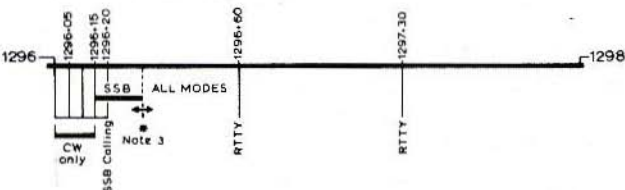
Notes

1. Area coverage by regional beacons having an erp of 50W or greater.
2. No regional planning for low power beacons (erp of 5W or less).
3. The upper limit of ssb is flexible.

23cm Band Plan

MHz	Allocation
1,296-1,296-15	CW
1,296-1,296-01	E-M-E
1,296-2	SSB calling
1,296-6	RTTY (dx)
1,297-3	RTTY (local)

MHz	Allocation
1,296-1,296-15	CW
1,296-1,296-01	E-M-E
1,296-2	SSB calling
1,296-6	RTTY (dx)
1,297-3	RTTY (local)



Notes

1. Area coverage by regional beacons having an erp of 50W or greater.
2. No regional planning for low power beacons (erp of 5W or less).
3. The upper limit of ssb is flexible.

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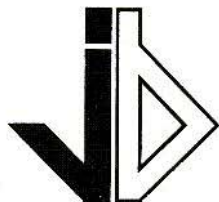
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Gain: 15.2 dB/Dipole
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 Weight: 6.4 kg (14 lbs)
 Hor. beamwidth (-3 dB: 24°)

Long-yagi antennas are well-known for their high gain characteristics. However, this high performance is only provided over a relatively low bandwidth when the antenna has been designed for maximum gain. The Parabeam type of antenna combines the high gain of a long-yagi antenna with the inherently wider bandwidth of skeleton slot fed arrays.

The actual Parabeam unit comprising a skeleton slot and similar reflector radiates similar to two stacked two-element yagi antennas and will therefore provide 3 dB gain over a single dipole and reflector configuration, and about 2 dB gain over a conventionally fed long-yagi. Heavy duty construction with special quality aluminium.

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Minikit	DC 6 YF 005 (7 capacitors, 34 resistors)	DM 16.--
<u>Kit</u>	DC 6 YF 005 complete with above parts	<u>DM 130.--</u>
<u>DC 6 YF 006</u>	<u>DIGITAL VOLTMETER (Analog-Digital Converter)</u>	<u>Ed. 1/1974</u>
PC-board	DC 6 YF 006 (with printed plan)	DM 14.--
Minikit	DC 6 YF 006 (3 ICs, 1 diode, 3 indicator tubes)	DM 70.--
<u>Kit</u>	DC 6 YF 006 complete with above parts	<u>DM 84.--</u>
<u>DJ 3 SC 001</u>	<u>TRANSISTORIZED LINEAR AMPLIFIER for 70 cms</u>	<u>Ed. 1/1974</u>
PC-board	DJ 3 SC 001 (with printed plan)	DM 18.--
Semiconductors A	DJ 3 SC 001 (1 x C 1-12, 1 x C 3-12, 1 x C 12-12, 1 diode)	DM 139.--
Semiconductors B	DJ 3 SC 001 (1 x C 3-12, 1 x C 12-12, 1 x C 25-12, 1 diode)	DM 241.--
Minikit	DJ 3 SC 001 (8 trimmers, 10 chip capacitors, 3 feed through capacitors, 1 ferrite choke, 1 ferrite toroid)	DM 39.--
<u>Kit A</u>	DJ 3 SC 001 with above parts and Semiconductors A	<u>DM 195.--</u>
<u>Kit B</u>	DJ 3 SC 001 with above parts and Semiconductors B	<u>DM 295.--</u>

THIRD FRENCH EDITION OF VHF COMMUNICATIONS

The great popularity of the first and second omnibus editions of VHF COMMUNICATIONS lead not only of a reprint of same but also to the publication of a third omnibus edition. This edition is packed full of most of the latest designs published in VHF COMMUNICATIONS. Please inform your French speaking friends of the availability of all omnibus editions. Further details can be obtained from our French representative under the following address:

Mlle. Christiane MICHEL, F 5 SM, Les Pillés, F-89117 PARLY, France

Special Offer: F1 / F2 / F3 + Binder: 70.00 F

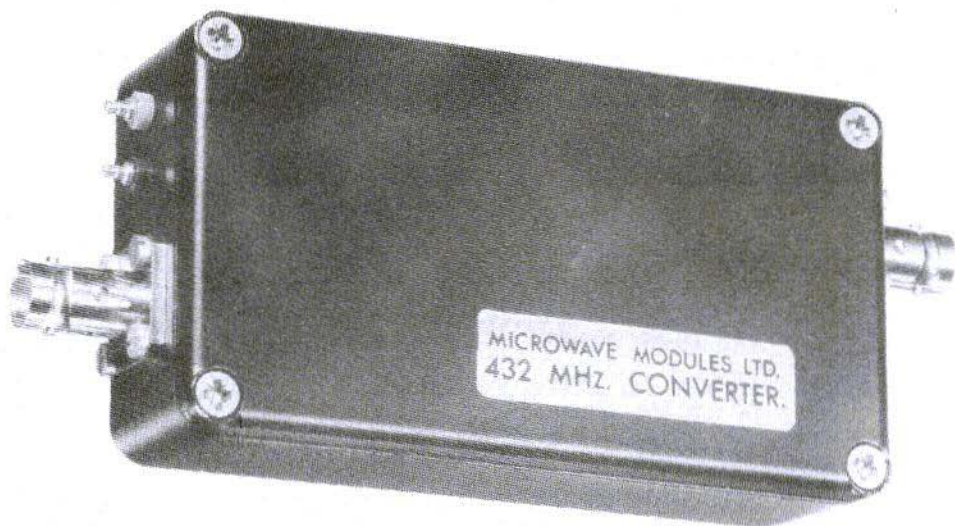
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MICROWAVE MODULES LIMITED

NEW READY-TO-OPERATE MODULES AVAILABLE IN
THE SALES PROGRAM OF VHF COMMUNICATIONS

1296 MHz CONVERTER

Microstripline, Schottky diode mixer
IF: 28-30 MHz or 144-146 MHz
Noise figure: typ. 8.5 dB
Overall gain 25 dB

432 MHz CONVERTER

2 silicon preamplifier stages.
MOSFET mixer. All UHF circuits in microstrip technology.
Noise figure: typ. 3.8 dB
Overall gain: typ. 30 dB
IF: 28-30 MHz or 144-146 MHz
9-15 V / 30 mA

144 MHz MOSFET CONVERTER

Noise figure: typ. 2.8 dB
Overall gain: typ. 30 dB
IF: 28-30 MHz, others on request.
9-15 V / 20 mA

VARACTOR TRIPLER 144/432 MHz

Max. input at 144 MHz: 20 W
(FM, CW) - 10 W (AM).
Max. output at 432 MHz: 14 W

VARACTOR TRIPLER 432/1296 MHz

Max. input at 432 MHz: 24 W
(FM, CW) - 12 W (AM)
Max. output at 1296 MHz: 14 W

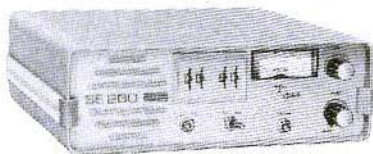
All modules are enclosed in black cast-aluminium cases of 13 cm by 6 cm by 3 cm and are fitted with BNC connectors. Input and output impedance is 50 Ohms. Completely professional technology, manufacture, and alignment. Extremely suitable for operation via OSCAR 7 or for normal VHF/UHF communications.

Available from :

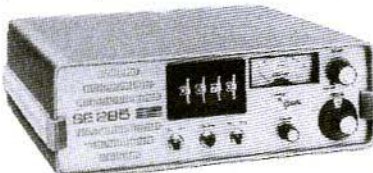
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and from their representatives throughout the world



High Performance VHF Equipment



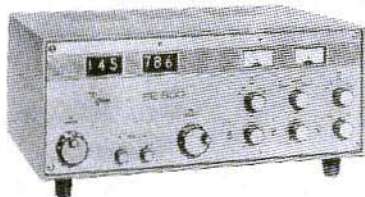
A matching AC power supply NT 280 is also available. Completely silicon transistorized with a BLY 88 A in the PA. Output power is 10 W RF. Insensitive to incorrectly matched antennas. Built-in squelch, 1750 Hz calling tone, and loudspeaker. Connector provided for an external loudspeaker.



Our popular SE 280 transceiver has now been extended for the immediate selection of five pre-programmed simplex or repeater channels. Channel selection is made with a six-position rotary switch. The selected channel is indicated in an illuminated window. In the "0" position, any channel can be selected on the 80 channel selector. Positions "1" to "5" are programmed internally for one repeater or simplex channel each. In the case of repeater channels, the calling and receive frequencies are programmed on one single plug. These plugs can be provided for any required channel and can easily be exchanged. All other data is identical to that of the SE 280 transceiver.

100 channel 2 meter FM Transceiver SE 285/11

This transceiver is the North American version of the SE 285. It has a 100 channel capability with a channel spacing of 30 kHz between 145 and 148 MHz. Five repeater or simplex channels can be selected immediately. All other channels can be selected on the thumbwheel switch on the front panel. All other data as for the transceivers SE 280/SE 285.



SSB/AM/FM/CW 2 meter Transceiver SE 600 digital

A transceiver that really offers you everything. Extremely low noise figure with excellent selectivity, and high cross and intermodulation rejection.

True transceive or separate operation of transmitter and receiver, which can be switched independently to the CW, LSB, USB, AM and FM modes. This versatility allows problemless operation via repeaters, satellite and balloon-carried translators.

Digital frequency readout from the built-in frequency counter using 13 mm Nixie tubes. Direct readout of the transmit and receive frequency; the indication jumps from one to the other on depressing the PTT button etc.

Separate crystal filters for each mode. True AM with plate/screen grid modulation. Built-in speech processor. Product detector for SSB and a crystal discriminator for FM, VOX, antitrip and PTT facilities, as well as RF-output and S-meters. Built-in antenna relay. Built-in power supplies for AC and 12 VDC operation.

SSB/AM/FM/CW 2 meter Transceiver SE 600

This transceiver possesses the same specifications as the SE 600 digital but is equipped with two analog scales. The SE 600 can be equipped with an optional 25 kHz or 50 kHz calibration spectrum generator and calling tone oscillator.

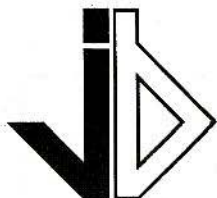
Our manufacturing program also includes 2 m, 6 m, 70 cm converters; 2 m/70 cm varactor triplers and transverters and an active CW filter.

Please request our data sheets

Karl Braun · Communications Equipment
D-85 Nuernberg, Deichlerstraße 13, W. Germany

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TWO-METER ANTENNAS



Jaybeam Limited

HALO

A Broad Band Halo type antenna with no capacity loading and a correct Gamma Match to coaxial termination.



Width 12" (30½ cm)

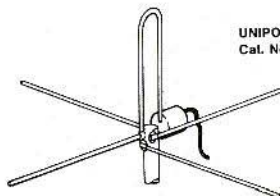
Head only to fit 5/16" — 1" diam. Mast **Cat. No. HO/2M**

Complete with ½" diam. Mast **Cat. No. HM/2M**

Weight 8 ozs.

Wind loading 10 lbs. at 100 m.p.h.

UNIPOLE AND GROUND PLANE Cat. No. UGP/2M



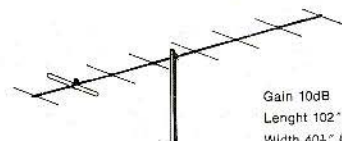
Gain : Unity

Unipole and ground plane aerial with clamp to fit to masts up to 2" O.D.

Weight 3 lbs.

Wind loading 12 lbs. at 100 m.p.h.

8 ELEMENT YAGI Cat. No. 8Y/2M



Gain 10dB

Length 102" (260 cm)

Width 40½" (103 cm)

Horizontal Beamwidth between half power points 45°

Weight 4 lbs.

Wind loading 48 lbs. at 100 m.p.h.

5 ELEMENT YAGI Cat. No. 5Y/2M



Gain 7.8dB

Length 63½" (161 cm)

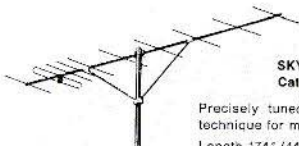
Width 40½" (103 cm)

Horizontal Beamwidth between half power points 52°

Weight 3 lbs.

Wind loading 39 lbs. at 100 m.p.h.

SKYBEAM 10 ELEMENT YAGI Cat. No. 10Y/2M



Precisely tuned using the "Long Yagi" technique for maximum gain 13.2dB.

Length 174" (443 cm)

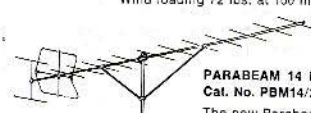
Width 40½" (103 cm)

Horizontal Beamwidth between half power points 33°

Weight 12 lbs.

Wind loading 72 lbs. at 100 m.p.h.

PARABEAM 14 ELEMENT YAGI Cat. No. PBM14/2M



The new Parabeam with increased gain — 15.2dB — and broader bandwidth.

Length 234" (595 cm) Width 41" (104 cm)

Horizontal Beamwidth between half power points 24°

Weight 14 lbs.

Wind loading 51 lbs. at 100 m.p.h.

FIVE OVER FIVE Cat. No. D5/2M



Gain 10.8dB

Slot Fed Double 5 Yagi

Length 63½" (161 cm)

Width 40½" (103 cm)

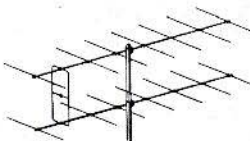
Height 46" (116 cm)

Horizontal Beamwidth between half power points 52°

Weight 7 lbs.

Wind loading 62 lbs. at 100 m. p.h.

EIGHT OVER EIGHT Cat. No. D8/2M



Gain 12.6dB

Slot Fed Double 8 Yagi

Length 102" (260 cm)

Width 40½" (103 cm)

Height 46" (116 cm)

Horizontal Beamwidth between half power points 45°

Weight 9 lbs.

Wind loading 90 lbs. at 100 m.p.h.

Mounting Kit for Slot Fed Aerials Vertical Polarisation

Cat. No. SVMK/2M

RECOMMENDED STACKING SPACING BETWEEN CENTRES

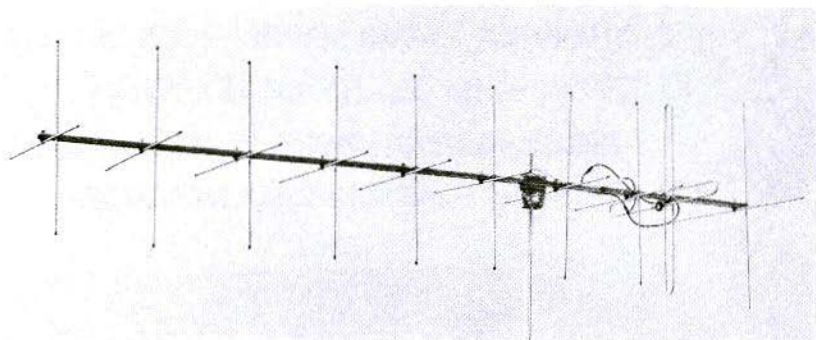
HO/2M	Halo	41" (104 cm)	10Y/2M	10 Element Yagi	132" (335 cm)
XD/2M	Crossed Dipoles	41" (104 cm)	PBM14/2M	14 Element Yagi	144" (366 cm)
5Y/2M	5 Element Yagi	82" (208 cm)	D5/2M	Double 5 Slot	147" (373 cm)
8Y/2M	8 Element Yagi	100" (254 cm)	D8/2M	Double 8 Slot	160" (405 cm)

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THE NEW J-BEAM MOONBOUNCERS

Introducing the new generation of J-Beam MOONBOUNCER antennas. The cooperation between J-BEAM and VHF COMMUNICATIONS has now led to the introduction of a completely new range of the versatile MOONBOUNCER antennas. These antennas have been developed according to the very latest technologies. This has reduced the length of the 10 element crossed Yagi, for instance, from 4.92 m to 3.65 without any reduction of the performance whatsoever. The quality of the new range has also been improved considerably and is now virtually of full professional standard. Especially non-corrosive aluminium is used throughout, with cast aluminium mounts for the elements, and a heavy-galvanized steel mast clamp. All in all, an antenna that will not rot away and fall down every few years, but an antenna that is constructed for a long life.

All of the MOONBOUNCER antennas can be either connected for circular polarisation at the antenna with one feeder to the shack, or if two feeders are fed down to the shack, it is possible to select vertical, horizontal, as well as clockwise and anti-clockwise circular polarization.

Circular polarisation is most certainly the polarisation of the future. The advantages of this form of polarisation were discussed in a recent article by G 3 JVQ/DJ Ø BQ in VHF COMMUNICATIONS. The possibility of switching to any required polarisation to find the momentary most favourable polarisation is a great advantage of the MOONBOUNCE antennas.

The following four types are available, which can be stacked and bayed to form arrays suitable for extreme DX modes such as MS and EME:

Type	Elements	Istr. Gain (dipole)	Hor. Beamwidth	Boom length
5XY/2 m	2 x 5	11 dB (8.8 dB)	52°	1.67 m
8XY/2 m	2 x 8	12.2 dB (10.0 dB)	45°	2.85 m
10XY/2 m	2 x 10	14.2 dB (12.0 dB)	33°	3.65 m
12XY/70 cm	2 x 12	15.2 dB (13.0 dB)	35°	2.60 m



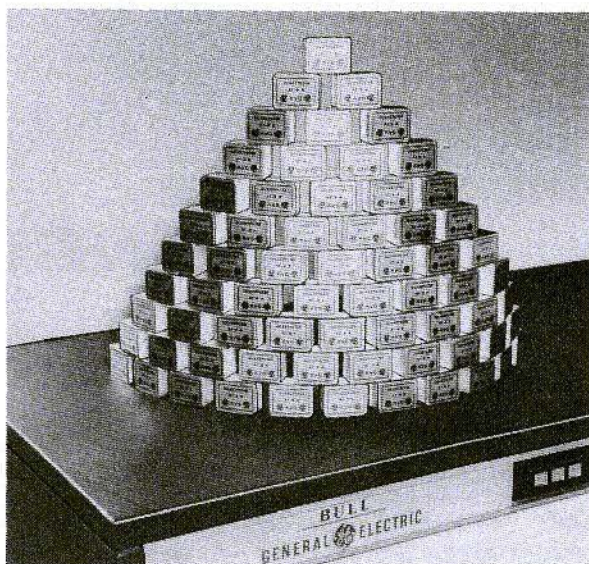
CRYSTAL FILTERS - FILTER CRYSTALS - OSCILLATOR CRYSTALS
SYNONYMOUS for QUALITY and ADVANCED TECHNOLOGY

PRECISION QUARTZ CRYSTALS. ULTRASONIC CRYSTALS.
PIEZO-ELECTRIC PRESSURE TRANSDUCERS

Listed is our well-known series of

9 MHz crystal filters
for SSB, AM, FM
and CW applications.

In order to simplify matching, the input and output of the filters comprise tuned differential transformers with galvanic connection to the casing.



Filter Type	XF-9A	XF-9B	XF-9C	XF-9D	XF-9E	XF-9M
Application	SSB-Transmit.	SSB	AM	AM	FM	CW
Number of Filter Crystals	5	8	8	8	8	4
Bandwidth (6dB down)	2.5 kHz	2.4 kHz	3.75 kHz	5.0 kHz	12.0 kHz	0.5 kHz
Passband Ripple	< 1 dB	< 2 dB	< 2 dB	< 2 dB	< 2 dB	< 1 dB
Insertion Loss	< 3 dB	< 3.5 dB	< 3.5 dB	< 3.5 dB	< 3 dB	< 5 dB
Input-Output Termination	Z ₁ C ₁	500 Ω 30 pF	500 Ω 30 pF	500 Ω 30 pF	500 Ω 30 pF	1200 Ω 30 pF
Shape Factor	(6.50 dB) 1.7	(6.60 dB) 1.8 (6.80 dB) 2.2	(6.60 dB) 1.8 (6.80 dB) 2.2	(6.60 dB) 1.8 (6.80 dB) 2.2	(6.60 dB) 1.8 (6.80 dB) 2.2	(6.40 dB) 2.5 (6.60 dB) 4.4
Ultimate Attenuation	> 45 dB	> 100 dB	> 100 dB	> 100 dB	> 90 dB	> 90 dB

KRISTALLVERARBEITUNG NECKARBISCHOFSHHEIM GMBH
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