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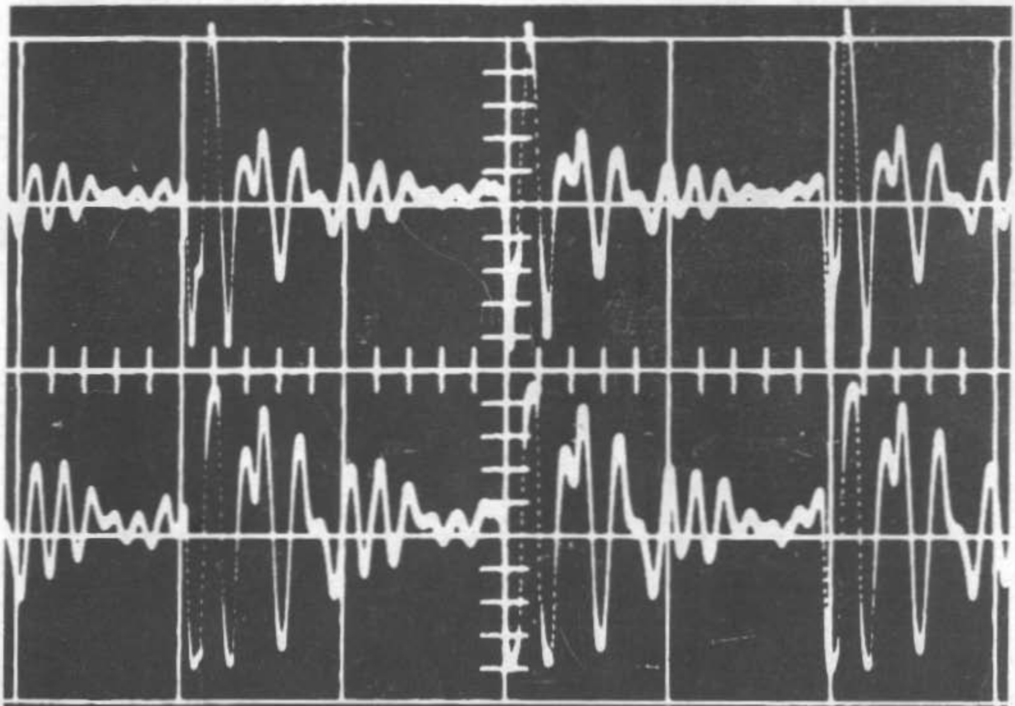
VHF COMMUNICATIONS

A PUBLICATION FOR THE RADIO AMATEUR
ESPECIALLY COVERING VHF, UHF AND MICROWAVES

VOLUME NO. 3 EDITION 1 FEBRUARY 1971 DM 4.00



SPEECH PROCESSING

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Published by:	Verlag UKW-BERICHTE, Hans J. Dohlus oHG, 8520 Erlangen, Gleiwitzer Str. 45, Fed. Rep. of Germany. Tel. (0 91 31) 3 33 23/3 54 09
Publishers:	T. Bittan (30 %), H. Dohlus (40 %), R. Lentz (30 %)
Editors:	Terry D. Bittan, G3JVQ/DJØBQ, responsible for the text Robert E. Lentz, DL3WR, responsible for the technical contents and layout

Advertising manager: T. Bittan, Tel. (0 91 91) — 31 48

VHF COMMUNICATIONS, the international edition of the German publication UKW-BERICHTE, is a quarterly amateur radio magazine especially catering for the VHF/UHF/SHF technology. It is published in February, May, August and November. The subscription price is DM 12.00 or national equivalent per year. Individual copies are available at DM 4.00, or equivalent, each. Subscriptions, orders of individual copies, purchase of P. C. boards and advertised special components, advertisements and contributions to the magazine should be addressed to the national representative.

Printed in the Fed. Rep. of Germany by Richard Reichenbach KG, 8500 Nuernberg, Krelingstr. 39

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SPEECH PROCESSING
PRACTICAL CIRCUIT OF AN EFFICIENT AF CLIPPER

by D. E. Schmitzer, DJ 4 BG

INTRODUCTION

The theoretical considerations for the dimensioning of AF amplitude limiters (clippers) having favourable characteristics were covered and certain parts of the circuit were described in (1). This article is to describe a complete clipper circuit with practical assembly on a printed circuit board. The circuit combines, in the simplest possible manner, a preamplifier having a bandpass characteristic, a balanced limiter that does not go into saturation and an active low-pass filter that exhibits a very low overshoot in spite of the steep skirt of the attenuation curve.

1. THE CIRCUIT AND ITS CHARACTERISTICS

Fig. 1 shows the circuit diagram of the clipper. An integrated circuit type CA 3046 and two transistors are used. The operating voltage can be in the range of 9 to 18 V, the current consumption only amounts to approximately 1.7 mA. The maximum gain of 2500 (68 dB) is suitable for use with dynamic microphones whereby a signal-to-noise ratio of over 50 dB is achieved. A limited and filtered output voltage having a peak-to-peak value of 3 V is available at a source impedance of approx. 50 Ω.

1.1. PREAMPLIFIER WITH FILTER

Three individual transistor systems of the integrated circuit CA 3046 are used for the preamplifier and the first low-pass filter. They are designated in Fig. 1 as T 1, T 2 and T 3. The microphone signal at connection point Pt 13 is amplified in the first two transistors. The signal is then fed to the galvanically coupled active low-pass filter which suppresses all non-required frequencies above approximately 3 kHz. The base bias voltage of transistors T 1 and T 2 is taken via the voltage divider comprising R 11/R 12 from the emitter of transistor T 3. Together with the negative current feed-back of the first two transistors and the mentioned galvanic coupling between transistors T 2 and T 3, a very good stabilization of the operating points of these three transistors results.

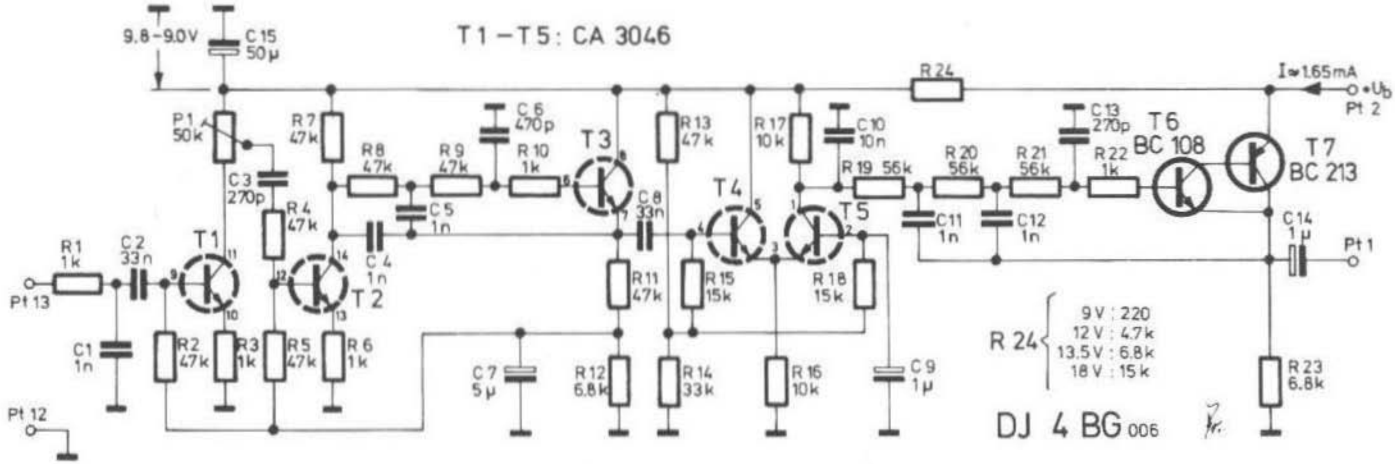

Fig. 1: Circuit diagram of the clipper

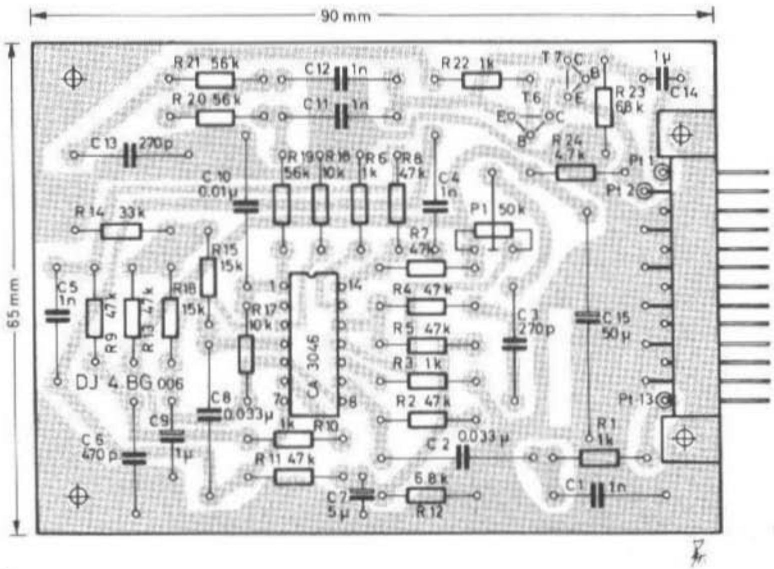

Fig. 3: Printed circuit board DJ 4 BG 006 with component location plan

The RC link R 1/C 1 suppresses any RF voltages induced into the microphone cable. The very low capacitance value for the coupling capacitor C 3 of 270 pF forms, together with the connected resistors a low-pass filter that attenuates frequencies lower than 4 kHz by 6 dB per octave.

The active low-pass filter is formed by the resistors R 7, R 8 and R 9 together with capacitors C 4, C 5 and C 6 and transistor T 3. The dimensioning of such low-pass filters was given in (2). In addition to this, the coupling capacitors at the input and output of this circuit (C 2 and C 8) are dimensioned so that frequencies of less than approximately 300 Hz are attenuated. The actual limiter is therefore fed with a signal whose bandwidth and spectral energy distribution is most favourably dimensioned for the highest speech intelligibility.

1.2. LIMITER

Transistors T 4 and T 5 form a differential amplifier which operates as a balanced limiter. Under rest conditions, e.g. without drive, the current flowing via the emitter resistor R 16 distributes itself equally to the two transistors. Prerequisite of this is that the two transistors have virtually the same characteristics, which is the case with the integrated circuit used. It is therefore not advisable to use individual transistors for the construction of this clipper. According to whether a voltage of positive or negative polarity is fed to the input of the limiter stage (base of T 4), the current distribution will be shifted in favour of transistor T 4 or T 5. When feeding an alternating voltage to the base, the current distribution will alter with the frequency of the alternating voltage. With a signal of 100 mV peak-to-peak or more, transistors T 4 and T 5 alternately take over the whole current which means that one of the transistors will always be blocked. The current through transistor T 5 and thus the voltage drop across the collector resistor has more or less a squarewave form. The input signal is therefore available at resistor R 17 in an amplified and limited form.
The value of resistor R 17 is sufficiently low (10 kΩ) that transistor T 5 also receives enough collector-emitter voltage when it takes over the whole current flow. This means that the limiter cannot be saturated. Except for this, the limiter circuit corresponds to the description given in (1).

1.3. SUBSEQUENT FILTER

The low-pass filter subsequent to the limiter stage suppresses any harmonics caused during the limiting process that are in excess of approximately 3 kHz. Since this filter is fed with a squarewave voltage, it should not only exhibit a steep skirt but also only a small overshoot. Any overshoot condition would cause overmodulation unless the mean depth of modulation was correspondingly reduced. Active audio filters exhibiting the required characteristics were described in detail in (3) so that they need not be mentioned in detail here.

At the output of the filter (Pt 1), the limited and filtered audio signal is available at an amplitude of 3 V peak-to-peak. This means that the modulator, or a varactor diode for FM, can be directly driven. The input impedance of the modulator stage connected to the clipper output should be at least 5 kΩ. If the terminating impedance is too low, the output stage of the filter will be overloaded. If the clipper output is loaded by a large capacitance - e.g. by a long screened cable - a neutralizing resistor of approx. 100 to 500 Ω should be connected in series with the output capacitor C 14. This is necessary because an emitter follower stage, as used in the filter, tends to oscillate when capacitively loaded. However, the built-in neutralization formed by the base resistor R 22 should be sufficient for most applications.

To conclude the circuit description, Fig. 2 shows the overall frequency response of the clipper circuit at low levels.

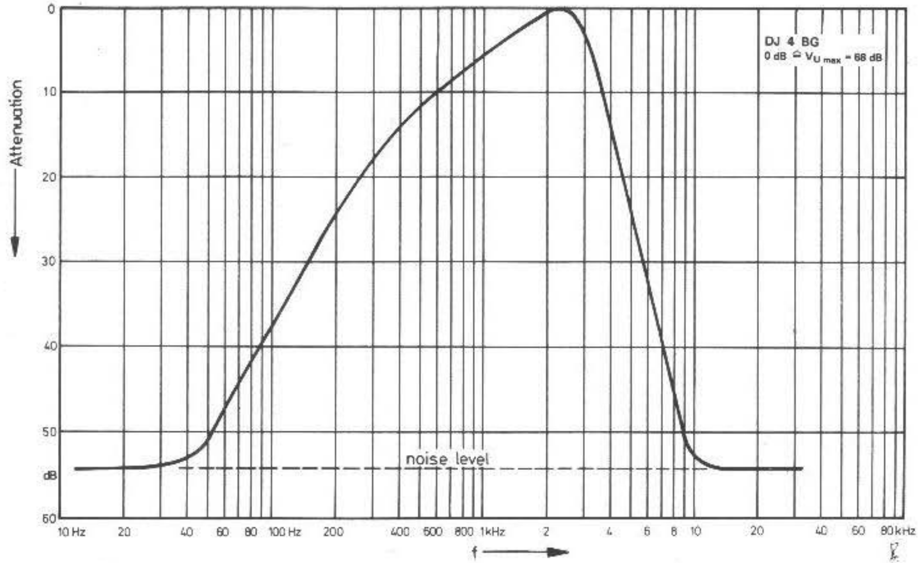

Fig. 2: Overall frequency response of the clipper

2. CONSTRUCTION

The described clipper is built up on a printed circuit board having the dimensions 90 mm x 65 mm. This printed circuit board, which has been designated DJ 4 BG 006, is given in Fig. 3, which also shows the corresponding component location plan. The clipper board can be mounted to a 13-pole connector and used as a plug-in module. Such connectors are available from the publishers.

2.1. SPECIAL COMPONENTS

T 1 - T 5 : integrated circuit CA 3046, manufactured by RCA

T 6 : BC 108, BC 148, BC 168, BC 183, BC 238, 2 N 3904 or a similar silicon NPN audio transistor having B $\geq$ 100 at I_c = 2 mA.

T 7 : BC 158, BC 178, BC 213, BC 308, 2 N 3906 or a similar silicon PNP audio transistor.

3. INSTRUCTIONS FOR OPERATION OF THE CLIPPER

3.1. OPERATING VOLTAGE

The clipper can be operated from DC voltage sources of between 9 and 18 V by altering the value of resistor R 24. Further modifications are not necessary. It is only important that the operating voltage of the limiter and preamplifier stages - that is the voltage measured across capacitor C 15 - is between 8.8 and 9.0 V. This value represents the nominal voltage, e.g. with new batteries or at the nominal power line voltage. The following table lists the value of resistor R 24 as a function of the operating voltage:

U_b	9 V	12 V	13.5 V	18 V
R 24	220 Ω	4.7 kΩ	6.8 kΩ	15 kΩ

The power supply voltage for the clipper should be well filtered, but not stabilized. This is especially the case for battery operation. The clipper should be fed with the same voltage as the modulator and transmitter output stage. This has the following advantage: When the operating voltage falls, the drive range of the transmitter and modulator stages will be reduced which means that if the AF drive remained constant, overmodulation could be caused. However, since the operating voltage of the clipper is also reduced, the AF output voltage of the clipper will also be decreased so that any predetermined drive level is maintained.

3.2. ALIGNMENT OF THE GAIN

The preamplification of the clipper is adjusted once for the microphone to be used so that a slight limiting occurs when speaking into the microphone at normal volume at a distance of 10 to 20 cm. This means that no dynamic compression will occur but only that the highest amplitude peaks will be limited. This degree of clipping is suitable for communication under low noise operating conditions; it limits the bandwidth of the signal and ensures that overmodulation cannot occur, but does not force the receiving station to listen to clipped speech.

Under poor communication conditions, it is then only necessary to speak louder and/or to speak closer to the microphone in order to obtain compressed speech. Since this is a natural reflex under poor operating conditions, the operating of a correctly adjusted clipper is extremely fool-proof.

If the microphone is to be used at greater distances, a microphone transformer could be used.

4. EDITORIAL NOTE

It has been found that some integrated circuits CA 3046 possess a relatively high noise level and are therefore not suitable for use in this circuit. The integrated circuits offered by the publishers have been selected for their low-noise characteristics.

5. AVAILABLE PARTS

The printed circuit board DJ 4 BG 006, the semiconductors as well as a kit of parts are available from the publishers or their national representatives. Please see advertising page.

6. REFERENCES

(1) D. E. Schmitzer: Speech Processing
VHF COMMUNICATIONS 2 (1970), Edition 4, Pages 217-224

(2) D. E. Schmitzer: Active Audio Filters
VHF COMMUNICATIONS 1 (1969), Edition 4, Pages 218-225 + 226-235

(3) D. E. Schmitzer: Steep-skirted Active Audio Filters
VHF COMMUNICATIONS 2 (1970), Edition 4, Pages 210 - 216

DEMANDS MADE ON A BALLOON-CARRIED TRANSLATOR

by D. Vollhardt, DL 3 NQ

INTRODUCTION

The interest shown in our article describing a simple balloon-carried translator (1) has led to this more extensive description of the German ARTOB system and the experience that has been gained during more than 40 flights that have been made by them. This article is based on a lecture given by the author at the North-German VHF meeting in 1970.

The successes and failures encountered during the 40 odd ARTOB flights over the last few years have allowed a number of primary and secondary demands to be laid down that are made on a balloon-carried translator and its auxiliary equipment. The more these demands are realized, the greater will be the efficiency of the system as a whole.

1. GENERAL REQUIREMENTS

The following general demands are valid for balloon-carried translator flights:

1. The longest possible flight at the highest altitude.
2. The translator should possess a very sensitive receiver and powerful transmitter system. The transmission bandwidth should be greater than 200 kHz.
3. It should provide non-fading transmissions, which means that exactly omnidirectional antennas are required.
4. Correct operation of the equipment must be guaranteed at temperatures between -40 °C and +30 °C and during heavy rain. They should not be damaged by a hard landing.
5. Recovery of the equipment must be guaranteed at all times.

The importance of demand 1. is underlined in Fig. 1 which shows the maximum coverage attainable at two different altitudes. It can be seen that the coverage is far greater when the translator is at an altitude of 25 km than at the lower altitude of only 10 km. The given coverage represents that attainable under normal conditions at normal antenna heights and does not take any tropospheric effects into consideration. In practice, the coverage is somewhat greater. In addition to this, the coverage can be slightly shifted when the balloons are launched from different locations, etc.

It can be seen that it is very important for the translator to be kept above an altitude of 10 km for the longest possible period. Below this altitude, the coverage does not justify the expense of launching such a project. This is the reason why previously discussed projects, such as the use of aircraft, were not used.

At the moment, it is not possible to couple two balloon-carried translators (e.g. one in Northern and one in Southern Germany) to increase the coverage. The present output power level of the translators and the omni-directional antennas would not allow low-noise transmissions between these two translators. The antenna gain and the receive bandwidth of a ground station, which is dimensioned to receive only one station, results in a system gain of approx. 20 to 30 dB, which would be missing during the transmission from one balloon to another.

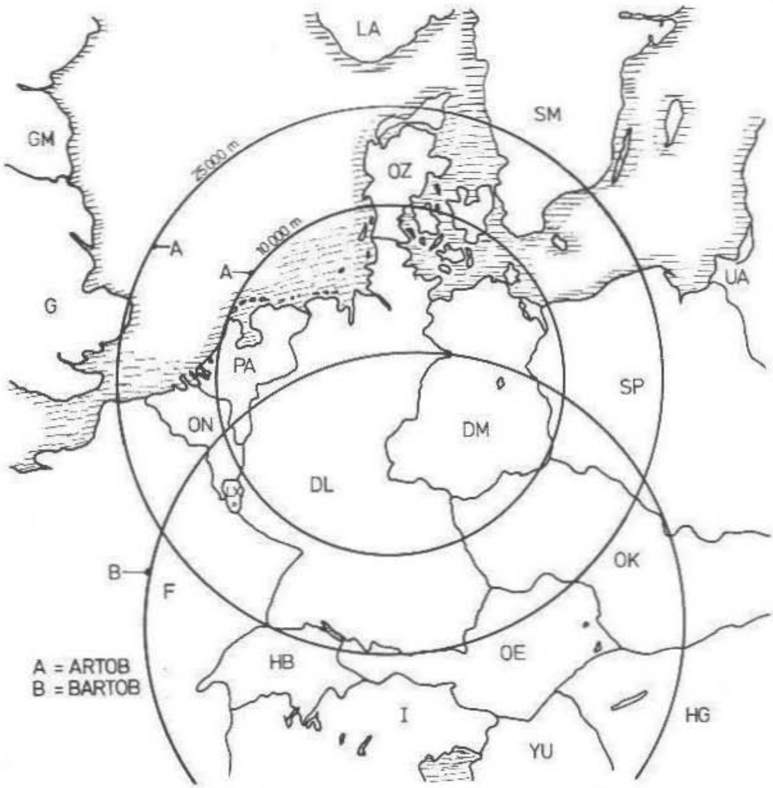

Fig. 1: Maximum coverage at two different altitudes

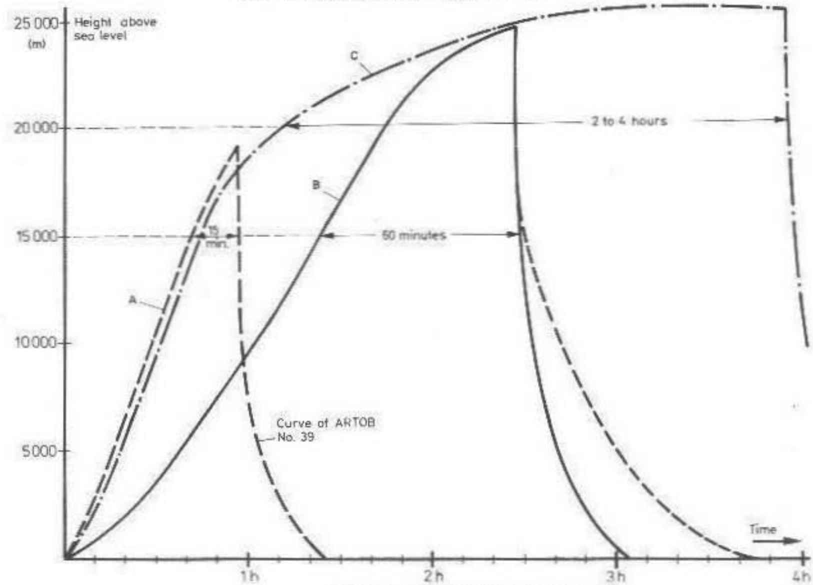

Fig. 2: ARTOB flight curves

The question is now how to achieve the longest possible flight at the highest possible altitude. Fig. 2 shows several typical flight curves for ARTOB flights.

ARTOB flight No. 39 (May 7th, 1970) is shown in Fig. 2 as a dashed line. This flight exhibited the highest ascent speed that could be obtained with a well-filled balloon. The result of this was, however, that the balloon burst before reaching an altitude of 20 km. The equipment falls rapidly after the balloon bursts - especially when only a small parachute is used - which means that the flight time above an altitude of 15 km only amounted to 15 minutes. By carefully dimensioning the filling and payload, which is only possible under non-wind conditions on the ground, it is possible for the balloon to start with only 100 to 200 g of ascent force. It is true that the balloon only rises slowly and it is endangered by obstacles, however, the balloon will burst far later due to the reduced pressure inside the balloon. This results in a flight curve having a useful period of approx. 60 minutes at an altitude above 15 km. The flight curve of this is given as the continuous curve in Fig. 2. In order to achieve even longer periods, it is necessary for gas to be released from the balloon at a certain altitude. It would then be possible to launch a well-filled balloon which would rapidly obtain a useful height where some of the gas could be released before bursting so that the ascent is reduced until possibly a virtually stationary condition is achieved. It would then be possible that the balloon only bursts after a long period at an altitude of approx. 25 km which means that an operating period of two to four hours could be obtained at an altitude in excess of 20 km.

The demands 2 and 3 are self-explanatory and need not be mentioned in detail here. All these demands lead to a number of special demands on the auxiliary units of the translator.

2. SPECIAL DEMANDS

1. An altimeter is required.
2. Some means of controlling the altitude is very advisable.
3. The weight of the equipment should be as low as possible so that the balloon need only be filled to a low degree. This reduces the loading on the balloon envelope and thus delays the time of burst.
4. A means of direction finding is required to locate the translator during the flight and on landing. This is to ensure that the equipment can be recovered. It is extremely important that the approximate landing site is known before landing since it is very difficult to locate the translator after landing at any considerable distance. This allows the rough location to be established from where the actual search for the equipment can be made.
5. The antennas should also be able to cope with a hard landing so that the beacon signal is still radiated effectively after landing and, of course, because one does not wish to re-construct antennas before each launch.
6. The antennas should be as omni-directional as possible.
7. A certain amount of redundancy should be provided so that the failure of one part will not cause the whole equipment to fail and, for instance, make it impossible to recover the equipment. This means that two beacon transmitters should be provided as well as safety circuits for switching to reserve circuits should a failure occur.

8. Since the accuracy of the required distance and direction measurements can be adversely affected by interference, low-interference channels should be provided for this purpose.
9. Since the prevailing winds in West Germany are westerly, and since we cannot expect that equipment that flys over the East German border will be returned, it is very advisable for a separation device to be provided.
10. The power supply for the beacon should have an especially long life so that it is able to operate for several days during long search sessions.

2.1. ADDITIONAL WISHES WITH RESPECT TO THE AUXILIARY EQUIPMENT

Such equipment is to be covered under this heading that is not absolutely necessary for the safety of the equipment, but morè to assist the operation and utilization.

1. The equipment should be able to be quickly prepared for the next launch so that the frequency of launches can be increased. This means that antennas must be able to stand a hard landing, rechargeable batteries as well as easily accessible test points for a rapid checking must be provided.
2. The measuring systems of the control station on the ground should be easy to operate, and where possible automatic, since only one person is usually available. This would include such items as an automatic recorder for the altitude measurement with injected time markers.
3. Additional coded information should be transmitted on a certain frequency, besides the identification (e.g. ARTOB), indicating the type of translator launched. It is then only necessary for interested stations to tune to this frequency in order to obtain information as to when, in what direction, and with which translators (frequencies) the balloon has been launched. Since failures can occur on the balloon, equipment or antennas, it is advisable to be able to switch this information so that the correct code can be selected just before take-off.
4. It should also be possible to pass on the evaluated position data of the balloon from the control station to the recovery personnel during the flight. This information should be given over the beacon transmitter so that the receivers of the recovery personnel need only be tuned to one beacon frequency, but are still kept informed regarding the flight and position of the balloon. This means that the recovery station only requires a receiver with direction-finding antenna, and, of course, a vehicle. Under such conditions, it may be possible to find more volunteers for the recovery. Anyway, this is very good practice for fox hunts (DF-Events).
5. Of course, communication facilities must also exist between the control station and the recovery personnel after landing. This can be achieved using shortwave mobile stations since the landing point is not always within the VHF range of the control station. Of course, it is possible for a number of VHF stations to relay the information back to the control station.
6. Due to the fact that the time of launch is not usually known very much in advance, a powerful two metre SSB station is advisable as well as a station on one of the shortwave bands who is able to inform interested amateurs ablut launching plans that are not within the range of the VHF station. Since most of the balloons are launched on Sundays, the most favourable sked time for such transmissions would be Saturday evening or Sunday morning.

3. DETAILS OF THE LATEST ARTOB SYSTEM

The block diagram of a measuring and beacon system that is being tested at present is shown in Fig. 3. The heart of this system is a AM transmitter which is followed by a low-pass filter so that the harmonics are not introduced into the 70 cm command receiver. A pulse generator controls electronic switches which cyclically switch the identification, altitude and type of translator coding to the modulator of the AM transmitter. The identification is supplied by a coder. The altitude information is provided by a altitude-dependent audio frequency. The dash information indicates the type of translator.

The automatic run of the beacon signal is as follows:

A R T O B	Altitude Tone	Dash-Identification	Rx "on"
20s		20s	

A 2 : 850 - 1500 Hz

The dash-information is made in A 1. The coding is given in the following table:

Number of dashes	Type of translator
1	2 m/2 m
2	70 cm/2 m
3	23 cm/2 m
4	12 cm/2 m
5	70 cm/ 2 m + 23 cm/2 m
6	as 5 but with extended flight time
7	free

The altitude measuring system actuates a switch at an altitude of 500 m which switches on the transmitter and receiver (70 cm FM RX) and the balloon separation unit. These are only required if the equipment is not wirking normally. This ensures that the transmit-receive link for remote measurements, direction finding and for command use is in operation and that the balloon separating explosive is not live on and after landing if it was not used during the flight.

A 20 minute delay circuit switches the beacon transmitter from continuous operation to pulse operation 20 minutes after passing an altitude of 5000 m. Due to the reduction of the power consumption, it is possible for the beacon transmitter to be operated for a period of approx. 100 hours.

The voltage stabilizing circuit should also be mentioned. This circuit is designed to avoid the previous problems where the voltage of nickel cadmium batteries dropped with falling temperature and caused some difficulties with the identification.

During the normal, automatic run controlled from the pulse generator, the command receiver is switched on for a short time during each cycle. If a signal is then received from the control station, the automatic cycle is broken until the information has been passed to the recovery personnel. In addition to this, it is possible to actuate the gas valve and the balloon separation device via the command receiver. During the remote measurement, the beacon transmitter transmits a measuring tone.

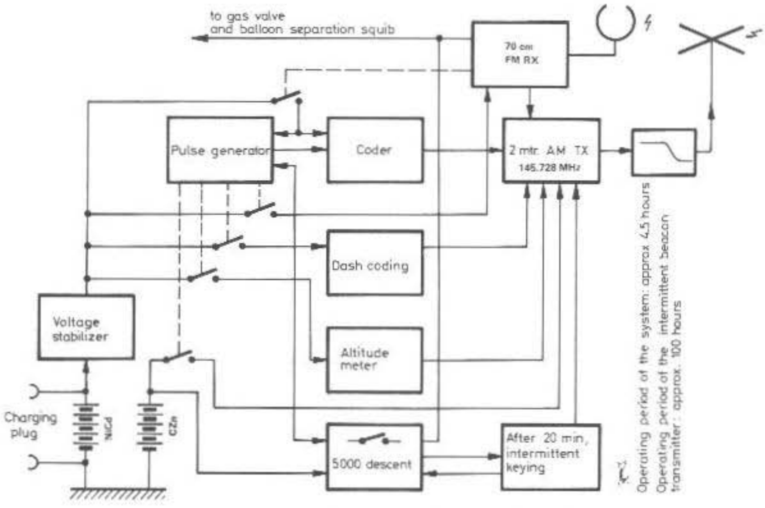

Fig. 3: Block diagram of the measuring module and beacon

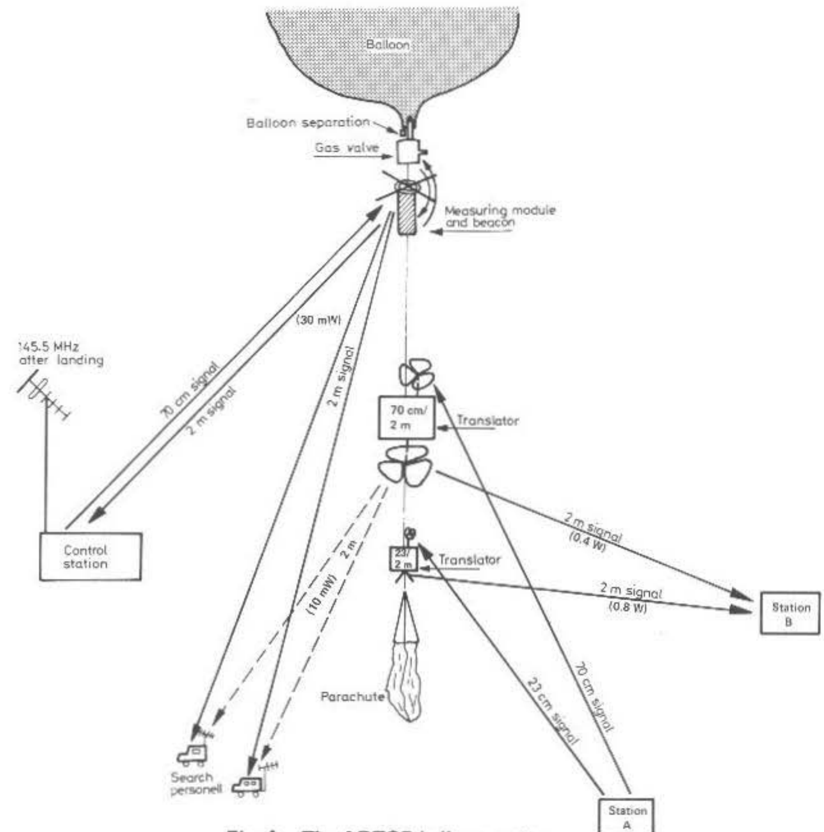

Fig. 4: The ARTOB balloon system

Finally, Fig. 4 indicates the arrangement of the various units that are attached below the balloon. The spacing between the individual antennas is very important in order to achieve a certain amount of decoupling. The clover leafshaped antennas are "big wheel antennas" as were used during flight No. 39 for 2 m, 70 cm and 23 cm. Unfortunately these very effective antennas are not able to withstand a hard landing. On the other hand, the turn-stile antenna made out of steel tape used for the beacon is very robust. However, they flatter somewhat during a rapid descent, which causes a certain amount of fading. If, however, at a later date, the altitude can be controlled with the aid of the gas valve and the balloon separation device allows accurate landings to be made, a larger parachute could be used without danger to property on landing. This could ease the antenna problem to a considerable degree.

To end this description, we would like to mention the translator frequency ranges that are in use in Germany. These list both the ARTOB (Northern Germany) and BARTOB (Southern Germany) frequencies.

ARTOB Translators	Ground station to balloon	Balloon to ground station
2 m/2 m	144.08 - 144.12 MHz	145.92 - 145.88 MHz
70 cm/2 m	432.0 - 432.3 MHz	145.3 - 145.6 MHz
23 cm/2 m	1296.0 - 1296.2 MHz	145.05 - 145.25 MHz

Beacon: 145.728 MHz   Temperature beacon: 145.75 MHz ± 5 kHz

BARTOB Translators	Ground station to balloon	Balloon to ground station
2 m/2 m	144.130 - 144.230 MHz	145.839 - 145.739 MHz
70 cm/2 m	432.0 - 432.3 MHz	145.2 - 145.5 MHz
2 m/70 cm	145.6 MHz ±25 kHz	432.5 MHz ±25 kHz

Beacon 1: 145.6383 : 145.970 MHz
Beacon 2: 145.470 : 145.910 MHz (Details from DL 7 HR)

4. EDITORIAL NOTES

We have heard from Timo Ekko, OH 1 SM, that similar balloon translators have also been launched in Finland. These balloons, which have been given the name ILMARI, have been launched successfully on three occasions. The equipment was constructed by Pauli Töryryla, OH 2 DV, with the assistance of Rolf Bächström, OH 2 BEW.

ILMARI 1 was launched on 28 May 1967 in the vicinity of Helsinke and was equipped with a beacon transmitter having an output power of approximately 100 mW on 144 MHz and 432 MHz.

ILMARI 2 was launched on 19 May 1968 from Tampere in Central Finland. The translator received A 1 and A 3 signals on 432.30 ± 0.1 MHz and retransmitted them on 145.6 MHz. At the same time, a beacon transmitter was operating on 145.98 MHz. The flight lasted approximately 2 hours. Approximately 12 different Finnish as well as several Swedish VHF amateurs were able to make contact via this translator.

ILMARI 3 was launched on 1 June 1969, also launched from Tampere and equipped with the same translator. However, a far greater number of Finnish and Swedish stations were able to communicate with each other than was the case with the second launch. A large number of 80 metre mobile stations as well as an aircraft equipped with an 80 metre station were used for the recovery.

ILMARI 4 was planned to be launched in July 1970. It was planned to carry a 1296.85 MHz translator which was to be transposed to 145.6 MHz. However, the editors have not received any information as to whether this flight was successful.

It is felt that if more cooperation was made on an international basis, a great deal could be done to further this relatively new mode of amateur communication.

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The VHF-UHF Manual is out-of-print at the moment. The reprint of this manual will not be available until April 1st, 1971. Any order received previous to this date will be made at the old price.

AN INEXPENSIVE POWER AMPLIFIER MODULE FOR 200 W PEP ON 144 MHz USING TWO PL 504 TUBES

by V. Thun, DJ 7 ZV

1. INTRODUCTION

At the moment, double tetrodes YL 1060 (QQE 06/40) or tubes of the 4 X 150/250 series are used for 2 metre power amplifier stages when power levels of 150 W PEP or more are required. However, the double tetrodes are very expensive and the mechanical considerations that must be made when building up a 4 X 150 PA stage are extensive. In the latter case, it is also necessary to obtain expensive special sockets and a cooling blower. A further disadvantage of the 4 X 150 is the high plate voltage required by this tube.

Experiments made by D. Seidel, DJ 1 OP, and the author have shown that a PEP output power of 200 W can also be obtained with two PL 504 (horizontal-deflection tubes designed for monochrome television receivers) in push-pull. PL 505, PL 508 and PL 509 (horizontal-deflection tubes for colour television receivers) were not suitable.

A power amplifier equipped with these inexpensive tubes, which are readily available in Europe, can be operated from a low plate voltage of 600 V. Conventional consumer electronic components can be used. However, due to the relatively low plate dissipation power it is not possible for these tubes to be run at peak power continuously as in the case of the 4 X 150. This phenomenon is well known in shortwave SSB transceivers using similar horizontal deflection tubes. This means that the PA stage is not suitable for operation in the AM (A 3) and FM (F 3) modes, except when the input power is drastically reduced, which is hardly worth while. For amateur SSB operation (A3j ICAS), on the other hand, this module represents a very high power output together with a simple construction.

One disadvantage of the PL 504 PA stage is the relatively low power gain of approx. 10 - 13 dB when compared with other tubes such as the 4 X 150 with a power gain of 20 dB. This means that an input power (PEP) of 10 - 20 W must be provided for the control grids of the two PL 504 tubes. This is the reason why a driver stage equipped with two PL 81 tubes is provided in the described power amplifier. An amplifier equipped in this manner exhibits a power gain of approx. 26 dB. This means that the full output power of 200 W PEP is obtained over the whole 2 metre band with an input drive power of only 0.5 W.

This relatively low drive power can be obtained from a transistorized exciter equipped with an "Overlay" output transistor. The transmitter concept used by the author, which has a combination of transistors and tubes, is shown in the block circuit diagram given in Fig. 1 together with details of the power level values.

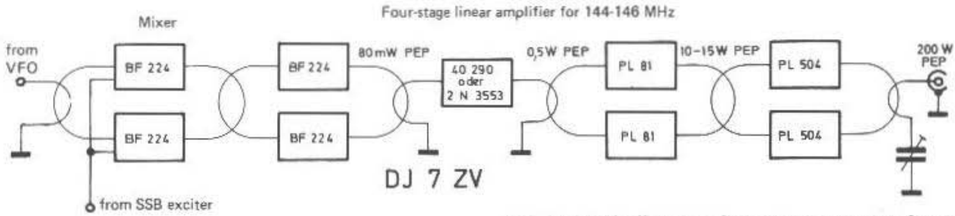


Fig. 1: Block diagram of the 2 m SSB transmitter

2. CIRCUIT DESCRIPTION

2.1. TRANSISTOR DRIVER STAGE

The output stage of the previously mentioned transistorized exciter is now to be described. The circuit diagram is given in Fig. 2. The author used the "Overlay" transistor 2 N 3553 of RCA, however, type 40290 is even more suitable for operation from an operating voltage of only 13.5 V. The final amplifier operates in a stabilized class A condition, where its operating point is determined by a 2 N 3702 transistor. The 2 N 3702 transistor is a silicon PNP transistor manufactured by Texas Instruments. The operating point of this transistor and thus the operating point of the output transistor is adjusted with the 1 kΩ-potentiometer. The lower the (positive) voltage on the wiper, the higher is the current passed by the transistors. One contact of the transmit-receive relay separates the potentiometer from ground so that the base voltage is increased to 13.5 V where both stages will be blocked. The RF transistor must be provided with cooling fins. It is also advisable to provide a brass screening panel through which only the base lead is fed into the front chamber. The emitter connection should be soldered to the base circuit ground a maximum of 2 mm below the transistor case. The base connection should also be kept short because such RF power transistors exhibit a very low input impedance. FXC is a wideband ferroxcube choke (e.g. 4312 020 36701 of Philips).

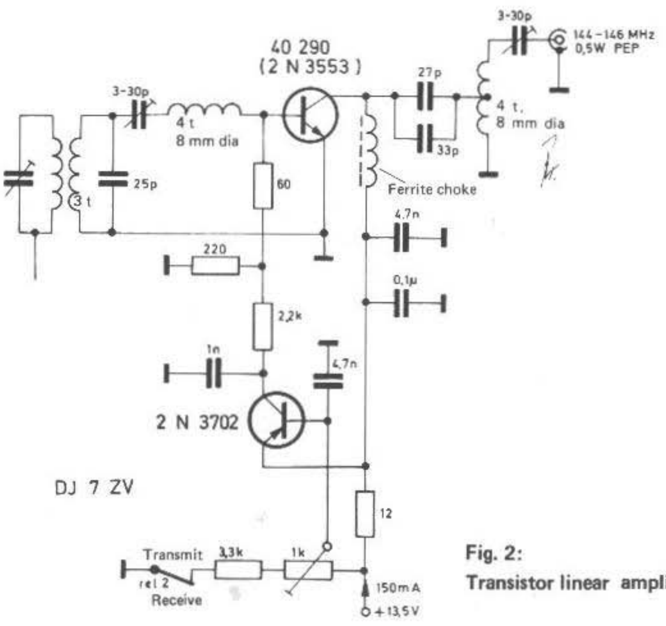


Fig. 2:
Transistor linear amplifier

2.2. TWO-STAGE POWER AMPLIFIER

The tubed two-stage linear amplifier for an output power of 200 W PEP can be fully driven by the previously described transistor amplifier. If a SSB transmitter having a PEP output power of approx. 20 W is available, the power amplifier can be operated without the driver stage. When driving the two PL 504 tubes with a power of 8 W PEP, an output power of approximately 150 W PEP will be obtained. The circuit of the two-stage power amplifier is shown in Fig. 3.

2.2.1. DRIVER STAGE

The inductivity of the input coupling L 1 is brought into series resonance at 145 MHz with the aid of trimmer capacitor C 1. The grid circuit of the push-pull driver stage operates with trimmer capacitors C 2 and C 3 in series with the tube input capacitances; the grid bias voltage is fed via resistors R 1 and R 2. The screen grids are connected together, by-passed and fed with a stabilized voltage of 150 V. The push-pull plate circuit with trimmer capacitor C 8 and inductance L 3 is connected to the plates via a short piece of flexible wire.

2.2.2. POWER AMPLIFIER STAGE

The output power of the driver stage is fed to the grid circuit of the final amplifier via a coupling link comprising inductances L 4 and L 5, using the variable capacitor C 10 to bring the circuit to series resonance. Due to the high RF voltages at this point, the grid bias voltage is fed via RF chokes (Ch 2 and Ch 3). The screen grid connections are connected together and provided with an unstabilized, but low-impedance voltage of 300 V. This voltage also feeds the plates of the driver stage.

The plate circuit of the power amplifier is in the form of a $\lambda/4$ Lecher-line that is shortened by the push-pull output capacitance of the tubes. The connection to the plates is made by a short piece of flexible wire in order to avoid mechanical tensioning due to heat-expansion or contraction from reaching the tubes, and to facilitate tube replacement. The telescopic form of the Lecher-line allows it to be tuned for resonance.

The plate voltage of approx. 600 V is fed to the tubes via the high-voltage feed-through capacitor C 18, a piece of flexible wire, and the ferroxcube choke Ch 4. In the author's prototype, however, a simple feed-through was used together with a high-voltage capacitor instead of the feedthrough capacitor.

The output coupling link, made from a well-insulated, thick copper wire, is spaced only a few millimetres from the Lecher-circuit. The inductivity of the output link is brought to series resonance at 145 MHz using the variable capacitor C 17. This results in a very low loss and allows any possible slightly reactive components of the terminating impedance (antenna) to be compensated so that the dip in the plate current coincides with the point of maximum output power. The degree of coupling is varied by altering the distance between the coupling link and the Lecher-circuit.

All resonant circuits of the two-stage final amplifier need only be aligned to the centre of the band during the initial tune-up. The output coupling also only needs to be aligned for optimum on one occasion. Since the drive power is sufficient, it is only necessary for the drive of the driver stage to be adjusted to the maximum permissible value on changing the frequency. Variable capacitor C 10 need not be varied.

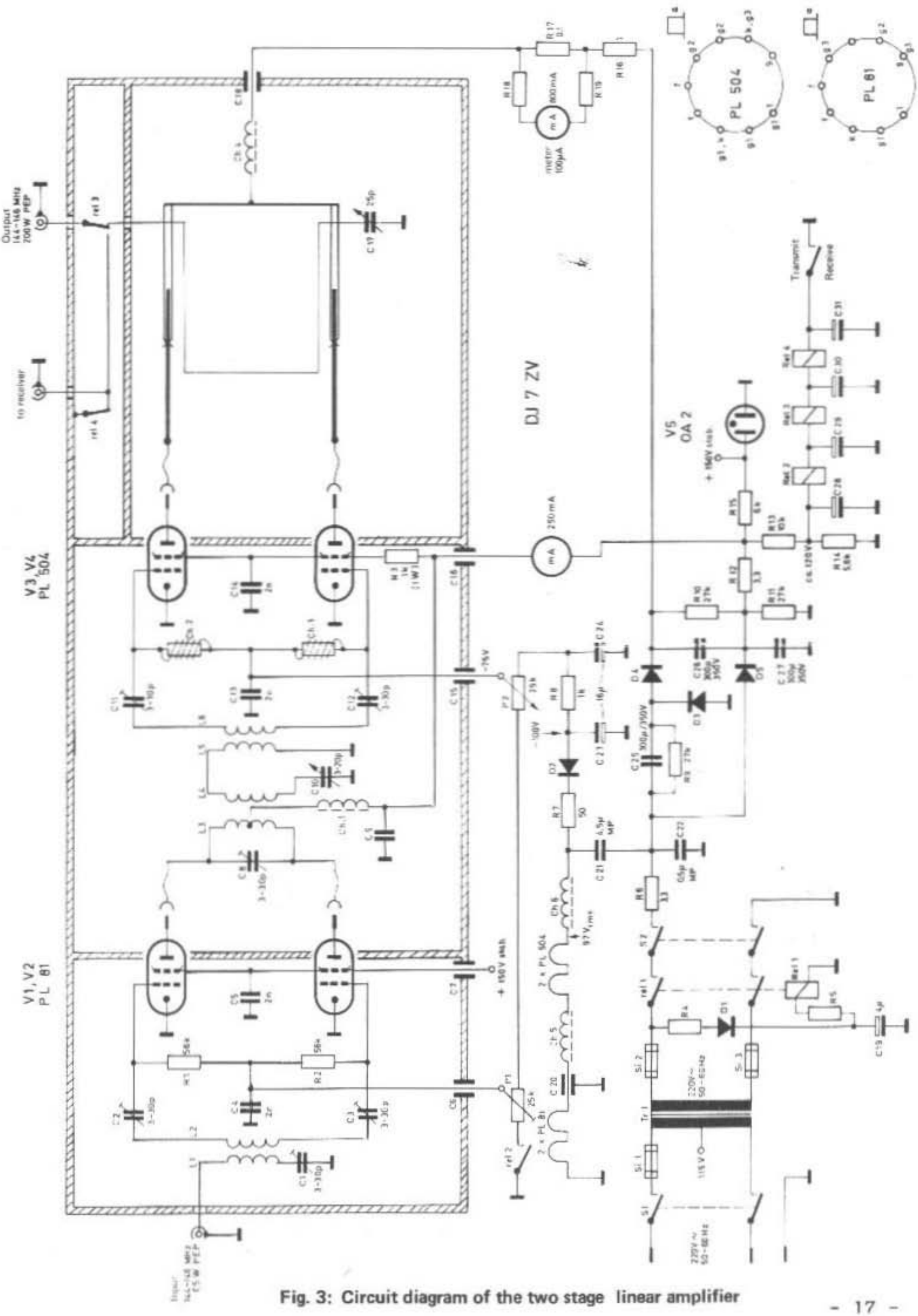


Fig. 3: Circuit diagram of the two stage linear amplifier

2.3. POWER SUPPLY

2.3.1. PROTECTIVE CIRCUIT AND ISOLATING TRANSFORMER

The power supply built into the two stage final amplifier does not use a transformer; the required higher voltage is obtained by voltage doubling. This means that a protective circuit must be provided which only allows the power supply to be switched on when the power line lead carrying the highest voltage to ground is connected to the PH. (phase) connection and the protective ground connection to MP. (middlepoint). This is made using relay Rel. 3. If the connection is correct, relay Rel. 1 will be actuated and it will be possible for the final amplifier to be switched on with the aid of switch S 2. If this is not the case, the switch will be non-effective.

In Germany and in a number of other countries, the electrical authorities require a galvanic isolation of the consumer from the power line. This means that radio amateurs of these countries must provide an isolating transformer in front of the power supply. Of course the protection circuit will then no longer be required. This transformer is shown in the circuit diagram given in Fig. 3. The primary of this isolating transformer can, of course, be dimensioned for an input voltage of 115 V which makes it suitable for operation in North America and in other areas where a power line voltage of 220 V is not available.

2.3.2. TUBE HEATING

Since series-heated tubes are used, it is advisable for the heater circuit to be built up in a similar manner to that found in television receivers. Since the series-connected heaters of these 4 tubes require an effective AC voltage of approx. 97 V, some form of voltage-dropping must be provided. A capacitive and thus low-loss means of dropping the voltage is used.

The capacitance of the dropper resistance is calculated for 50 Hz in the following manner:

$$\boxed{C = \frac{4{,}35}{\sqrt{1-\left(\frac{R_f}{735}\right)^2}}} \qquad \boxed{R_f = \frac{U_f}{I_f}}$$

U_f in V = total heater voltage (97 V)

I_f in A = series-heater current (0.3 A)

R_f in Ω = resistance of the heater circuit

C in μF = capacitive dropping resistance

In the case in question, the value for C 21 was found to be 4.8 μF. The selected value of 4.5 μF can also be used on 60 Hz networks. The capacitor must, of course, be uni-polar and be dimensioned for at least 220 V. If a driver stage is not to be included, the heater of the PL 81 tube should be replaced by a 50 Ω/7 W resistor in order to ensure that the grid bias voltage is sufficient.

2.3.3. GRID BIAS VOLTAGE

Since no more than - 100 V are required as grid bias voltage, it is quite favourable to use the 97 V heater voltage dropped by C 21. The additional loading is negligible. The bias voltage source can be of high impedance because no grid currents are exhibited. The grid bias circuit consists of a halfwave rectifier (diode D 2), a simple RC-filter link (R 8, C 24), and two trimmer potentiometers (P 1 and P 2) for tapping off the two different voltages. The relay contact rel 2 of the transmit-receive relay Rel. 2 isolates the potentiometer from ground in the receive mode so that the bias voltage increases to a peak value of over 100 V which blocks the tubes.

If the tube heating circuit is broken, the negative bias voltage will increase to approx. 300 V. For this reason, diode D 2 and capacitors C 23 and C 24 are, for safety reasons, dimensioned for this voltage.

2.3.4. 300 V PLATE VOLTAGE, 150 V STABILIZED VOLTAGE

The driver stage requires a plate voltage of 300 V which is also used as the screen grid supply for the final amplifier. This voltage is obtained from the power line voltage by half wave rectification using diode D 5. An RC link comprising resistor R 6 and capacitor C 22 ensures that high-frequency voltage peaks that sometimes occur on the power line voltage do not reach the power supply. The filter capacitor C 27, which is provided with a discharge resistor (R 11), filters the voltage. Resistor R 12 serves as a fuse. Its rating is so low that it blows virtually immediately under short circuit conditions which causes the voltage supply to be broken. This happens so quickly that the tubes, diodes and power line fuse are not affected.

The stabilized voltage of 150 V required for the screen grid of the driver stage is obtained from a neon stabilizer tube OA 2. This voltage is taken via the dropper resistor R 15 from the plate voltage of 300 V.

2.3.5. 600 V PLATE VOLTAGE

The plate voltage of 600 V, required for the final amplifier, is obtained by voltage doubling from the power line voltage using capacitor C 25 and diodes D 3 and D 4. The RF-filter link R 6/C 22 is also effective here. The filtering is made by the series-connected capacitors C 26 and C 27. The parallel-connected resistors equalize the leakage currents and discharge the capacitors after switching off.

A protective resistor is also used in the 600 V link as a fuse (R 16).

2.4. METERING

Two meters are used: One in the plate current path of the power amplifier - that has been shunted for a full scale deflection of 800 mA - and one that has been shunted for 250 mA for the plate current of the driver stage and the screen grid current of the power amplifier. If the latter meter should indicate a very high current, this will indicate that the power amplifier stage is not provided with plate voltage but only with screen grid voltage.

The power amplifier meter is protected by two further resistors (R 18, R 19) from the high voltage which could momentarily appear across the shunt resistor under short circuit conditions. The values of these resistors depend on the sensitivity and resistance of the meter.

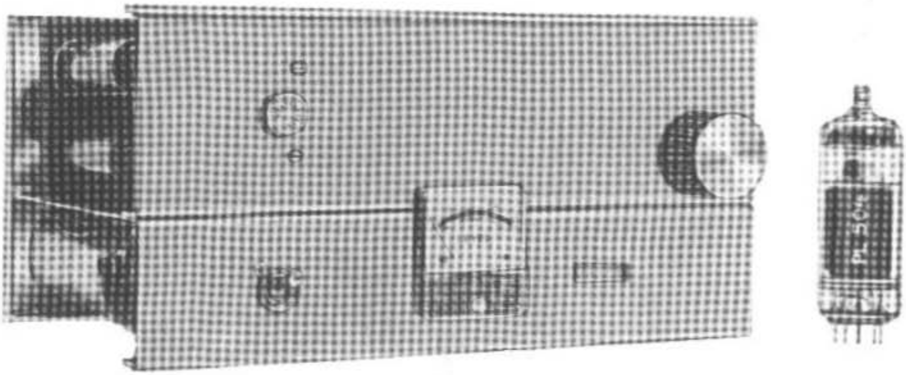


Fig. 4: Front panel of the power amplifier

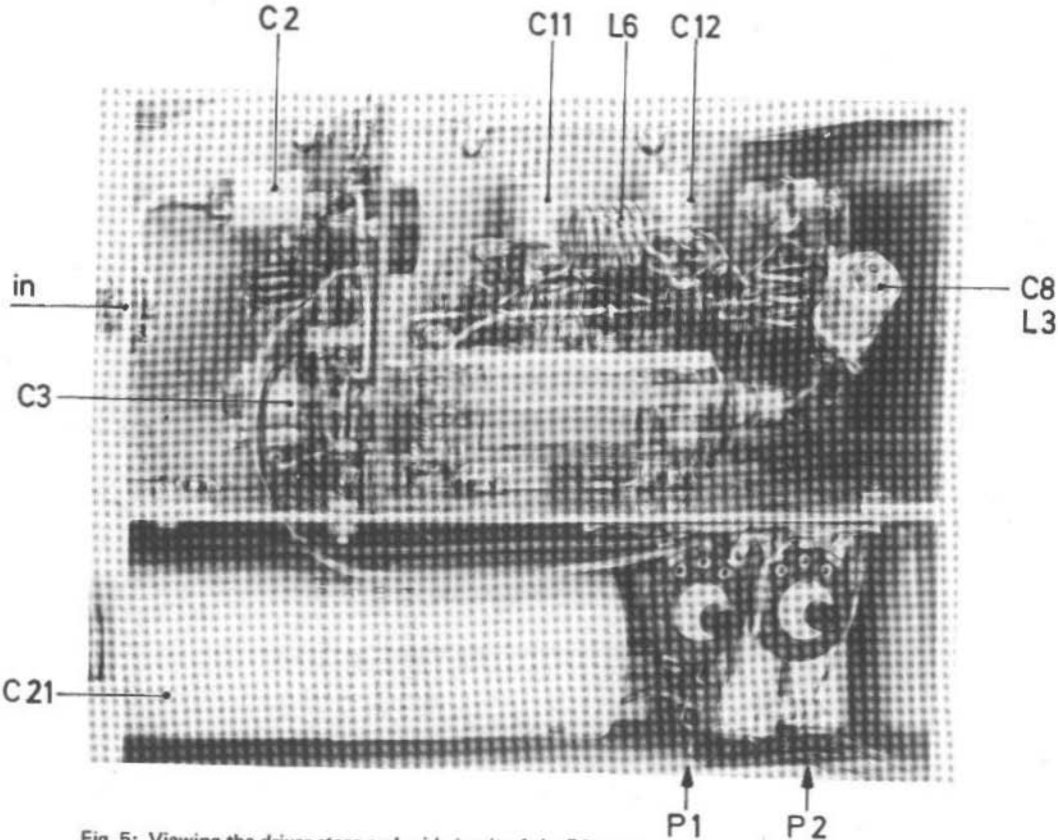


Fig. 5: Viewing the driver stage and grid circuit of the PA stage

2.5. RELAYS

Three relays are used in addition to the relay for the protection circuit: Relay Rel. 2 as transmit-receive relay for the voltages in the transmitter, relay Rel. 3 as antenna relay and Rel. 4 to short the input of the receiver whilst transmitting. Relay Rel. 4 is accommodated in the power amplifier stage near to the coaxial socket for the receiver. All three relay solenoids are connected in series. The relays used by the author require a total of approx. 120 V which is obtained from the plate voltage of 300 V using a voltage divider comprising R 13 and R 14. The transmit-receive switch is a contac t (or a switching transistor) in the VOX circuit of the exciter.

3. MECHANICAL ASSEMBLY

The two-stage linear amplifier is combined with the power supply to form one unit; however, the isolating transformer is not included. The dimensions of the linear amplifier only amount to 250 mm by 150 mm by 120 mm. Figures 4 to 7 allow an impression to be gained regarding the construction. The assembly is made in a conventional manner on an aluminium chassis; the screening panels are screwed into place.

Figure 8 shows the arrangement of the chassis pieces. The whole power supply (without isolating transformer) is accommodated on chassis part A. The mechanical assembly of the power supply need not be described because it is dependent on the mounting and connection material available. However, Fig. 7 allows a general impression to be gained. The only important point is to ensure that capacitors C 21, C 23, C 24, C 25 and C 26 are insulated from the chassis and further insulated so that they do not represent a shock hazard.

The chassis parts B, C, and D (Fig. 10, 11 and 12) are screwed onto the top of part A where they represent screening panels and part of the cabinet respectively.

The tube sockets with most of the RF circuitry are located on boards 1 and 2. The location of the boards is given in Fig. 8; the dimensions and required holes in Figures 13 and 14. The boards are made from single-coated PC-board material and arranged so that the coated side is on the same side as the socket connections. The copper-coating can therefore be used as the ground area to which the individual ground connections can be soldered. The mounting brackets (Fig. 15) are soldered onto the boards so that the latter can be screwed onto the chassis parts A to D and soldered together.

3.1. CHASSIS PART A

The assembly is commenced by making the holes given in Fig. 9. This ensures that the holes for the other chassis parts are accessible and not blocked after installing the power supply underneath chassis part A. No holes are given for mounting the power supply components, since this depends greatly on the available components and mounting facilities.

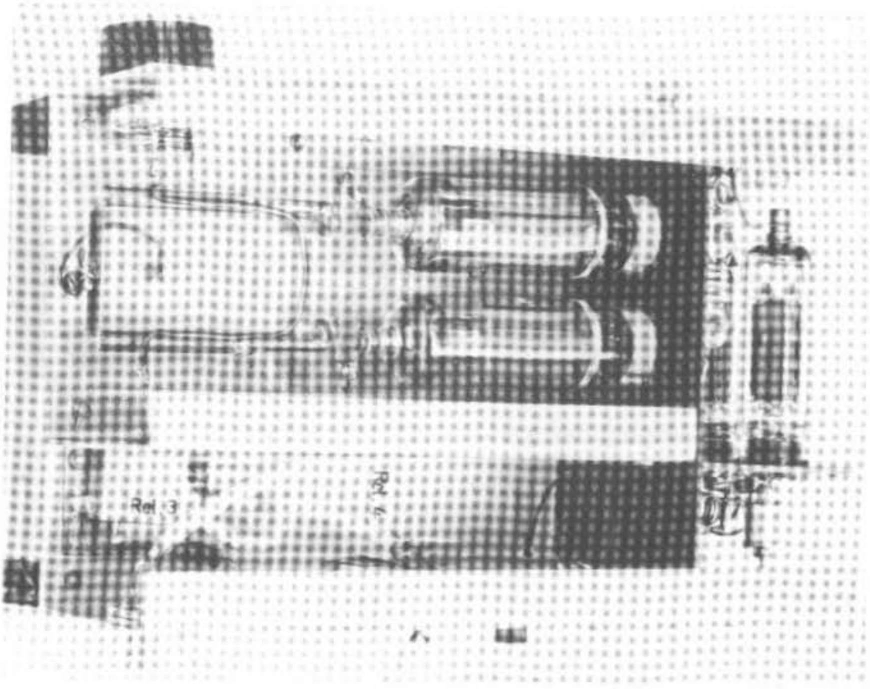


Fig. 6: View from above

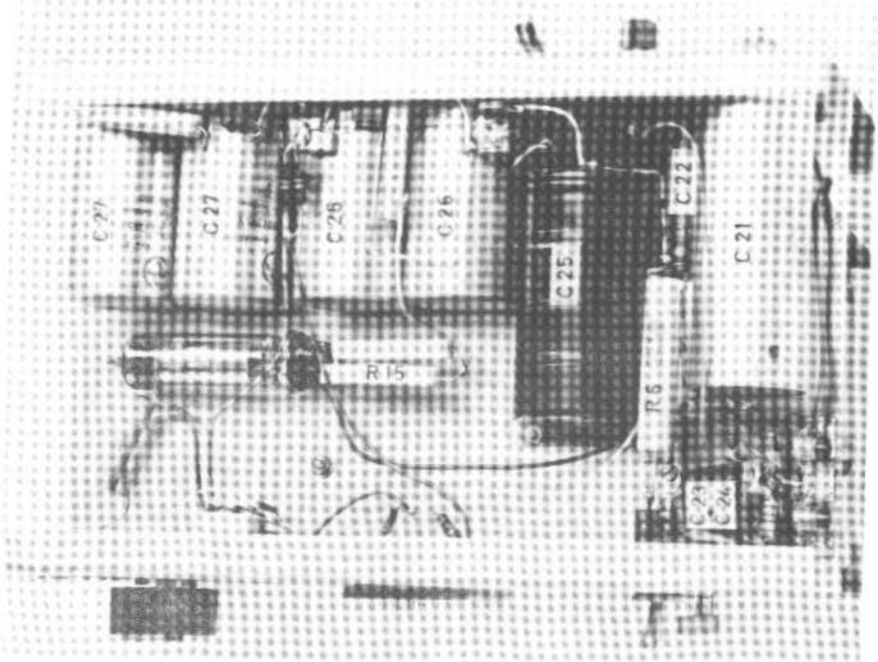


Fig. 7: Power supply (view from below)

3.2. CHASSIS PARTS B, C, D

These chassis parts are prepared as shown in Figures 10, 11 and 12. The variable capacitors C 10 and C 17 are built onto chassis part B. Three coaxial sockets and a control voltage socket for the relay voltage are provided on Part D. Besides the mounting holes, chassis part C only receives a large hole through which the coaxial cable is run. This cable will then connect the output coupling link to the antenna relay Rel. 3.

3.3. BOARD 1

This single-coated, un-etched printed circuit board accommodates the components for the driver stage. It is drilled according to Fig. 13. The ceramic noval-sockets (for PC-board mounting) are now soldered into place on the copper-coating with the bent cathode and grid 3 contacts so that the control grid connections point to the positions shown in Fig. 13. The screen grid connections are all joined together. The centre of the screen grid connection is connected via the bypass capacitor C 5 to the copper-coating.

Whereas the grid circuit is mounted onto the grid connections with the spindle trimmers, the plate circuit is built up on a small board in the vicinity of variable capacitor C 10. The additional board, which can be seen in Figures 5 and 6, is soldered onto board 2.

3.4. BOARD 2

This board should be prepared according to Fig. 14 and the ceramic magnoval sockets (for PC-board mounting) soldered into place so that the two control grid connections are at the same level and point in an upward direction. The socket is soldered into place with connections 3 and 8 (cathode and grid 3) which are bent outwards and connected together with 2 mm dia. wire. Connection 9 of both sockets should be shortened as far as possible. The two control grid connections of each socket are joined together. The stator connections of the spindle trimmers C 11 and C 12 are connected to the common grid connection with the hexagonal portion pointing in an upward direction. The grid inductance L 6 is soldered between the two rotor connections. Chokes Ch 2 and Ch 3 are also mounted using short connections.

3.5. LECHER-LINE CIRCUIT AND OUTPUT COUPLING

Fig. 16 shows the individual parts of the Lecher-circuit and the output coupling link fo the linear amplifier. The two telescopic pieces of the Lecher-circuit must have a good contact to another. This can be ensured by sawing the end of the tube 4 to 6 times and pressing it together or by soldering on a spring-loaded contact; such spring-contacts are often to be found in old microwave equipment. e.g. as the cathode contact for a 2 C 39 tube.

The thin tubes of the Lecher-circuit are soldered onto two ceramic supports so that they are spaced 24 mm from the chassis. The flexible leads for connection of the tube plates are also soldered to these supports. Since the tubes will get very hot, attention should be paid to ensure that a very good contact is made to the plates. If necessary, the connection caps should firstly be depressed and then soldered onto the tubes.

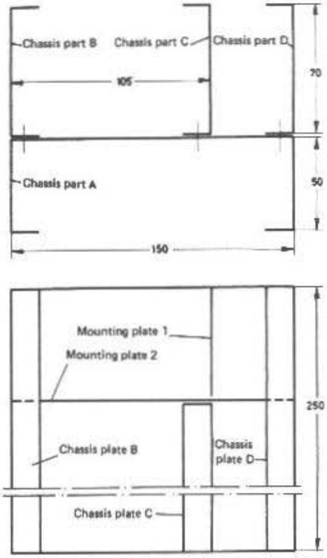
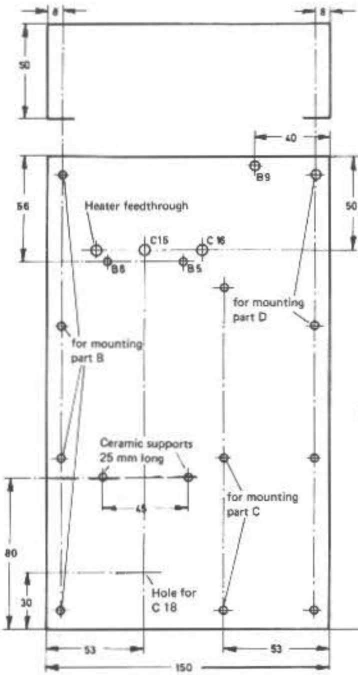
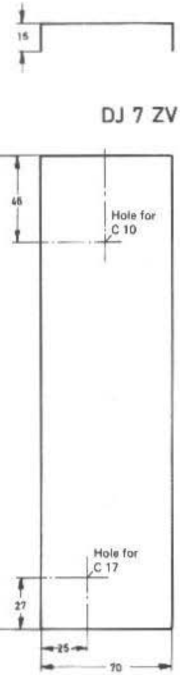


Fig. 8: Construction of the chassis parts Side and end view



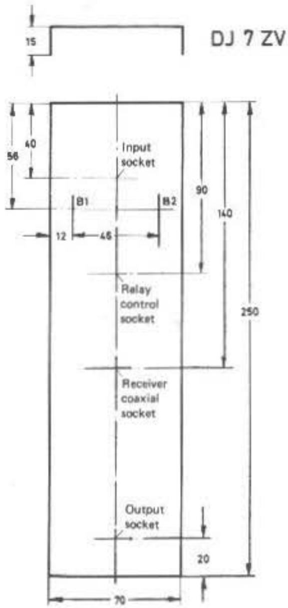
2 mm thick aluminium

Fig. 9: Chassis part A without holes for the powersupply



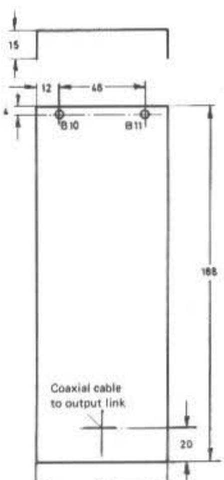
2 mm thick aluminium

Fig. 10: Chassis part B



Material: 2 mm thick aluminium

Fig. 11: Chassis part C



Material: 2 mm thick aluminium

Fig. 12: Chassis part D

Material: 2 mm thick Pc-board

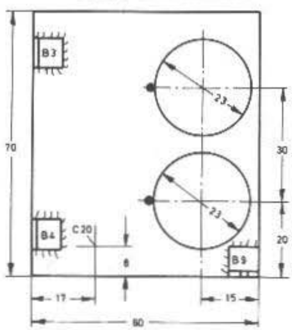
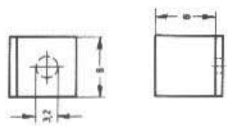


Fig. 13: Mounting plate 1 with soldered mounting brackets



Material: 1 mm brass

Fig. 15: Mounting brackets; 2 without hole; 7 with one hole and 2 with two holes

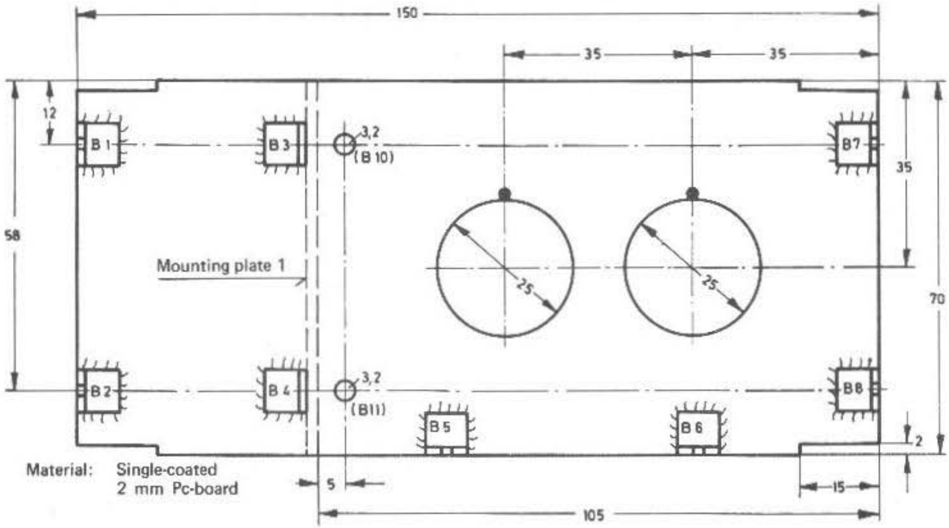
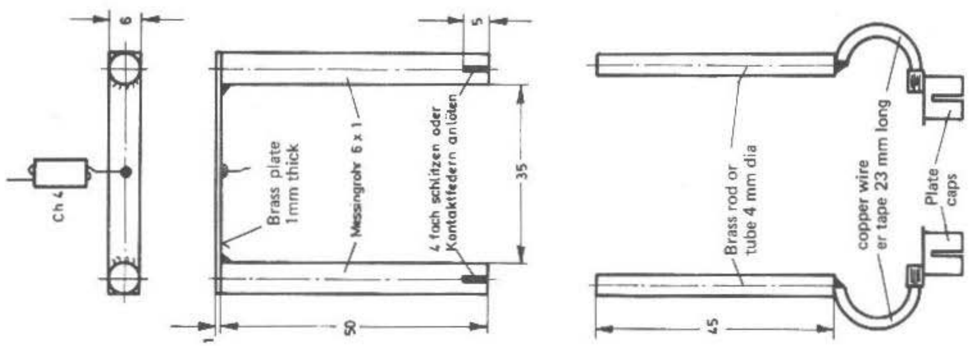
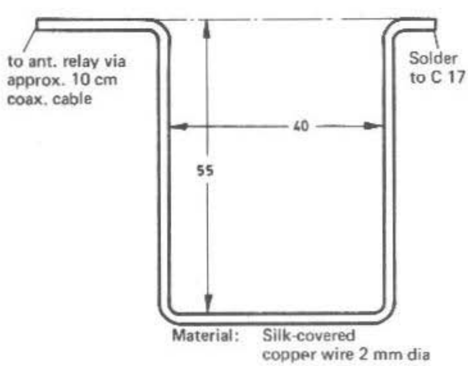


Fig. 14: Mounting plate 2 with 8 soldered, mounting brackets (B). Viewing coated side





mount tube sockets so that the grid connections are at the marked positions "●"

Fig. 16:

Telescopic Lecher circuit of the PA stage and coupling link

3.6. RELAYS

The relay Rel. 3 and Rel. 4 are accommodated in the space between chassis parts C and D. Relay Rel. 4 is used to short the receiver input so that the limited coupling attenuation of the antenna relay Rel. 3 does not endanger the receiver input. The type of relay used for Rel. 4 is not critical. Conventional relay types or a reed-contact relay as described in (1) can be used.

It is recommended that the transmit and receive path be checked using a reflectometer after connecting the relay.

3.7. CABINET, COOLING

The chamber on top of the Lecher-circuit is closed with a brass or aluminium plate which should be screwed in six positions.

The whole linear amplifier should be covered with perforated aluminium plate or wire mesh. The high temperature generated in the final amplifier can be reduced using a small blower. Such a blower is not completely necessary during pulse-type SSB operation, especially since it has virtually no effect on the cooling of the anode plate. Even with ambient temperatures of 33 ^{o}C, the linear amplifier was found to operate perfectly without blower, although it became very hot. A good air circulation should be provided.

3.8 COMPONENTS, COIL DATA

L 1: 3 turns of insulated wire wound onto a 8 mm former, self-supporting placed into L 2.

L 2: 6 turns of 1.5 mm dia. (15 AWG) wound on a 8 mm former, self-supporting, coil length 15 mm.

L 3: 3 turns as L 2, 3 mm spacing between turns.

L 4: 2 turns as L 1, placed between the turns of L 3.

L 5: 3 turns as L 1, placed between the turns of L 6.

L 6: 6 turns as L 2, 1 mm spacing between turns.

PA lecher line: (Fig. 16) 3 x 1.5 sq.mm, 23 mm long at the plate connections; followed by 45 mm long brass tubes of 4 mm outer diameter finally 50 mm long brass tubes of 5 mm inner and 6 mm outer diameter with spring loaded contacts at the front; far end shorted with a copper strip of 12 x 45 x 1 mm.

Output coupling link: 2 mm diameter (12 AWG) insulated copper wire formed as shown in Fig. 16.

Ch 1: Ferroxcube-wideband choke, e.g. 4312 020 36701 (Philips)
Ch 2, Ch 3: 15 turns of 0.3 mm (29 AWG) enamelled copper wire wound onto a resistor of 12 kΩ/0.5 W
Ch 4, Ch 5, Ch 6: As Ch 1

R 1, R 2: 56 kΩ
R 3 : 1 kΩ/1 W
R 4, R 5: According to the voltage and current requirements for relay Rel. 1
R 6 : 3.3 Ω/4 W (or 2 resistors 6.8 Ω/2 W)
R 7 : 50 Ω/0.5 W
R 8 : 1 kΩ/0.5 W

R 9, R 10, R 11: 27 kΩ/4 W (or 2 resistors each of 51 kΩ/2 W)
R 12 : 3.3 Ω/0.5 W
R 13 : 10 kΩ/0.5 W
R 14 : 5.6 kΩ/0.5 W
R 15 : 6 kΩ/6 W (from 3 resistors of 18 kΩ/ 2 W)
R 16 : 1 Ω/0.5 W
R 17 : 0.1 Ω
R 18, R 19: Protective resistors according to the meter

P 1, P 2: 25 kΩ/0.5 W lin. trimmer potentiometer

Si 1: Fuse 1 to 3:3 A, slow blow

C 1, C 2, C 3: 3 - 30 pF air-spaced trimmer (Philips C 005 CA/30 E or WN 40 163)
C 4, C 5: approx. 2 nF ceramic disc capacitors, 500 V
C 6, C 7: approx. 2 nF feed-through capacitors, screwfitting, 500 V
C 8 : as C 1
C 9 : as C 4
C 10 : 3 - 20 pF shortwave variable capacitor
C 11, C 12: as C 1
C 13, C 14: as C 4
C 15, C 16: as C 6
C 17 : 5 - 25 pF shortwave variable capacitor
C 18 : 180 pF or more, ceramic feed-through capacitor 1.5kV
C 19 : 4 μF/350 V electrolytic capacitor
C 20 : as C 6
C 21 : 4.5 μF/350 V metal-paper capacitor
C 22 : 0.5 μF/350 V metal-paper capacitor
C 23, C 24: 2 x 15 μF/350 V, electrolytic capacitor
C 25, C 26, C 27: 300 μF/350 V (electrolytic capacitor for television receivers or photoflash, 2 of 150 μF)
C 28 ... C 31: approx. 4 μF/100 V

D 1: according to the voltage and current requirements of relay Rel. 1
D 2 ... D 5: BY 237, BY 103, 1 N 4007 or other silicon diode for 1 kV/0.8 A

V 1, V 2: PL 81
V 3, V 4: PL 504. Experience gained in northern Germany has shown that only those types of PL 504 are suitable that possess a straight wire to the plate cap.
V 5: OA 2, 150 C 2 or similar.

4. PRELIMINARY OPERATION AND ALIGNMENT

4.1. OPERATING VOLTAGES, HEATER CIRCUIT

The first item to be checked is the operation of the incorrect-polarity protection circuit if an isolation transformer is not to be used.

The non-load voltages of the power supply should now be measured. They should correspond to the following values:

$U_a = 620$ V $\qquad U_{g2} = 310$ V $\qquad U_{g1} = -100$ V

The grid bias voltage will only obtain this value if the heater circuit is connected. The series-heater current should be checket at the same time: it should amount to 300 mA. If the heater current is too small, metal-paper (MP) capacitors of 0.1 or 0.25 μF can be connected parallel to C 21.

4.2. ALIGNMENT OF THE DRIVER STAGE

The grid circuit of the driver stage is coarsely tuned by measuring the grid current of one PL 81 with the heater switched on, but without plate, screen grid, and control grid bias voltage. In addition to this, the adjustment of the coupling inductance L 1 is made for maximum grid current. Trimmer capacitor C 1 is also aligned for maximum grid current.

Whilst measuring both grid currents, trimmer capacitors C 2 and C 3 should be carefully altered so that both grid currents are equal. Of course, the resonance condition should be maintained.

Finally, all operating voltages are fed to the driver stage and the plate current is temporarily increased without drive to 250 mA with the aid of potentiometer P 1. After this, a quiescent current of 100 mA should be adjusted.

After decreasing the drive power by approx. 20 dB ($<$ 10 mW) the plate circuit of the driver stage and the grid circuit of the final amplifier are aligned by making a grid current measurement of the PA tubes which are only heated and not provided with any other operating voltage. The coupling links L 4 and L 5 are adjusted for maximum grid current. A resonance condition must be achievable with capacitor C 10.

4.3. ALIGNMENT OF THE FINAL AMPLIFIER

After the grid currents of the final amplifier have been aligned to equal values by carefully adjusting trimmer capacitors C 11 and C 12, the drive is switched off and the DC-supply voltages are connected to the final amplifier. With the aid of potentiometer P 2, the plate current of the final amplifier tubes is momentarily increased to a value of 400 mA, after which a quiescent current of 75 mA is selected.

At reduced drive, it is now possible for the Lecher-circuit and the output coupling to be tuned for maximum output power. Finally, the final alignment is made during a very short period of full drive. This PEP-drive condition should not last longer than 30 to 40 seconds, after which a relatively long cooling period should be allowed. The tube plates and plate connection will glow red during this short period.

4.4. NOTES REGARDING THE ALIGNMENT

The following table gives a summary of the adjustment values of the driver and final amplifier stage:

	Driver stage	Output stage
Plate voltage	300 V	600 V
Screen grid voltage	150 V	300 V
Plate quiescent current	100 mA	75 mA
Plate current at full drive	250 mA	800 mA

The plate voltage will fall to approx. 570 V under full drive conditions.

The author measured the following PEP values of the output power as a function of the plate current of the final amplifier:

I_a (mA)	P_{out} (W)
75	0
100	4
200	16
400	50
800	200

When speaking into the microphone, the (relative) indication of the RF output voltage should fluctuate between 1/3 and 1/2 of the outputs indicated when feeding with a sinusoidal single-tone signal.

If one is able to measure the intermodulation ratio, it is possible for the operating points to be corrected. In addition to this, the value of the screen-grid resistor R 3 influences the intermodulation ratio. It is therefore possible for a more favourable value to be found by measurements in individual cases.

Moreover, when adjusting final amplifier tubes that are not intended by the manufacturer to operate in class AB_1, the following information will be of interest:

The final amplifier is only driven by the residual carrier and the grid-bias voltage is reduced (from the higher value) until only a very slight gain increase results. To make this measurement, the RF output voltage should be indicated, for instance using an absorption circuit.

5. NOTES

Since the described plate circuit of the final amplifier is not able to guarantee a harmonic suppression of 60 dB, a bandpass or low-pass filter, e.g. as given in (2), should be placed in the antenna feeder.

Moreover, it is only fair that such a high-power final amplifier should be checked thoroughly with respect to the intermodulation ratio of the final amplifier and the total bandwidth of the exciter signal. A spurious signal that is not suppressed by at least 60 dB when spaced 20 kHz from the required signal should not be amplified to 200 W.

6. LITERATURE

(1) E. Berberich: A Coaxial Relay with a High Coupling Attenuation and Good SWR
VHF COMMUNICATIONS 1 (1969), Edition 2, Pages 124-125

(2) H. Dohlus: Coaxial Low-pass Filters for VHF and UHF
VHF COMMUNICATIONS 2 (1970), Edition 3, Pages 166-178

VARIABLE FREQUENCY OPERATION ON 2 METRES USING THE VFO OF A SHORTWAVE SSB TRANSMITTER

by F. Boersch, DK 1 YZ

Since it is often the case that a shortwave SSB transmitter is available in addition to a crystal-controlled VHF transmitter, the author has developed a simple circuit which allows the variable frequency oscillator of the shortwave transmitter to be used for feeding the VHF transmitter. This results in variable frequency operation on the 2 metre band, without having to provide a seperate VFO for the 2 metre transmitter or to purchase or build a complicated SSB transverter. The VFO of a modern SSB transmitter is normally very stable. On the other hand, the required measures to obtain the same frequency stability when using a VHF-VFO or to construct a SSB transverter would be more extensive. This means that the following accessory could be very useful in achieving this aim: VFO operation on VHF in the most inexpensive and easiest manner.

1. CIRCUIT DETAILS

The principle of this VFO accessory can be seen from the block diagram given in Fig. 1. The variable frequency from a SSB transmitter VFO is mixed in a balanced modulator with the fixed frequency of a crystal oscillator. This is followed by filtering out the frequency range of 24 - 24.5 MHz which is subsequently amplified. The VHF transmitter is equipped with a switch that allows the (8 MHz or 6 MHz) crystal to be disconnected and the control grid of the oscillator tube to be connected to a wideband preamplifier. This wideband amplifier increases the level of the auxiliary frequency so that it is sufficient to drive the oscillator tube into class C. The described circuit is based on a variable frequency oscillator of 5 - 5.5 MHz, as are used in SSB transmitters equipped with 9 MHz crystal filters. This means that the crystal oscillator must operate at 19 MHz in order to generate an output frequency of 24.0 - 24.5 MHz. Of course, other VFO frequencies as well as other crystal-controlled frequencies can be used.

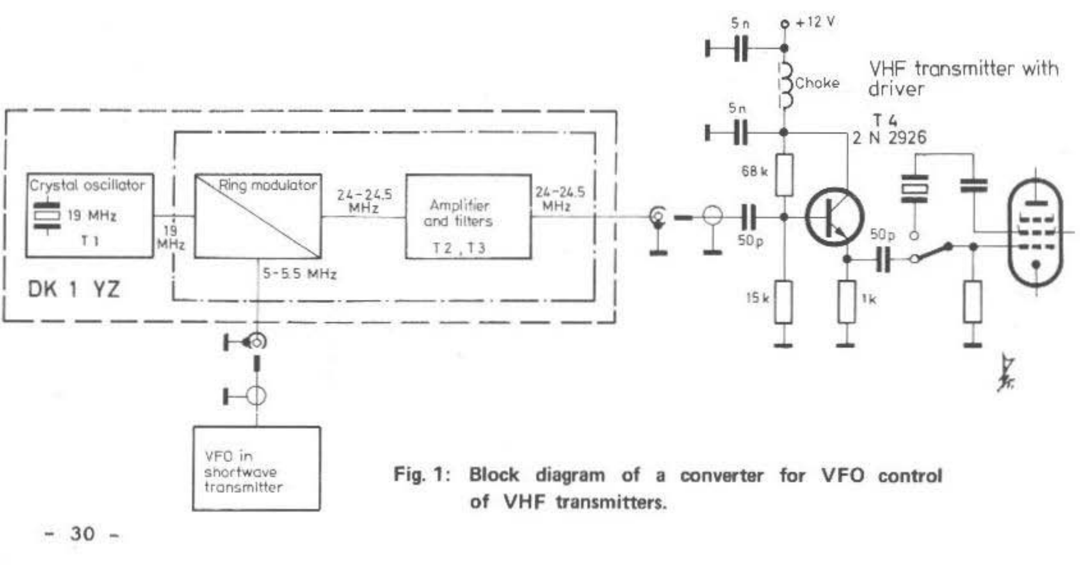


Fig. 1: Block diagram of a converter for VFO control of VHF transmitters.

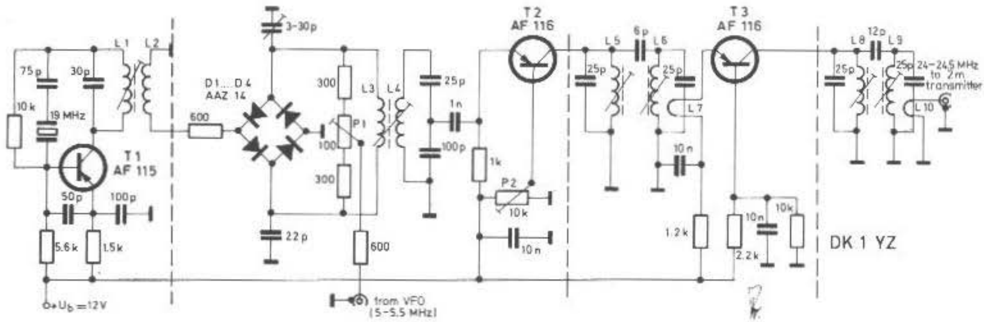


Fig. 2: Circuit diagram of the VFO converter

2. CONSTRUCTION

Fig. 2 shows the circuit diagram of the converter. The wideband amplifier stage in the VHF transmitter is no longer given in Fig. 2, because the dimensioning depends greatly on the transmitter used, and, in some cases, it may be possible for it to be deleted completely.

The printed circuit board DL 7 HR 001 is available from a previous publication. The crystal oscillator (T 1) of the original circuit was modified for 19 MHz and the bandpass filter of the amplifier stages (T 2, T 3) were dimensioned for a frequency range of 24.0 to 24.5 MHz. In the original description, the balanced mixer and the two-stage amplifier were accommodated on this board. The use of this PC-board is the reason why germanium transistors are used; on the other hand, there are no important technical reasons for using silicon transistors in this application.

The printed circuit board DL 7 HR 001 is given in Fig. 3, as is the corresponding component location plan. A photograph of the converter is given in Figures 4 and 5.

3. COMPONENTS

T 1: AF 115, AF 135, AF 106, 2 N 1502 A
T 2, T 3: AF 116, AF 137, AF 121, 2 N 370 or similar
T 4: 2 N 2926, BC 108 or similar
D 1 to D 4: AAZ 14 or 4 x OA 154 Q

All inductances are wound on 7 mm diameter coil formers with 6 mm core.

Wire: enamelled copper wire 0.5 mm diameter (24 AWG)

L 1: 12 turns	L 5, L 6, L 8, L 9 : 15 turns
L 2: 3 turns at the cold end of L 1	L 7: 3 turns at the cold end of L 6
L 3: 1 turn at the cold end of L 4	L 10: 3 turns at the cold end of L 9
L 4: 15 turns	

It may be necessary for the resonant circuits comprising inductances L 5, L 6, L 8 and L 9 to be damped with 10 kΩ resistors.

4. AVAILABLE PARTS

The printed circuit board DL 7 HR 001, the semiconductors, crystal, a partial kit and a complete kit are available from the publishers or their national representatives.

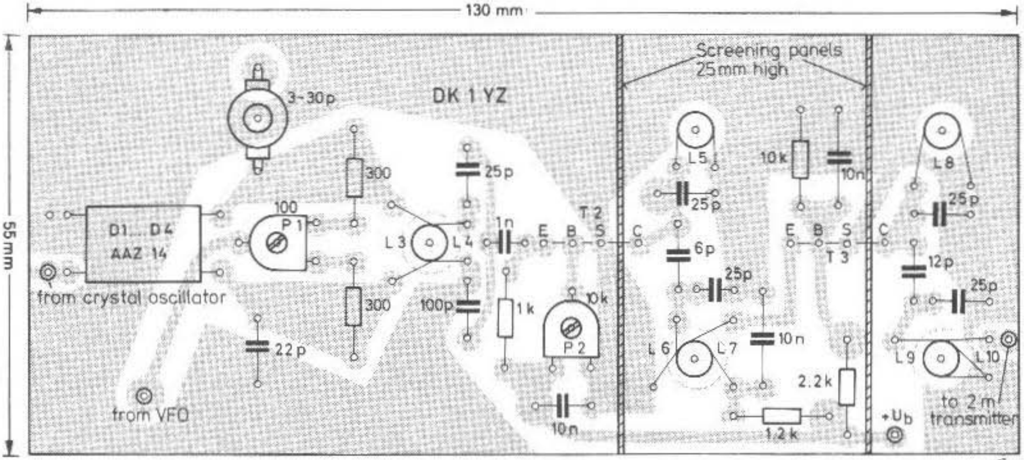


Fig. 3: Printed circuit board DL 7 HR 001 and component location plan

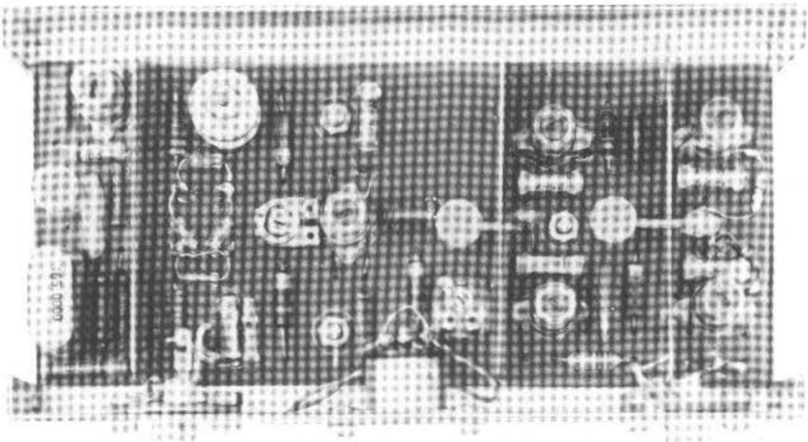


Fig. 4: VFO accessory with printed circuit board DL 7 HR 001 from above

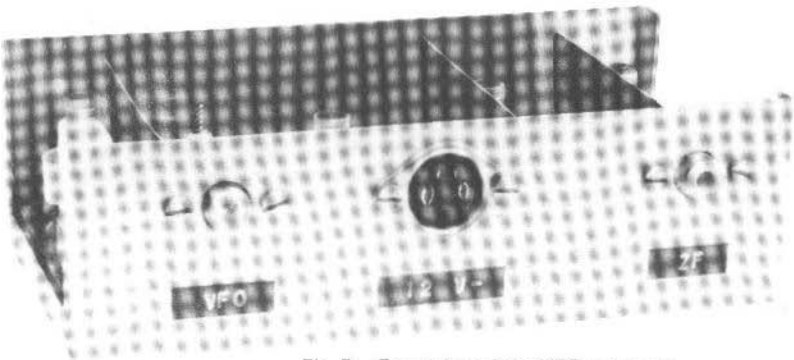


Fig. 5: Front view of the VFO accessory

A 70 cm TRANSMITTER WITH VXO EXCITER

by E. Berberich, DL 8 ZX

A 70 cm transmitter is to be described that is suitable for both AM and video transmissions. The exciter of this transmitter is based on a 27 MHz VXO similar to that described in (1). Such a VXO was found to be extremely favourable since, firstly, crystals in this frequency range are available inexpensively with spacings of 10 kHz and, secondly, because the frequency multiplication factor of 16 results in a wide frequency variation range. The block diagram given in Fig. 1 indicates the frequency processing and other details of the transmitter line up. The 2 metre band is avoided during the frequency multiplying process so that no spurious 2 metre signal is present when working duplex 2 m/70 cm or when operating in conjunction with a frequency translator (e.g. ARTOB or OSCAR 6). The last four stages are equipped with tubes; the power amplifier stage equipped with the EC 8020 is cathode-modulated. The four-stage transistorized modulator possesses wideband characteristics and can therefore be used for amateur television transmissions. The video signal is fed to the modulator via a 4.5 MHz lowpass filter. In the voice mode, the modulator is fed via a two stage preamplifier.

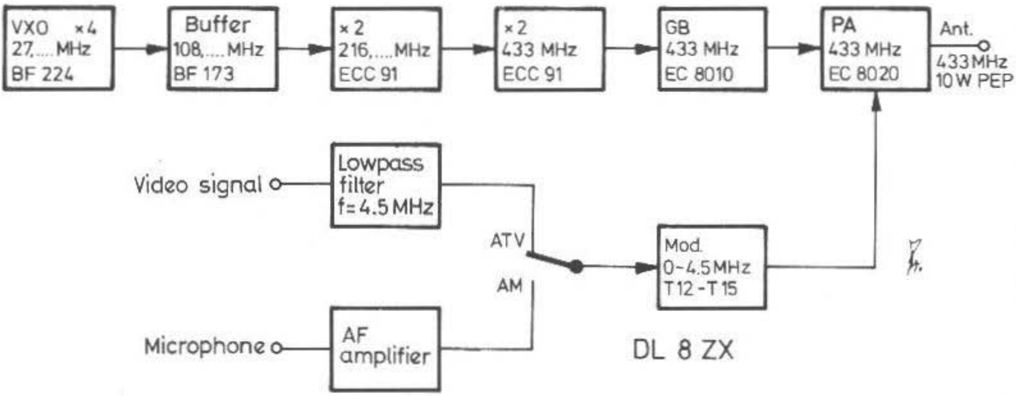


Fig. 1: Block diagram of the 70 cm transmitter for AM and television operation.

1. THE VXO EXCITER

Figure 2 shows the circuit diagram of the VXO exciter. The oscillator stage operates in a common-collector configuration at the crystal frequency. The switchable crystals and the frequency pulling reactance L 4/C 4 are to be found in the feedback link between the emitter of transistor T 1 and a tap on the 27 MHz resonant circuit comprising L 1, C 1 and C 2. The resonant collector circuit comprising L 2 and C 5 is tuned to a frequency of 108 MHz. Due to the large frequency spacing and the very low reactive capacitance of the transistor, practically no reaction on the base circuit can be observed when tuning the collector circuit.

The collector circuit forms a bandpass filter together with the base circuit of the following stage. The very low reactive transistor T 2 operates as a buffer. Approximately 250 mV are available at 108 MHz on the 60 Ω tap of the collector resonant circuit.

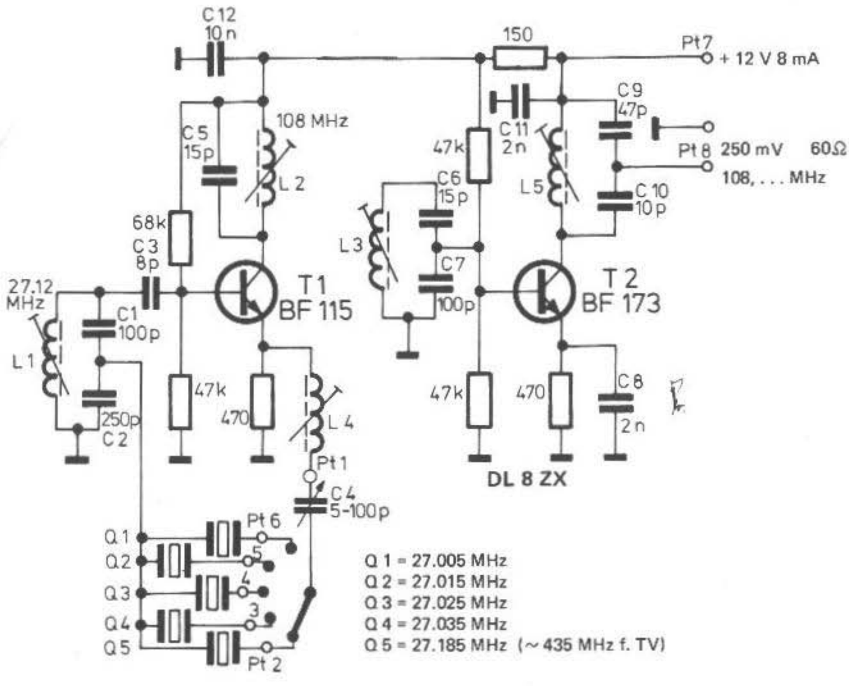


Fig. 2: Circuit diagram of the VXO exciter

This VXO circuit will also be suitable for operation on the 2 metre band if 29 MHz crystals are used and the resonant circuits dimensioned so that the 5th harmonic is selected. However, pulling range and output voltage will be lower.

Of course, diodes can be used instead of the switch for selecting the crystals. A suitable circuit was given in (2).

If a varactor diode (e.g. BA 124 or 1 N 5472 A) is used instead of the variable capacitor C 4, it is possible for the transmitter to be used in the FM mode as described in (3).

1.1. ASSEMBLY OF THE VXO EXCITER

The VXO exciter circuit given in Fig. 2 can be built up on a printed circuit board with the dimensions 70 mm x 40 mm. Figure 3 shows the printed circuit board DL 8 ZX 001 together with the component location plan. The printed circuit board can be enclosed in a metal casing as shown in Figure 4. The band-pass filter comprising inductances L 2 and L 3 is accommodated in a common screening can. Inductance L 1 is also screened. Further details of the construction can be seen in Figure 4.

The variable capacitor C 4 and the crystal switch should be connected using short straight wires to the connection points on the PC board.

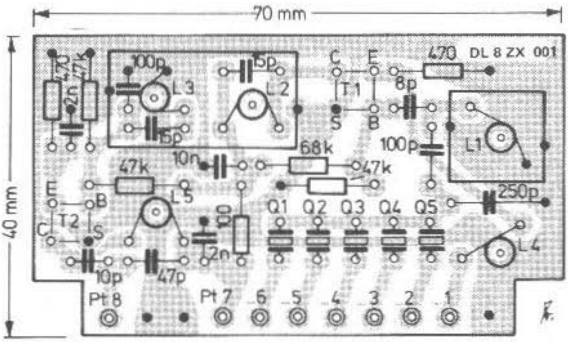


Fig. 3: Printed circuit board DL 8 ZX 001 of the VXO exciter

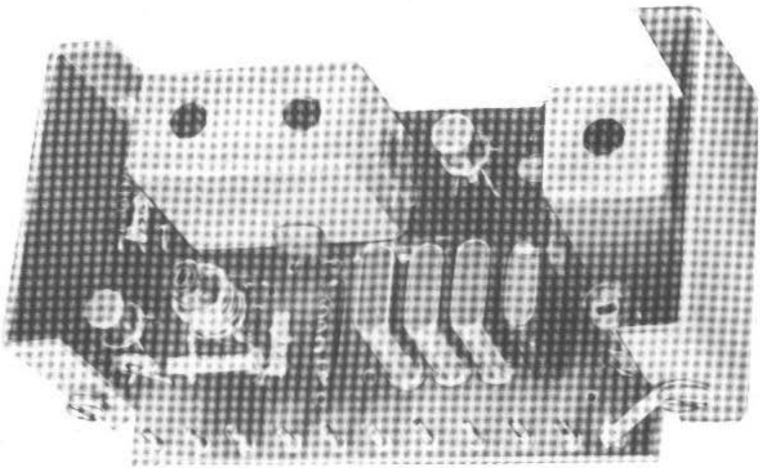


Fig. 4: Photograph of the VXO exciter

1.2. COMPONENTS

T 1: BF 115, BF 224, BF 173
T 2: BF 173, BF 224

L 1: 10 turns of 0.6 mm dia. (23 AWG) silk-covered copper wire on a 4.3 mm coil former with core. Screening can: 12.5 mm x 12.5 mm x 18.5 mm

L 2, L 3: 5 turns of 0.8 mm dia. (20 AWG) silver-plated copper wire wound onto coil formers as for L 1 with VHF core. Spacing between the centres of the 2 inductances: 12.5 mm
screening can: 25 mm x 12.5 mm x 18 mm

L 4: 15 turns of 0.25 mm dia. (30 AWG) silk-covered copper wire on a coil former and core as for L 1.

L 5: 6.5 turns, wire, coil former and core as for L 2

All crystals are HC-18/U types.

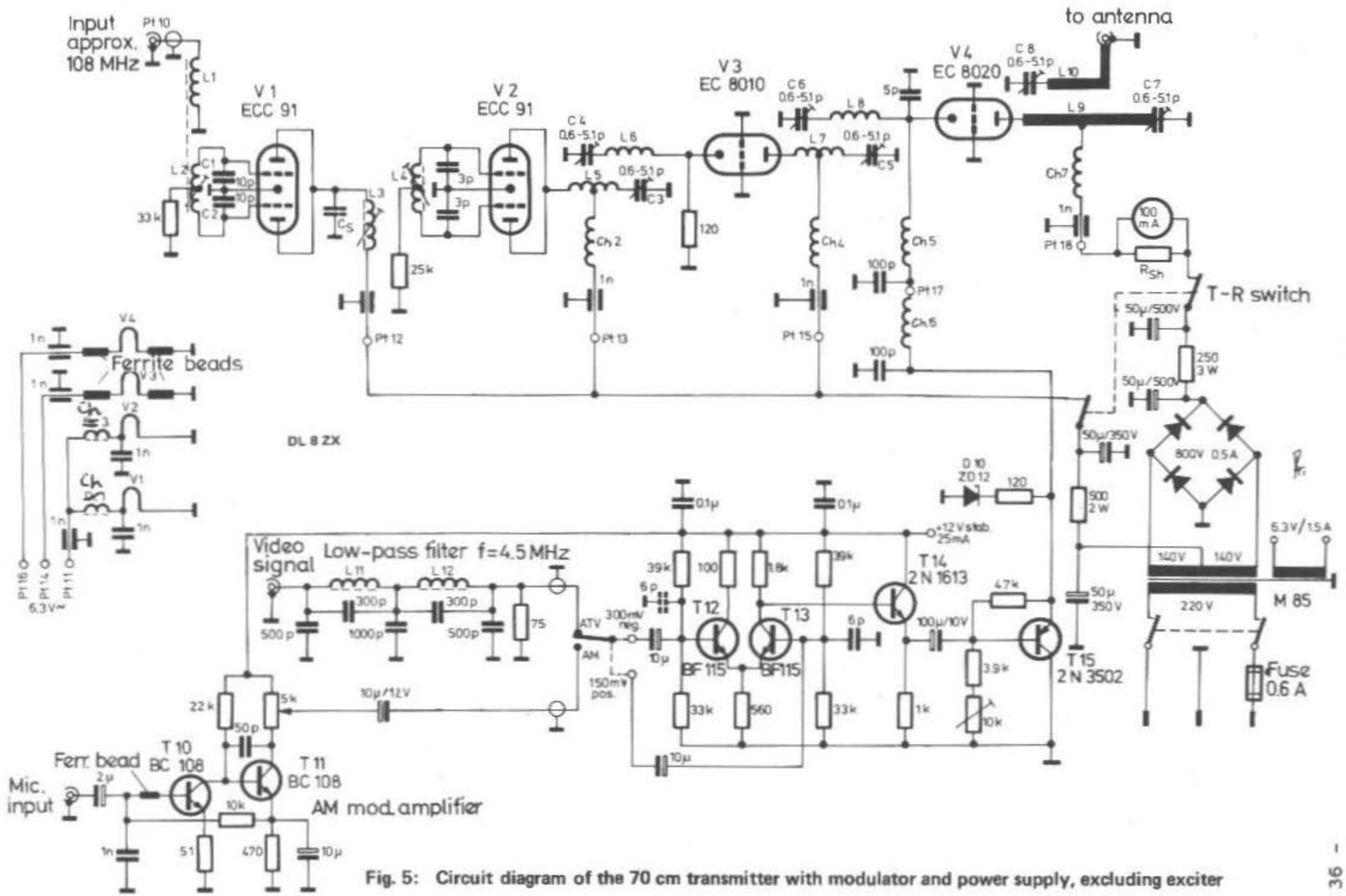


Fig. 5: Circuit diagram of the 70 cm transmitter with modulator and power supply, excluding exciter

1.3. ALIGNMENT OF THE VXO EXCITER

The inductances L 2 and L 3 are preliminary aligned in their unscreened condition to 108 MHz with the aid of a dipmeter. The cores should be inserted by approximately half. The operating voltage should be connected so that the transistor capacitances attain their operative values. After the preliminary alignment has been carried out, the screening can should be mounted into place. Inductance L 1 can now be preliminary aligned. The final alignment is made for maximum output voltage. The frequency variation range at 432 MHz amounts to approximately 100 kHz for each crystal. If the previously mentioned frequency modulation attachment is to be used, this can be adjusted by monitoring the signal on a VHF-FM receiver tuned to 108 MHz.

3. FREQUENCY MULTIPLIER, POWER AMPLIFIER, MODULATOR

Figure 5 shows the circuit diagram of the 70 cm transmitter with modulator and power supply. The 108 MHz signal from the exciter is fed to connection point Pt 10 from where it is fed to the two push-push doubler stages (V 1, V 2). These stages are fed in push-pull. The parallel-connected anodes, however, operate in push-push which means that frequency doubling occurs. The balance of this arrangement ensures that no uneven harmonics are generated. The subsequent driver and power amplifier stages are equipped with modern, high-gain triodes. A bandpass filter is provided between all stages; the cathode circuits of the last two stages are series resonant circuits comprising a coupling link and a trimmer capacitor.

The amplitude modulation is made by driving the transistor T 15 which represents the cathode resistor in this circuit. The operating point is adjusted with the aid of the base resistor.

The modulator transistor T 15 is fed via the driver transistor T 14 from a differential amplifier comprising transistors T 12 and T 13. If transistor T 12 is fed with the video signal, no phase reversal will take place, whereby when driving transistor T 13, a phase reversal (and 6 dB gain) will result. According to the polarity of the output voltage from the television camera, the TV/AM switch should be connected to either T 13 or T 12. The 6 pF capacitor for treble lift is soldered to the base of the non-driven transistor.

The power supply provides two DC voltages in addition to the heater voltage: approximately 300 V for the power amplifier stage and approximately 150 V for the frequency multiplier and driver stages. The rectifier arrangement operates as a bridge circuit for the 300 V supply, whereas the 150 V voltage is obtained in a push-pull rectifier circuit using the two diodes whose anodes are grounded. The transistorized stages and the VXO exciter are fed from a stabilized 12 V voltage source. A 12 V zener diode protects transistor T 15 from excess voltages.

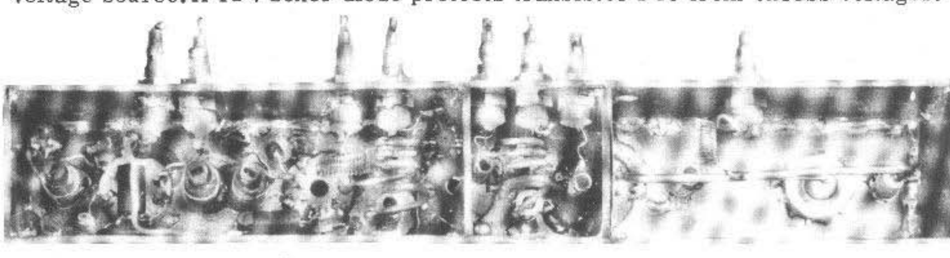


Fig. 7: Lower view of the 70 cm transmitter

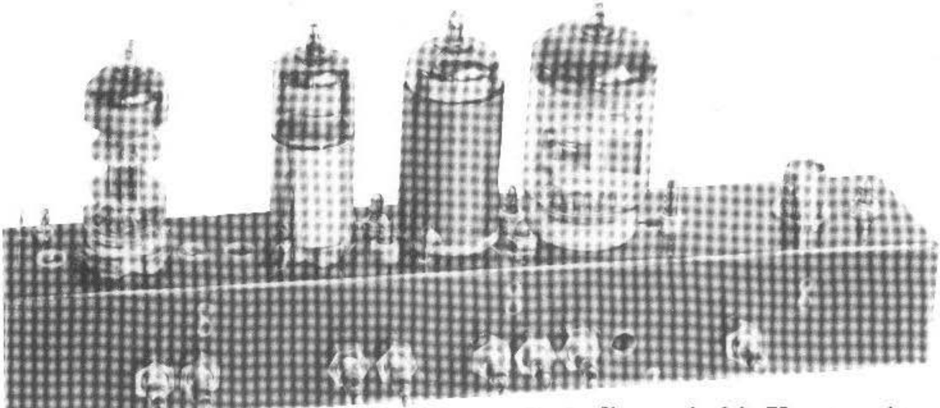


Fig. 6: Photograph of the 70 cm transmitter

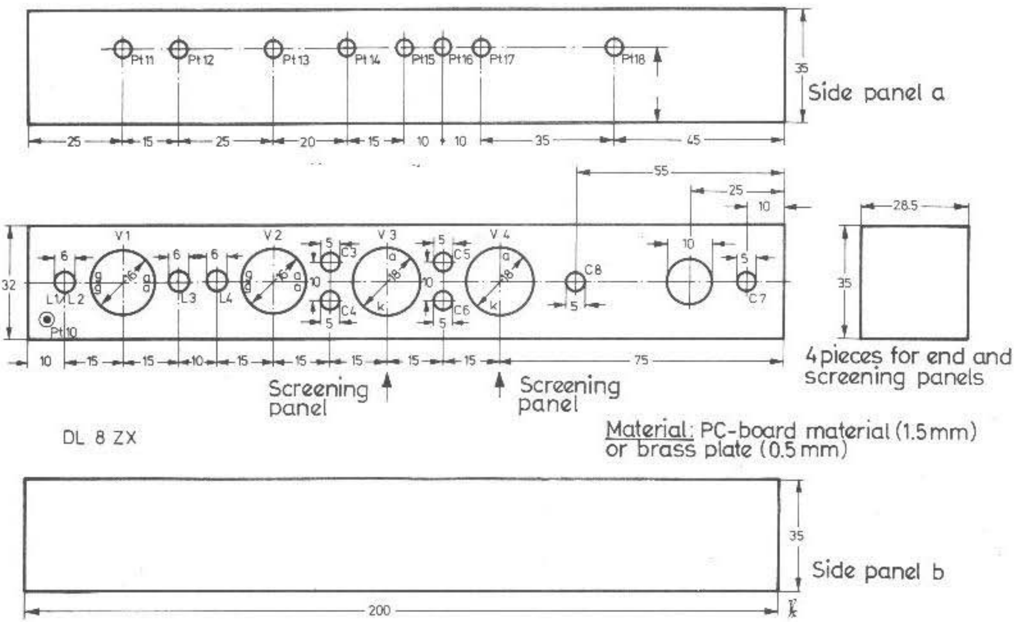


Fig. 8: Dimensional drawing of the 70 cm transmitter

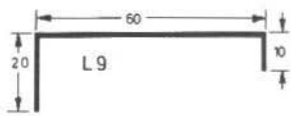
2.1. ASSEMBLY OF THE TRANSMITTER

The RF portion of the transmitter comprising the four tubed stages is built up on a chassis measuring 200 m long; 30 mm wide and 35 mm high. The chassis can be made out of brass plate or copper-coated PC-board material. The photographs Fig. 6 and 7 showing the author's prototype and the dimensional drawing given in Fig. 8, provide details as to construction. Screening panels are mounted across the tube bases of the two 433 MHz amplifier stages V 3 and V 4. All trimmer capacitors are aligned from above. All feed-through capacitors are located on one side. The inductances L 1/L 2, L 3 and L 4 are accommodated on coil formers; inductances L 5 to L 8 are self-supporting, L 9 and L 10 are resonant line circuits. The tube bases are mounted by soldering their cathode (V 1, V 2) or grid connections (V 3, V 4) to the ground surface and fixing with dual-component adhesive. Tubes V 2 and V 3 are provided with screening cans that are made out of thin tin or copper plate and connected by two short pieces of thick wire to the ground surface. The feed-through capacitors represent connection points Pt 11 to Pt 18. The modulator, lowpass filter and power supply are built up in a conventional manner and connected to these points. The wideband modulator should be well screened in order to avoid RF injection. Transistor T 15 should be provided with cooling fins.

2.2. SPECIAL COMPONENTS

V 1, V 2: ECC 91, 6 J 6; V 3: EC 8010; V 4: EC 8020;

T 10, T 11: BC 108, BC 183, 2 N 3903 or similar silicon AF types
T 12, T 13: BF 115 (possibly also BF 224, BF 173)
T 14 : 2 N 1613, 2 N 2219, BSY 84
T 15 : BC 160, 2 N 3502, 2 N 2905 A (silicon PNP, $I_{c\,max}$ = 0.6 A)
D 10 : ZD 12 or BZY 92/C 12 (12 V/1 W zener diode)
L 1: 2 turns of insulated copper wire wound onto L 2
L 2: 8 turns of 0.8 mm dia. (20 AWG) silver-plated copper wire wound onto a 6 mm dia. coil former, close wound, with VHF core.
L 3: 3 turns of 1.2 mm dia. (17 AWG) silver-plated copper wire wound onto a coil former with core as for L 2.
L 4: 4 turns with centre tap, otherwise as L 3
L 5: 3 turns of 1.2 mm dia. (17 AWG) silver-plated copper wire wound onto a 6 mm former, self-supporting
L 6: 1 turn of 0.8 mm dia. (20 AWG) insulated copper wire, same direction as L 5, spaced 3 mm from hot end.
L 7: as L 5
L 8: as L 6, in the same axis as L 7
L 9: 90 mm long piece of 1.2 mm (17 AWG) or thicker silver-plated copper wire, bent according to sketch.



L 10: Wire as for L 9, 30 mm long, spaced approx. 5 mm from L 9
L 11, L 12: 23 turns of 0.25 mm dia. (30 AWG) silk-covered copper wire close wound onto a 4.3 mm coil former with core.

Ch 1, Ch 3: Ferroxcube wideband chokes (Philips 4312 020 36701)
Ch 2, Ch 4 to Ch 7: $\lambda/4$ chokes of 0.5 mm dia. (24 AWG), 17 cm long, wound on a 5 mm former, close wound, self-supporting.
C 3 to C 8: 0.6 - 5.1 pF ceramic tubular trimmers (Philips 2222 802 96067)

3. AVAILABLE COMPONENTS

The P.C. board DL 8 ZX 001 and various components are available from the publishers or their national representatives. Please see advertising pages.

4. REFERENCES

(1) K.P. Timmann: Variable Frequency Crystal Oscillator (VXO)
VHF COMMUNICATIONS 1 (1969), Edition 2, Pages 87-94

(2) G. Laufs: A SSB-Transceiver with Silicon Transistor Complement
Part 2: The 9 MHz Transceiver
VHF COMMUNICATIONS 2 (1970), Edition 2, Pages 65-75

(3) E. Harmet: Narrow Band Frequency Modulation of
Overtone Crystal Oscillators
VHF COMMUNICATIONS 2 (1970), Edition 1, Pages 28-30

A SIMPLE METHOD OF MEASURING THE FREQUENCY DEVIATION

by C. Grey, VE 2 AQX

Whereas the method of measuring the modulation depth of amplitude modulation (AM) with the aid of an audio generator and an oscilloscope is well known by most amateurs, a simple method of measuring the frequency deviation of frequency modulation (FM) is virtually unknown. For this reason, such a method is most certainly of great interest to VHF-UHF amateurs since FM is gaining popularity, especially on the UHF bands.

1. FREQUENCY MODULATION

The radiated RF energy remains constant in the FM mode whereas the frequency is varied in step with the modulating audio frequency. At a modulating frequency of 1 kHz, the transmitted frequency varies around the mean frequency (unmodulated carrier frequency) 1000 times per second to the value of the frequency deviation.

The frequency spectrum of an FM signal modulated with a sinusoidal frequency can be described in a similar way to AM as a carrier frequency and side (band) frequencies. The spacing of the side frequencies to another corresponds to the modulating frequency. Theoretically speaking an infinite number of side frequencies are generated; the less that are transmitted, the higher will be the distortion of the modulating frequency. For high-quality FM transmissions, the bandwidth must be large enough that all side frequencies are transmitted at a minimum of 1% of the amplitude. For voice transmissions, it is sufficient when side frequencies of more than 10% of the unmodulated carrier frequency amplitude are radiated (1% of the power) (1). The following relationship is valid for the required bandwidth B in kHz:

$$B = 2 \times (D + f_{mod})$$

whereby: D is the maximum frequency deviation in kHz and
f_{mod} is the highest modulating frequency in kHz.

The sum of all power levels of all side frequencies and the carrier frequency is the constant transmit power level. The amplitude of each individual side frequency as well as that of the carrier frequency is dependent on the modulation index M. The dependence can be shown graphically as Bessel functions as illustrated in Figure 1. The amplitude of the carrier frequency and the first 26 side frequencies can be read off as a function of the modulation index M.

Without modulation (M = 0), the carrier frequency possesses the full amplitude 1 whereas all side frequencies have the amplitude 0. On modulating with M = 1, the amplitude of the carrier frequency will fall to approximately 0.77; the first side frequency obtains a value of 0.45, the second 0.11 etc. It can be seen that the carrier frequency amplitude passes zero for the first time at M = 2.4. Alternately the zero passes of the carrier frequency amplitude correspond to modulation indices of 2.4, 5.5, 8.7 etc. The frequency deviation can be calculated from the modulation index and the known modulating frequency f_{mod} in the following manner:

$$D = M \times f_{mod} \quad (\text{with } D \text{ and } f_{mod} \text{ in kHz})$$

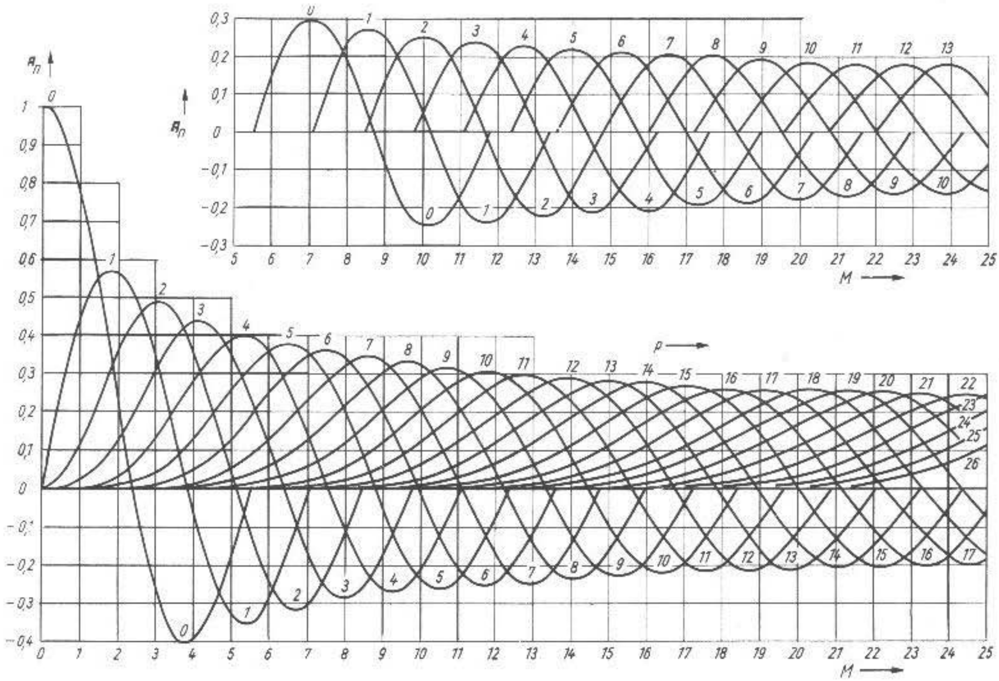


Fig. 1: Graph of the Bessel functions for determining the amplitude A of carrier and side frequencies as a function of the modulation index M

2. FREQUENCY DEVIATION MEASUREMENT

Practically speaking, the frequency deviation measurement is not as complicated as it may seem from the fundamental considerations of the previous section. The simplest method is to modulate the transmitter with f_{mod} = 1 kHz. A very narrow band receiver, tuned firstly to the carrier frequency, will indicate an amplitude minimum when the modulation index is M = 2.4 and thus the frequency deviation is 2.4 kHz. On increasing the frequency deviation further, a second amplitude minimum will be observed when M = 5.5 or D = 5.5 kHz is obtained.

The simplest method of making the measurement is to use a receiver equipped with a CW filter; the S meter can be used for indicating the signal amplitude. The author used an FM receiver which was equipped with a Q multiplier connected to the IF amplifier. Of course, the Q multiplier was well screened to avoid RF injection. By increasing the degree of feedback to just before the oscillation threshold, the bandwidth is so narrow that practically only the carrier frequency is passed. A valve voltmeter (VTVM) with RF-probe or an oscilloscope can be used for indication. No calibration is necessary. It is only important that the frequency of transmitter and receiver are stable enough that the carrier frequency remains within the pass band of the CW filter or Q multiplier. In addition to this, the receiver must have such a narrow bandwidth to ensure that the side frequencies are not evaluated in the indication. If only an SSB receiver is available (B = 2.4 kHz), the modulation frequency can be increased, for instance, to 2.5 kHz. At M = 2.4, D will be 6 kHz and at M = 5.5, D will be 13.75 kHz.

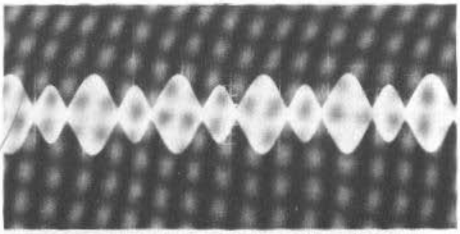


Fig. 2: Output voltage of the Q multiplier at the first zero pass of the carrier. Modulating frequency 1 kHz, time scale uncalibrated

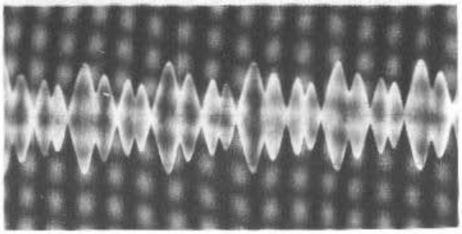


Fig. 3: Secondzero pass

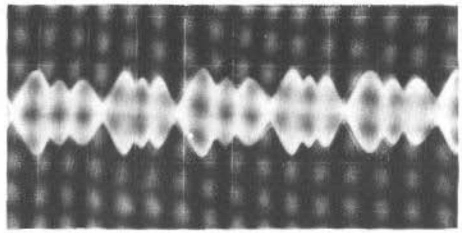


Fig. 4: Third zero pass, X-deflection increased by factor 2

Figures 2, 3 and 4 show the photographed oscilloscope traces of the Q multiplier output voltage at the first, second and third zero pass of the carrier signal. Practically, this can be carrier out by slowly increasing the low-distortion modulating voltage from zero and measuring the input voltage of the modulator at each zero pass. If the appropriate frequency deviation is drawn graphically as a function of the audio voltage input to the modulator, it is possible for the frequency deviation corresponding to a given audio voltage to be read off directly. If a variable, calibrated audio generator is available, the frequency deviation can be determined without calculation with the aid of the graph given in Fig. 5. More accurate and more extensive values are given in the table which lists those modulating frequencies by which the first and second zero pass of the carrier voltage will occur for the various frequency deviation values.

First zero pass (M = 2.4048)		Second zero pass (M = 5.5201)	
Frequency dev. in kHz	AF signal in Hz	Frequency dev. in kHz	AF signal in Hz
1	416	5	907
2	831	10	1815
3	1247	15	2718
4	1663	20	3625
5	2079	25	4530
6	2494	30	5430
7	2911	35	6340
8	3326	40	7250
9	3742	45	8160
10	4158	50	9070
15	6237	55	9975
20	8316	60	10880
25	10395	65	11780
30	12480	70	12690
35	14550	75	13590

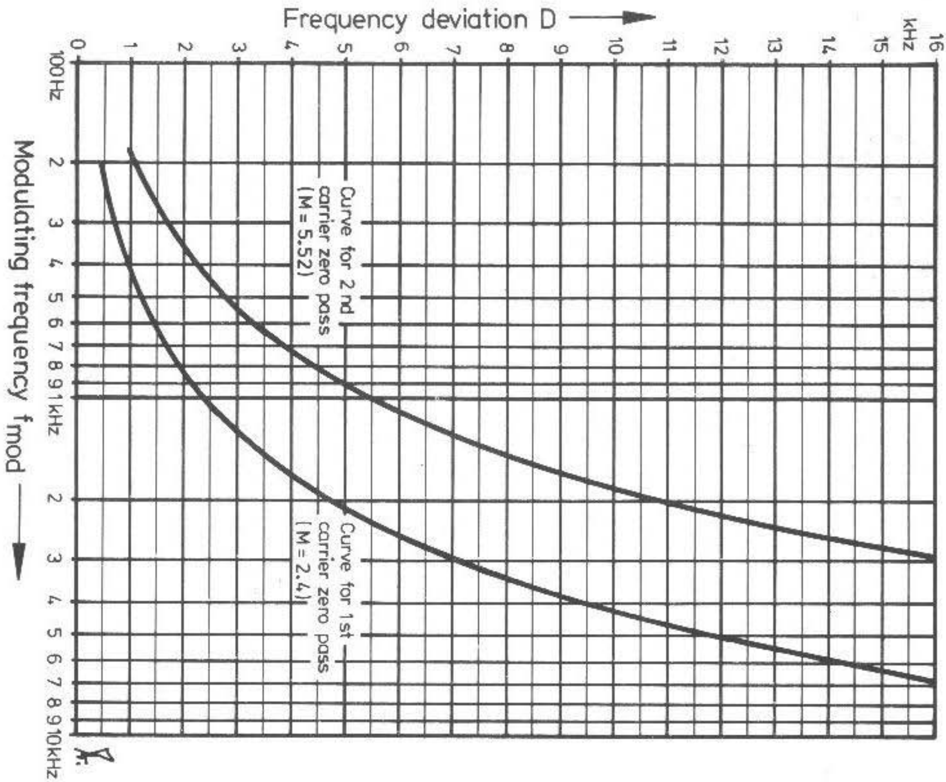


Fig. 5: Frequency deviation D as a function of the modulating frequency f_{mod} at the first and second zero pass of the carrier frequency

3. REFERENCES

(1) H. Koch: Transistorsender
Franzis Verlag, Munich, 1969, Frequency modulation section

(2) D. E. Schmitzer: Is Frequency Modulation Advantageous on the VHF-UHF Bands ?
VHF COMMUNICATIONS 2 (1970), Edition 1, Pages 21-24

VHF CONGRESS WEINHEIM (W. GERMANY) 1971

We would like to point out that the annual VHF Congress is once again taking place in Weinheim, near Heidelberg/W. Germany. This year the conference is to be held on the 18th and 19th of September. It offers continuous lectures by outstanding European VHF/UHF/SHF amateurs as well as facilities for discussion groups on diverse topics appertaining to amateur radio at the higher frequencies. We extend a cordial welcome to all VHF/UHF amateurs.

SUMMER HOLIDAY

The Publishers and the Material Sales Department will be taking their summer holiday during the month of August 1971. Since we are not able to dispatch orders or answer queries in this period, some delays could be encountered in receiving your orders or answers. If you require items within this period, please order them well before hand.

A SYNTHESIS VFO FOR 144-146 MHz OR 135-137 MHz

by G. Bergmann, DJ 7 JX and M. Streibel, DJ 5 HD

INTRODUCTION

The following article is to describe a variable frequency oscillator whose frequency is generated according to the frequency synthesis principle by mixing a variable oscillator frequency with that of a crystal oscillator. The block diagram given in Fig. 1 shows the frequency processing and the stages of the synthesis VFO, which consists of two modules. One module comprises the variable frequency oscillator of 11 to 13 MHz and a buffer stage. The other module consists of the crystal oscillator (66.5 or 62.0 MHz), a frequency doubler stage (133 or 124 MHz), the push-pull mixer stage and an amplifier stage tuned to the required output frequency range of 144 to 146 MHz or 135 to 137 MHz. A phase reversal stage previous to the mixer and a voltage stabilizer for the power supply of the variable frequency oscillator complete the second module.

The main consideration during the construction of this synthesis oscillator was that variable frequency oscillators possess a sufficiently high degree of frequency stability up to a frequency of approx. 12 MHz without having to provide extensive measures to achieve this aim. Due to the frequency conversion with a crystal-controlled frequency, the frequency stability remains practically the same at the output frequency. However, it is necessary for the crystal and image frequency to be suppressed by resonant circuits or filters and for the most favourable dynamic characteristic to be chosen so that the conversion products falling within the frequency range of interest are kept as low as possible. With the described oscillator, the combination frequency formed from the fourth harmonic of the crystal frequency (266 MHz) and the tenth harmonic of the variable frequency (110 - 130 MHz) is the lowest ordinal number falling within the 2 metre band. This did not cause any interference in the author's case. According to measurements made by the authors, the auxiliary frequency of 133 MHz is suppressed by more than 60 dB.

The synthesis VFO requires an operating voltage of 12 V. An RF voltage of approx. 0.4 V at an impedance of 50 Ω is available at the output. This means that it is suitable for feeding a straight-through, amplitude-modulated transmitter, for example, equipped with the following stages: BF 224 - 2 N 918 - 2 N 3866 - 2 N 3553. Fig. 2 shows the circuit diagram of such a transmitter as an example. The previously described transmitters DJ 1 NB 004 (1) and DL 3 WR 003 (2) can also be used in a similar manner if the initial stages are modified to 145 MHz.

With an output frequency of 135 to 137 MHz this synthesis VFO allows the two mixer stages of a SSB transmit-receive converter 9 MHz-145 MHz to be driven. Fig. 3 shows a block diagram of such a configuration. This means that this synthesis VFO can be used together with the SSB transmitter and receiver modules DJ 9 ZR 001 (3), DJ 9 ZR 003, DJ 9 ZR 005 (4) and DJ 9 ZR 006 (5).

1. CIRCUIT DETAILS

Fig. 4 shows the circuit diagram of the actual VFO module. The variable oscillator (T 101) is provided with a stabilized operating voltage of 8.5 V.

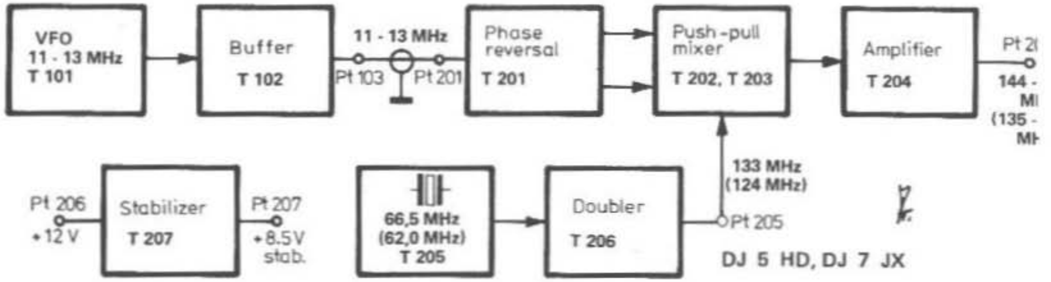


Fig. 1: Block diagram of the synthesis VFO for 144–146 MHz or 135–137 MHz

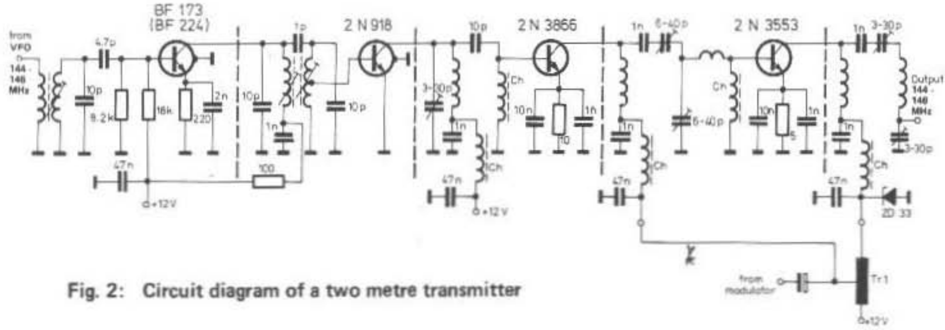


Fig. 2: Circuit diagram of a two metre transmitter

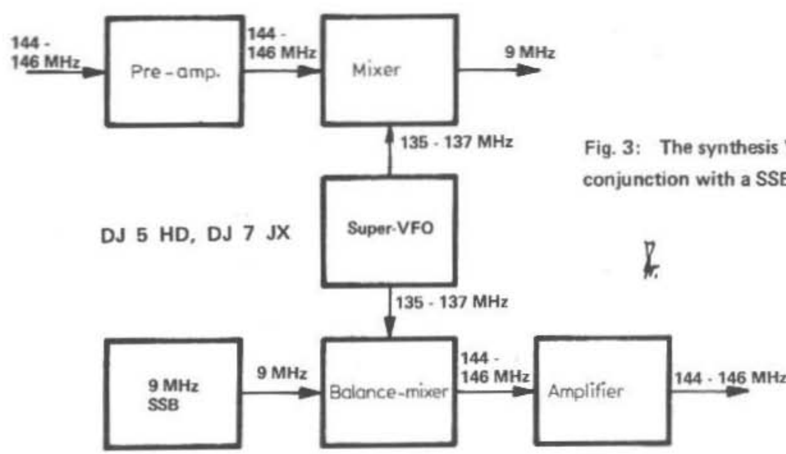


Fig. 3: The synthesis VFO in conjunction with a SSB transceiver

The feedback is made via a capacitive tapping on the resonant circuit so that no tapping points need to be soldered on to the coil. The frequency-determining components are dimensioned so that a reserve of approx. 100 kHz is available at each band limit. Since home-made inductances hardly ever possess a reproduceable temperature coefficient, it is not possible for TC compensation to be made. It is, however, favourable for all frequency-determining capacitors to have a TC value of approximately zero (black point).

With the given dimensioning, the output voltage of the oscillator module has a very low harmonic content, which simplifies the subsequent suppression of spurious waves considerably. The buffer stage equipped with transistor T 102 is only loosely coupled to the oscillator via capacitor C 110 and is not equipped with a resonant circuit. The buffer stage is provided with the full operating voltage of 12 V. The output signal of the VFO is available at connection point Pt 103 at low impedance (approx. 25 Ω).

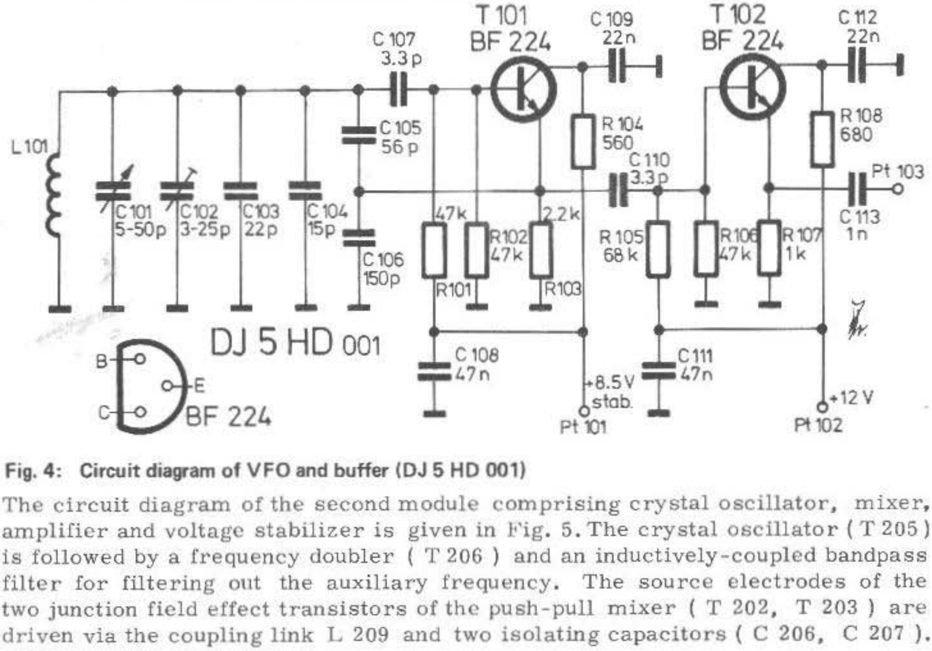


Fig. 4: Circuit diagram of VFO and buffer (DJ 5 HD 001)

The circuit diagram of the second module comprising crystal oscillator, mixer, amplifier and voltage stabilizer is given in Fig. 5. The crystal oscillator (T 205) is followed by a frequency doubler (T 206) and an inductively-coupled bandpass filter for filtering out the auxiliary frequency. The source electrodes of the two junction field effect transistors of the push-pull mixer (T 202, T 203) are driven via the coupling link L 209 and two isolating capacitors (C 206, C 207). This is made in push-push.

The variable frequency signal is fed from connection point Pt 201 to a phase reversal stage equipped with the field effect transistor T 201. At the source connection of this transistor, the signal is in phase with the input signal, at the drain connection, however, the phase is shifted by 180°. Since the two resistors R 202 and R 203 are equally great, both gate electrodes of the mixer stage will receive the same amount of signal in push-pull. The trimmer potentiometer P 201 in the source circuit of the mixer stage is used to balance the operating points. The push-pull drain circuit possesses two trimmer capacitors which allow the resonant circuit to be balançed. Together with the resonant circuit comprising L 202 and C 211, the push-pull drain circuit forms a bandpass filter tuned to the output frequency of 144 to 146 MHz or 135 to 137 MHz.

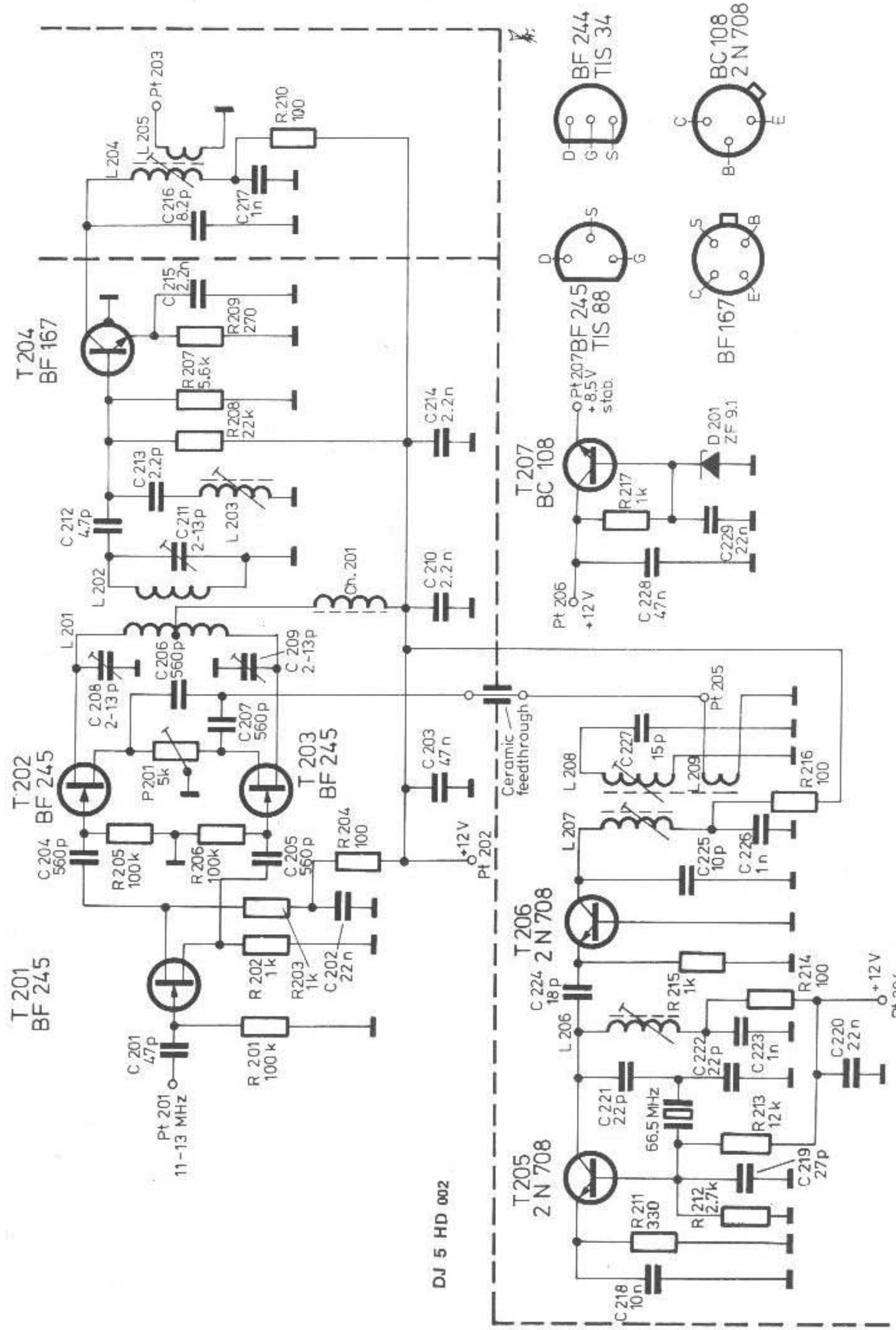


Fig. 5: Circuit diagram of crystal oscillator, mixer, amplifier and voltage stabilizer (DJ 5 HD 002)

The subsequent amplifier stage with transistor T 204 is a straight-through amplifier which means that a transistor with a very low reactive capacitance is required. At the base of this transistor, an absorption circuit (L 203/C 213) is provided which is tuned to the auxiliary frequency of 133 MHz or 124 MHz. This suppresses the auxiliary frequency in addition to the other measures by an additional 15 dB. The output coupling link L 205 provides a RF voltage of approximately 0.4 V measured at an impedance of 50 Ω at output Pt 203. The resonant circuits are coupled and tuned so that the output voltage remains approximately constant over the whole frequency range of interest.

2. MEASURED VALUES

Several prototypes of the described synthesis VFO were measured by the authors with respect to their frequency stability and suppression of the auxiliary frequency. The following values represent mean values resulting from measurements on several oscillators. 15 minutes after switching on, the frequency drift amounts to approximately 50 Hz/5 min. In continuous operation, a long-term drift of maximum 200 Hz/hour was determined 16 hours after switching on. Data obtained over a period of 3 hours after switching on is shown in Fig. 6.

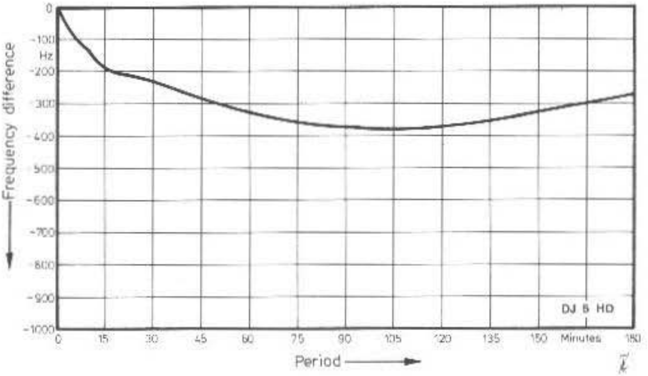


Fig. 6: Measured frequency drift of the VFO

A value of more than 60 dB was measured for the suppression of the auxiliary frequency of 133 MHz when referred to the output frequency of 145 MHz. Without cover, the auxiliary frequency suppression was only 50 dB, with cover but without the previously mentioned absorption circuit it amounted to 45 dB. Without cover and without absorption circuit, the auxiliary frequency is only 33 dB weaker than the required frequency.

When altering the operating voltage by ± 1 V, a frequency variation of ± 10 Hz resulted.

3. CONSTRUCTION

As already mentioned, the synthesis VFO consists of two modules which are shown in the photograph given in Fig. 7. The VFO module with vernier drive is shown to the left, the crystal oscillator and mixer module to the right. The covers of both modules were removed for the photograph.

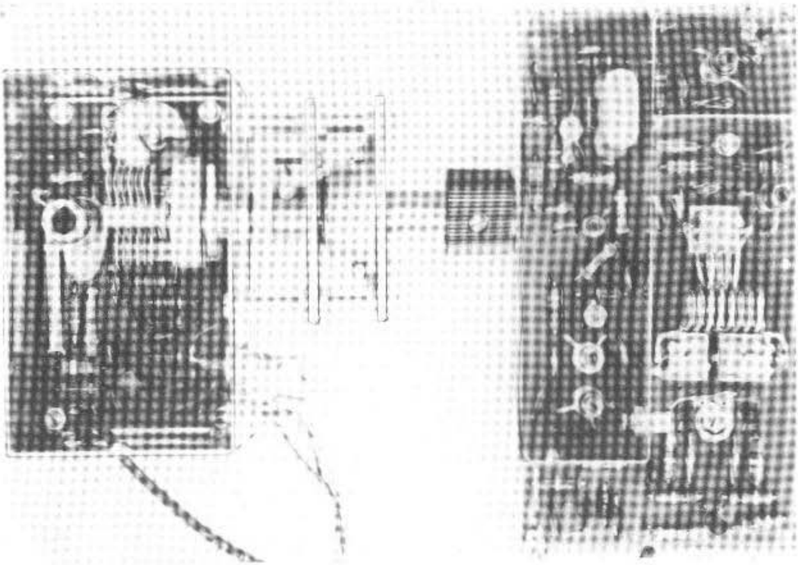


Fig. 7: Photograph of the complete synthesis VFO

3.1. MODULE DJ 5 HD 001

The printed circuit board for the variable frequency oscillator and buffer stage has been designated DJ 5 HD 001. This PC-board with its corresponding component location plan is shown in Fig. 8. The dimensions of this printed circuit board are 78 mm x 45 mm. The photograph and drawings given in Fig. 9 and 10 allow further details of the construction to be seen. An already available variable capacitor was used with single-sided support of the shaft. However, a capacitor having bearings on both sides would be more suitable. The authors found that the mechanical connection to the vernier drive, however, allowed sufficient stability.

In another prototype of the VFO, an inexpensive FM-broadcast capacitor of 2 x 15 pF was used and the two stators joined together. Due to the different capacitance values, it was necessary to vary some component values in the VFO. These are given in section 3.1.1. in brackets. The stability of this variable capacitor with built-in 3 : 1 vernier was found to be very good. However, an external vernier is most certainly required in addition.

As can be seen in the photographs, the variable capacitor is mounted on the printed circuit board DJ 5 HD 001 with the aid of a small bracket. This means that it is possible to accommodate it in a 45 mm high casing. It should be noted, that the thicker the metal walls of the casing, the lower will be the dependence on short-term temperature variations. The two operating voltages are fed into the casing via feed-through capacitors of 4.7 nF, the RF voltage is fed to the second module using a short piece of coaxial cable.

3.1.1. SPECIAL COMPONENTS FOR DJ 5 HD 001

T 101, T 102: BF 224 (Texas Instruments Germany)

L 101: 1.6 μH = 16.75 turns of 0.6 mm dia. (23 AWG) silk-covered, enamelled copper wire on a ceramic coil former of 9 mm dia., close wound, glued into place, hardened and aged. Without core. (2.9 μH = 27.5 turns).

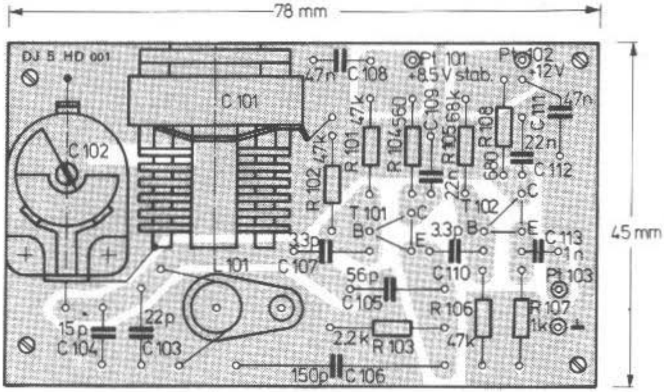


Fig. 8: Printed circuit board DJ 5 HD 001

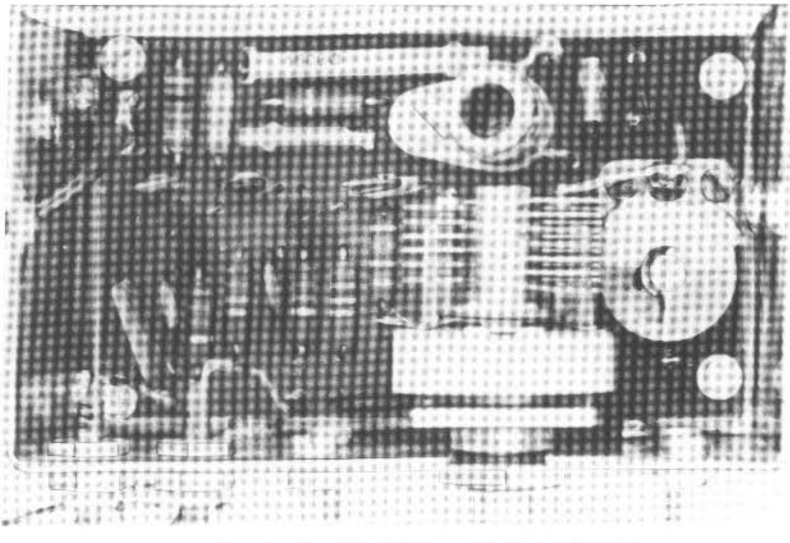
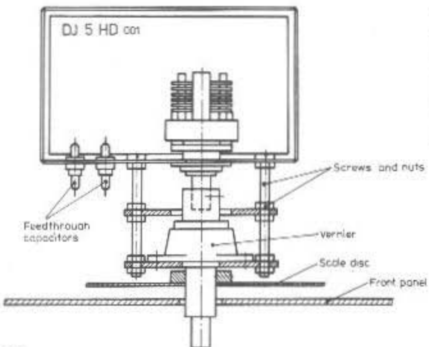


Fig. 9: Photograph of the VFO module (DJ 5 HD 001)



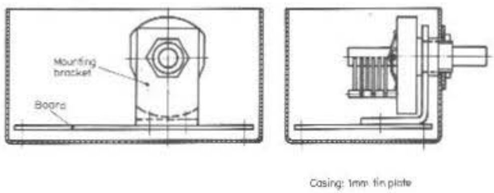


Fig. 10: Vernier drive of the variable capacitor

C 101: 5 - 50 pF air-spaced variable capacitor, e.g. Philips capacitor
2222 804 15007. (2 x 3 - 15 pF connected in parallel)
C 102: 3 - 25 pF air-spaced trimmer (the same with other variable capacitor)
C 103: 22 pF, TCO (not required with the other variable capacitor)
C 104: 15 pF, TCO (not required with the other variable capacitor)
C 105: 56 pF, TCO (33 pF)
C 106: 150 pF, TCO (100 pF)
C 107: 3.3 pF, TCO (likewise)

A spacing of 12.5 mm is provided on the printed circuit board for the resistors.

3.2. MODULE DJ 5 HD 002

All components of the crystal oscillator mixer module are accommodated on the printed circuit board DJ 5 HD 002. The dimensions of this printed circuit board, which is shown with its associated component location plan in Fig. 11, are 125 mm x 65 mm. The construction of the mixer output filter requires a short description: Inductances L 201 and L 202 are soldered to the printed circuit board with relatively long connections. In this manner, they can be self-supported beside trimmer capacitors C 208, C 209 as well as C 211 above choke Ch 201. A piece of wire is soldered exactly to the centre of inductance L 201 which is then soldered to the corresponding point on the printed circuit board. Fig. 12 shows the construction in the form of a drawing. Further details can be taken from Figures 13 and 14.

Philips spindle trimmers can be used instead of the trimmers used by the authors (which are available from the publishers) as long as the spindles are shortened by 4 mm at both ends and additional holes are drilled into the printed circuit board for the spindles.

Screening plates on the component side screen the three circuits: crystal oscillator with frequency doubler stage, input circuit, mixer and amplifier stages from another. The dimensions of these plates are also given in Fig. 12. The edges of the plates are soldered together and joined to the ground surface of the PC-board by small pieces of wire. A ceramic feed-through is provided in the longest screening plate, via which the auxiliary signal is fed from connection point Pt 205 to the mixer stage. Capacitors C 206 and C 207 are connected between this feed-through and their positions on the PC-board.

The cover shown in Fig. 15, containing holes for the alignment, completes the screening measures necessary for the spurious frequency suppression. Short tapped bushings which have been soldered to the screening walls are used for mounting the cover.

The resonant circuit with inductances L 204, L 207 and L 208 are preliminary aligned using a dipmeter before T 204 or T 206 are soldered into place.

3.2.1. SPECIAL COMPONENTS FOR DJ 5 HD 002

T 201, T 202, T 203: BF 245, BF 244 (TIS 88, 2 N 5245)
T 204: BF 167 (AEG-Tfk)
T 205, T 206: 2 N 708 or similar
T 207: BC 108, 2 N 3704 or similar silicon NPN transistor
D 201: ZF 9.1 (ITT-Intermetall), BZY 85/C9V1 (AEG-Tfk) or 1 N 4103

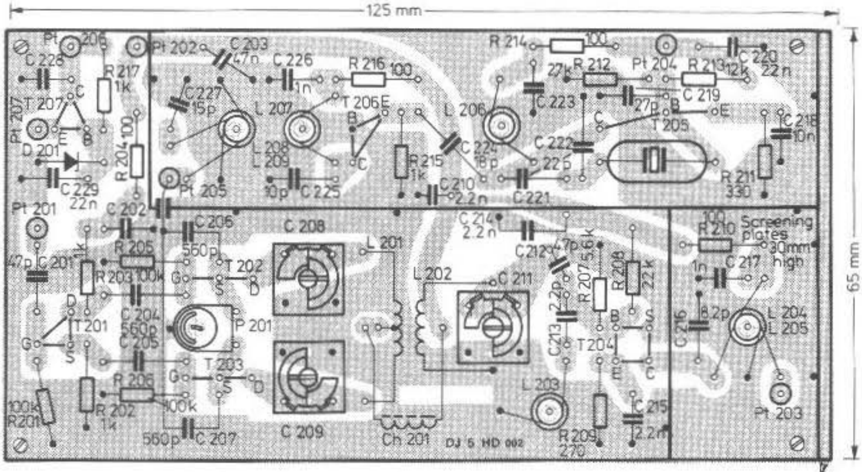


Fig. 11: Printed circuit board DJ 5 HD 002

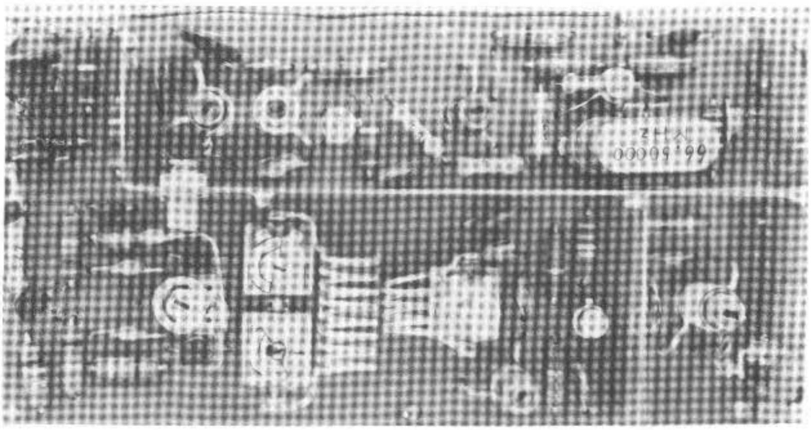


Fig. 13: Photograph of module DJ 5 HD 002

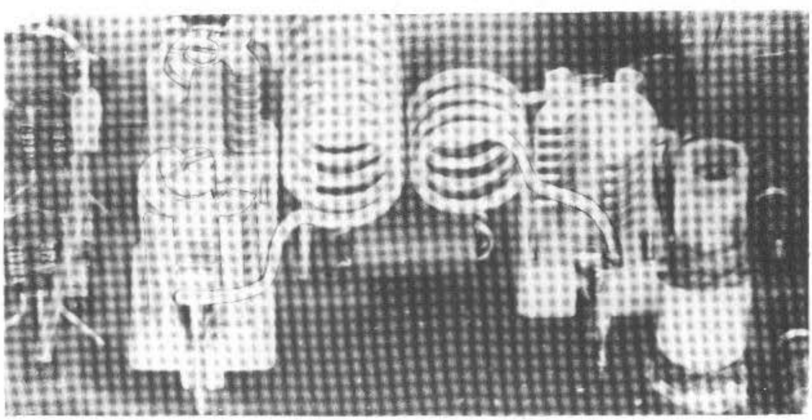


Fig. 14: Enlargement of the mixer output filter

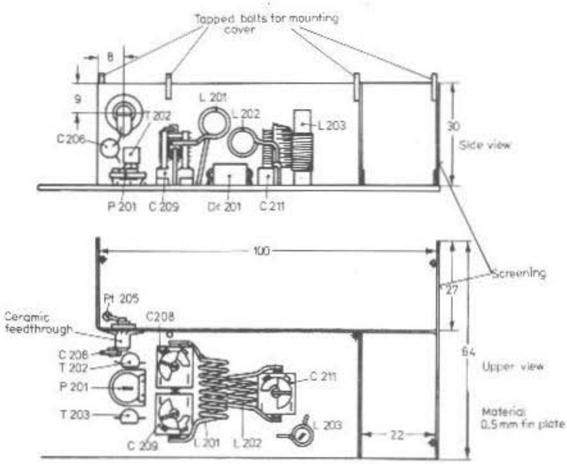


Fig. 12: Construction of the mixer output filter

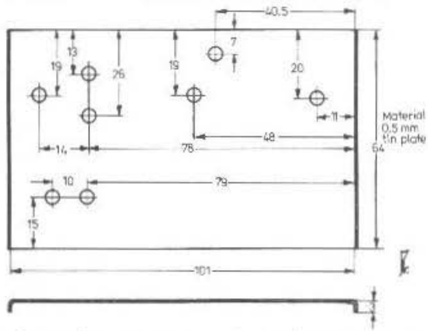


Fig. 15: Cover of module DJ 5 HD 002

When not otherwise stated, all inductances are made from 1 mm diameter (18 AWG) silver-plated copper wire.

L 201: 8 turns on a 7 mm former, centre tap, coil length 20 mm, self-supporting
L 202: 4 turns on a 7 mm former, coil length 11 mm, self-supporting
L 203: 11.75 turns of 0.6 mm dia. (23 AWG) silk-covered enamelled copper wire close wound on a 5 mm diameter coil former, coil length 25 mm, with VHF core
L 204: 6.5 turns, coil length 15 mm, on coil former with core as for L 203
L 205: 2 turns of 0.5 mm diameter (24 AWG) insulated wire at the cold end of L 204, ends twisted together and fed to the PC-board
L 206: 8.5 turns of 0.6 mm dia. (23 AWG) silk-covered enamelled copper wire close wound onto a coil former and core as for L 203
L 207: 5.75 turns onto a coil former with core as for L 203, coil length 11 mm
L 208: 5.25 turns onto a coil former with core as for L 203, coil length 11 mm
L 209: 2 turns of 0.5 mm diameter (24 AWG) insulated copper wire wound on the cold end of L 208, ends twisted together and fed to the PC-board

With inductances L 203, L 204, L 206, L 207 and L 208, the hot end of the coil is located near the PC-board.

A spacing of 12.5 mm has been provided for the resistors on the PC-board.

Ch 201: wideband ferrox choke (Philips 4312 020 36701)
P 201: 5 kΩ linear trimmer resistor for 10/5 mm spacing
Crystal: 66.5 MHz or 62.0 MHz in HC-6/U holder
C 208, C 209, C 211: 2 - 13 pF air spaced trimmer

4. ALIGNMENT OF THE SYNTHESIS VFO

Besides aligning the required frequency range, the variable oscillator module DJ 5 HD 001 does not require any further alignment. A dipmeter is sufficient for coarse alignment. The final alignment of the frequency range is made last, in conjunction with the complete synthesis VFO using a calibrated 2-metre receiver. The variable oscillator is not in operation during the alignment of module DJ 5 HD 002.

For the alignment of module DJ 5 HD 002, only the crystal oscillator is firstly brought into operation. This is done by connecting an operating voltage of 12 V to connection point Pt 204. The frequency of the crystal oscillator (66.5 MHz or 62.0 MHz) is checked with the aid of a dip-meter. After this, the operating voltage is also connected to connection point Pt 202. In order to align the auxiliary frequency bandpass filter with inductances L 207 and L 208, the RF probe of a valve voltmeter (VTVM) should be connected to connection point Pt 205 (ceramic feed-through). After aligning the inductances for maximum reading, a value of approximately 1 V should result.

For the following alignment of the mixer stage, the crystal oscillator is switched off by disconnecting the operating voltage from point Pt 204. The wiper of the balance potentiometer P 201 should firstly be brought to its centre position. Connection Pt 202 remains connected to the operating voltage because when operating in conjunction with field effect transistors, loaded resonant circuits can only be aligned when the FETs are in operation.

The primary circuit (L 201, C 208, C 209) is aligned to the desired band centre frequency with the dip-meter; both trimmers should exhibit the same value. The operating voltage is removed from Pt 202 for the alignment of the secondary circuit (L 202, C 211). This circuit is now aligned with the aid of the dip-meter to the band centre (145 MHz or 136 MHz).

The DC values at the source connections of transistors T 202 and T 203 should be equal. If the wiper of potentiometer P 201 must be varied greatly from its centre position, this will indicate that the transistors differ greatly from another. This will mean that one or the other should be changed from another transistor of the same type.

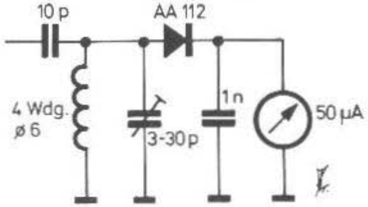


Fig. 16: Tuning aid

For the final balancing of the mixer stage to achieve the highest possible attenuation of the auxiliary frequency, a provisional tuning aid is built up as shown in Fig. 16. The resonant circuit of the tuning aid should be tuned for maximum reading at the resonant circuit L 208/C 227. The ground of the tuning aid should be connected to the PC-board ground near to the output Pt 203. The 10 pF capacitor is now placed on the hot end of inductance L 204. The balancing potentiometer P 201 and the absorption circuit with inductance L 203 should be aligned for minimum reading on the tuning aid. In spite of the low reading, the minimum can be easily seen.

5. INTERCONNECTION OF THE MODULES

After the two modules have been connected together according to Fig. 17, the tuning range can be set with the aid of a calibrated receiver. After this, the probe of an RF voltmeter is connected to connection point Pt 203 and 50 Ω resistor connected between Pt 203 and ground. In this condition, the secondary circuit of the mixer bandpass-filter is aligned with C 211 and the output circuit with L 204 in such a manner that a practically equal voltage is achieved over the whole frequency range of interest. The resistor should be removed after this. A coaxial cable can now be connected between the module DJ 5 HD 002 and the transmitter.

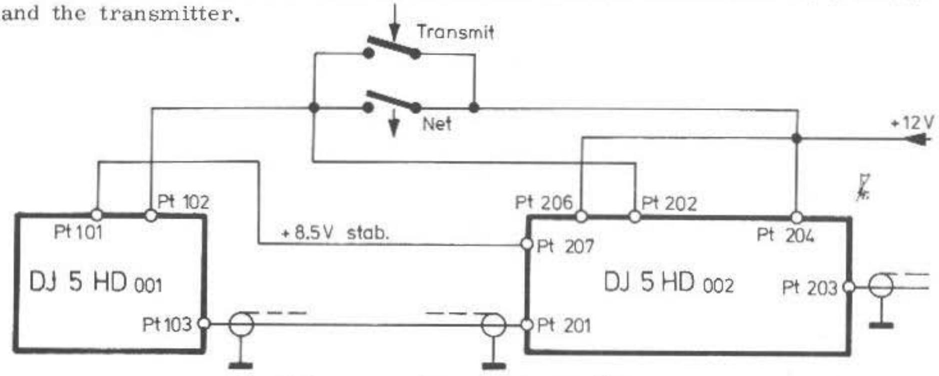


Fig. 17: Interconnection of the two modules

For test purposes, it should be mentioned that module DJ 5 HD 001 provides a voltage of approximately 0.5 V to the gate connections of the mixer transistors T 202 and T 203.

As can be seen in Fig. 17, both oscillators are continuously connected to the operating voltage via Pt 204 and Pt 206. In the CW mode, the variable oscillator should be keyed and not the crystal oscillator. In order to do this, the connection between Pt 207 and Pt 101 should be disconnected and fed to the key. To net onto the frequency and to transmit, the whole synthesis VFO receives a voltage via a contact on the transmit-receive switch.

6. AVAILABLE PARTS

The printed circuit boards and various components for the described synthesis VFO are available from the publishers or their national representatives. See advertising page.

7. REFERENCES

(1) E. Flügel: The Two Metre Transmitter UTS 5 with 2 Watts Mean Output at 12 V
VHF COMMUNICATIONS 1 (1969), Edition 3, Pages 179-187

(2) R. Lentz: A Universal VHF-UHF Transmitter for AM and FM
VHF COMMUNICATIONS 2 (1970), Edition 2, Pages 87-102

(3) K. P. Timmann: A 5 Watt Transistorized SSB Transmitter for 145 MHz
VHF COMMUNICATIONS 1 (1969), Edition 2, Pages 73-82

(4) K. P. Timmann: A 9 MHz IF-AF Portion using Integrated Circuits
VHF COMMUNICATIONS 1 (1969), Edition 3, Pages 136-150

(5) K. P. Timmann: A 144 MHz/9 MHz Receive Converter using Printed Inductances
VHF COMMUNICATIONS 1 (1969), Edition 3, Pages 129-135

TWO CIRCUITS FOR AUTOMATIC BAND SCANNING

Part 2: Automatic band scanner with stop device
and frequency indication

by E. G. Hoffschildt, DL 9 FX

INTRODUCTION

After the description of a simple band scanner in (1) this second part describes a more sophisticated band scanner, equipped with an automatic stop device which allows the scanning process to be interrupted for a short period of time to enable a station to be identified. It is also equipped with a frequency indication meter which allows the approximate frequency to be read off.

1. AUTOMATIC BAND SCANNER WITH STOP DEVICE AND FREQUENCY INDICATION

Fig. 1 shows a photograph of this versatile automatic band scanner. The mode switch, tuning potentiometers and the frequency indication meter will, if the band scanner is to be installed in a receiver, be mounted on the front panel. The control panel and the band scanner circuit have been combined here for demonstration purposes.

1.1. CIRCUIT DETAILS

Of course, the circuitry is more complicated if the automatic band scanner is to stop for a short period for identification of the received station. The circuit diagram of such a configuration is given in Fig. 2. The transistors T 1 and T 2 together with the associated components, form the astable multivibrator circuit in the same amnner as for the simple band scanner circuit. The discharge of capacitor C 2, however, does not only occur via resistor R 2, but also passes via the transistor T 3 in the discharge circuit. If this transistor is blocked, the charge of capacitor C 2 will remain at this value; the voltage at the base of transistor T 2 therefore remains constant. Since this voltage also controls the varactor diode D 1, the capacitance will not be altered and the scanning process will be stopped. The discharge process of C 2, and thus the scanning of the oscillator is continued again when transistor T 3 conducts.

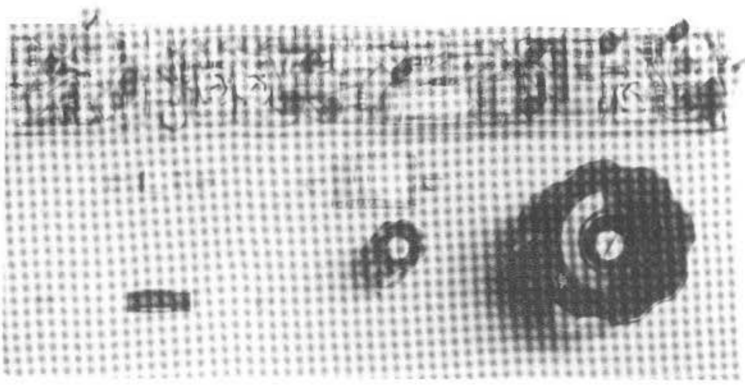


Fig. 1

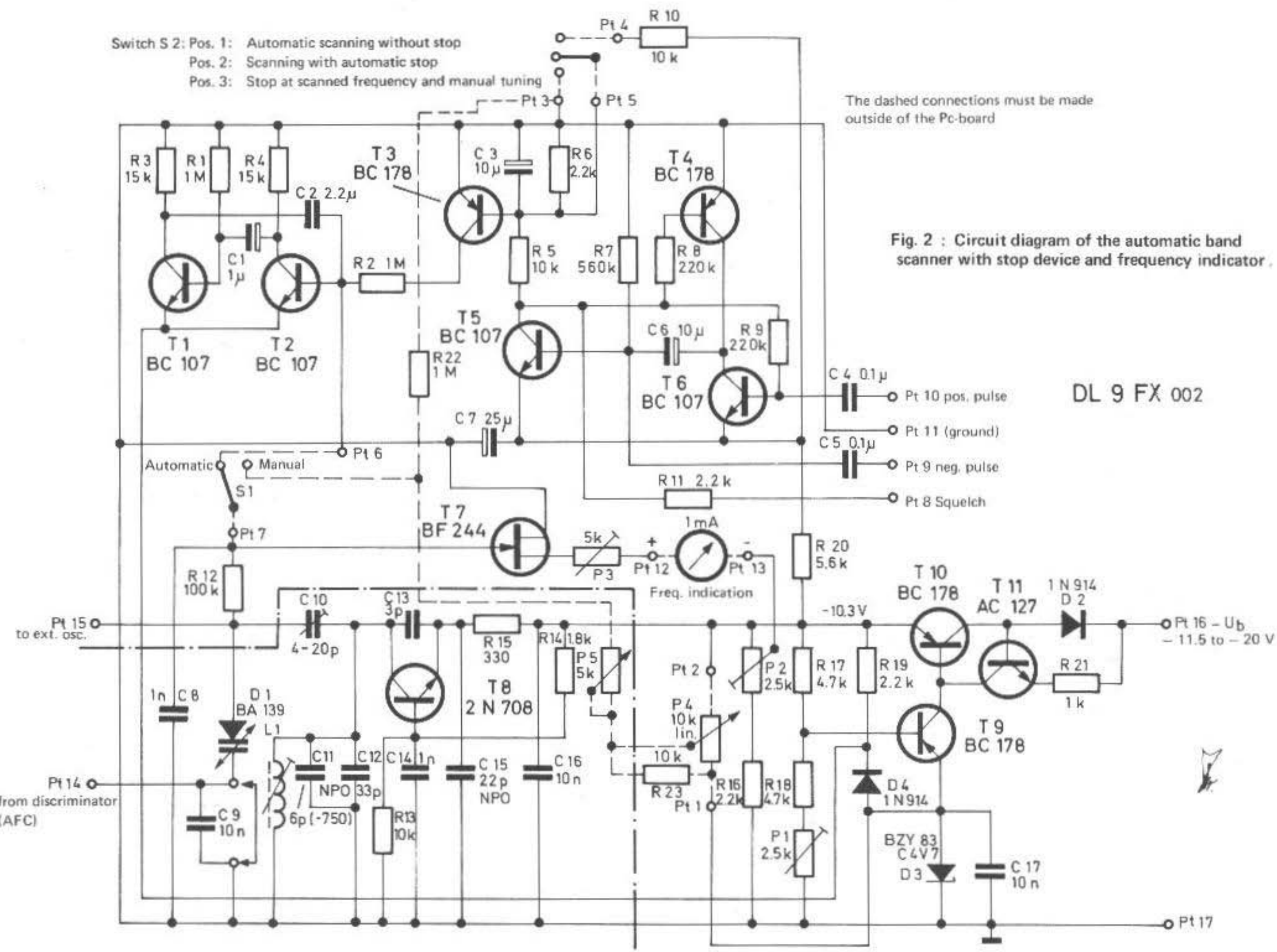


Fig. 2 : Circuit diagram of the automatic band scanner with stop device and frequency indicator.

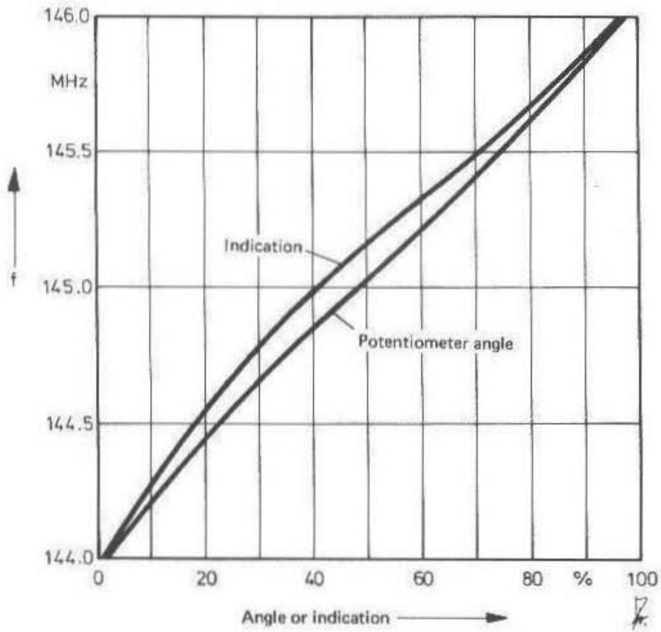


Fig. 3: Scale response of the meter as function of the angle

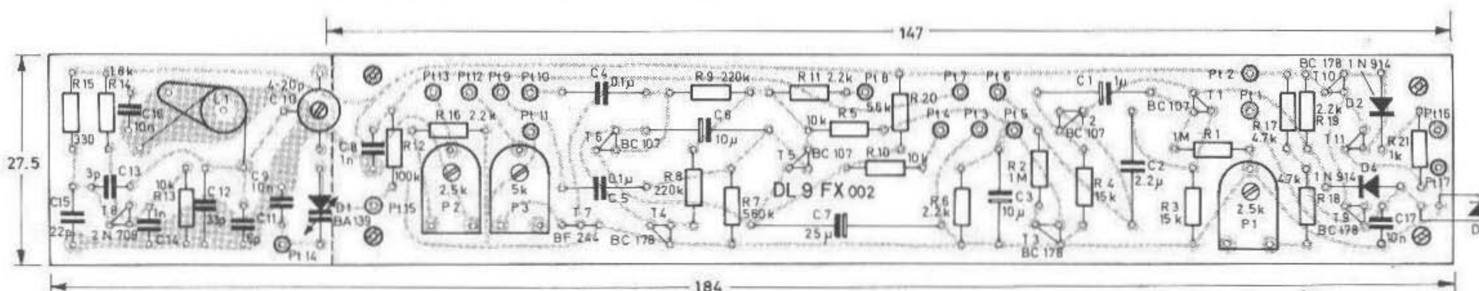


Fig. 4: Component location plan and Printed circuit board DL 9 FX 002 for the automatic band scanner with frequency indication and stop device

The blocking of T 3 is made using a monostable circuit (sometimes called monoflop) comprising transistors T 4, T 5, T 6 and the associated capacitors and resistors. Transistor T 5 conducts in its rest position since it receives the required base current via the base resistor T 7; T 6 is blocked since its base is connected to emitter potential via T 9 and T 5. If a positive pulse is fed to the base of transistor T 6, this will cause the transistor to conduct, whereby the pulse is fed via the coupling capacitor C 6 in opposite phase to the base of T 5. The previously conducting transistor T 5 is blocked by this which is also the case with transistor T 3 because this transistor no longer receives any base current. This means that the discharge of capacitor C 2 is ceased, and the band scanning process is stopped. The stop time is determined by the values of resistor R 7 and capacitor C 6; as with the multivibrator it amounts to:

$$t \approx 0.7 \times R\,7 \times C\,6$$

The stop-pulse is taken from the control voltage of the receiver; if this is positive, it must be fed to the base of transistor T 6, whereas a negative pulse can directly block transistor T 5. Of course, it is possible to use the AF voltage of the receiver instead of the AGC voltage. However, attention should be paid that the AF level is not too great since the receiver noise could, under certein circumstances, cause the automatic scanner to stop. It is favourable to provide a potentiometer with which the threshold value can be varied. It is possible in this manner to vary the threshold so that weak stations do not actuate the stopping process; for instance, when the receiver should only be actuated by local stations. Transistor T 4 ensures that the charging of C 6 occurs quickly so that the monoflop is actuated even by closely spaced stations.

The described circuit also allows a squelch effect to be obtained during the scanning process. This is made by connecting the collector of transistor T 5 via the decoupling resistor R 11 and an isolating capacitor to a high impedance point in the AF amplifier. The audio amplifier stage is then loaded by R 11. The load is increased on stopping the automatic scanning, and the AF level will be increased. The optimum dimensioning of the isolation capacitor as well as the most favourable position in the audio amplifier must be found by trial and error; it is not possible to offer any hard and fast rules since every audio amplifier is dimensioned differently. The AF level should, in any case, not be too great, otherwise correct operation of the circuit will not be possible.

During the scanning process, the frequency will be indicated on a meter. It is possible for the S-meter to be used for this. The control is made via the field effect transistor T 7 whose high input impedance ensures that no reaction occurs onto the circuit. The indication allows the frequency of the station stopping the automatic band scanner to be established and to be selected with the manual tuning if required. The stop time can be increased by blocking transistor T 3 manually. The maximum stop time depends on the leakage resistance of the components connected to capacitor C 2. Transistors T 2, T 3, varactor diode D 1 and the input of T 7 should therefore exhibit large blocking resistances. If one of these four semiconductors is too low or capacitor C 2 has a poor isolation resistance.

The manual tuning is made in a similar manner to the simple circuit using potentiometer P 4. The fine tuning can be made with P 5.

In order to achieve the most linear scale marking, the wiper of the tuning potentiometer P 4 should be loaded with 10 kΩ. Fig. 3 shows the frequency run and the scale response of the meter as a function of the rotation angle of potentiometer P 4.

The operating voltage is maintained at a very constant value of 10.3 V using a special stabilizer circuit so that fluctuations of the operating voltage have virtually no effect on the frequency. The circuit, by the way, must be fed with a negative voltage; the plus pole is connected to ground (Pt 11, Pt 17).

In order to ensure that the scanning process is not stopped on the skirt of the passband curve, a stop delay is provided by capacitor C 3. The capacitance value of C 3 is essentially dependent on the bandwidth of the receiver; large bandwidths require larger capacitance values; whereas low capacitance values are sufficient at narrow bandwidths. The most favourable value differs from case to case and should be found by experiment.

Although the sweep voltage is not linear, the scanning speed of the search oscillator is virtually constant since the non-linearities of the varactor diode characteristic and the sawtooth signal are opposite to another. This is the only reason why the circuit does not require a tuning discriminator (AFC). It has been found in pracitce that signals at both band limits can be tuned equally well, and do not require different delay times. If, however, a discriminator is available, it is possible for it to be used if the search oscillator is correspondingly dimensioned. Connection point Pt 14 is provided for this purpose.

The oscillator (T 8) is built up in a similar manner to the simple band scanner. If this oscillator is not required, the oscillator portion of the board can be separated from the rest of the circuit at the marked position. The printed circuit board (Fig. 4) of this automatic band scanner is designated DL 9 FX 002. It is 27.5 mm wide and the length is 147 mm without the oscillator portion. The associated component location plan is also given in Fig. 4.

2. SPECIAL COMPONENTS FOR DL 9 FX 002

T 1, T 2, T 5, T 6:	BC 107, BC 108, BC 183, 2 N 2926, 2 N 3903 or similar silicon NPN types
T 3, T 4, T 9, T 10:	BC 178, BC 213, 2 N 3905 or similar silicon PNP types
T 7	: BF 244 (2 N 5284), BF 245 or similar N-channel junction FET
T 8	:2 N 708, 2 N 918, BF 224, BF 173, BF 115 or similar
T 11	:AC 127, AC 186, AC 175, AC 187 K, 2 N 4105 (germanium-NPN)

D 1: BA 139, BA 121, BA 110, 1 N 5462 a (Mot.) (approx. 16 pF at 2 V)
D 2, D 4: 1 N 914 (or any silicon diode)
D 3 : 1 N 750, BZY 85/C4V7, ZF 4,7 (4.7 V zener diode)

L 1: 3.25 turns of 1 mm diameter (18 AWG) silver-plated copper wire wound onto a 7 mm diameter coil former with VHF core.

C 10: 6 - 30 pF ceramic micro disc trimmer

3. ALIGNMENT OF THE AUTOMATIC BAND SCANNER DL 9 FX 002

The alignment of the circuit is made in the following manner:
The stabilized voltage is firstly adjusted to approximately twice the value of the zener voltage. In the "manual tuning" mode, potentiometer P 4 should be adjusted to that stop which is connected to connection point Pt 2. If a fine tuning potentiometer (P 5) is provided, this should be in its centre position. The upper frequency limit is now aligned using the core of inductance L 1. After this, the tuning potentiometer P 4 is brought to the opposite stop and the lower frequency limit aligned with trimmer capacitor C 10. These two alignment processes should be corrected repeatedly until the required frequency range is achieved. In order to align the frequency indication, potentiometer P 2 should be aligned at the highest frequency for a small deflection of approx. 0.1 mA. After this, potentiometer P 3 should be adjusted at the lowest frequency to full scale deflection.

If a manual tuning is not necessary, potentiometer P 4 will not be required. The alignment is then made in a similar manner observing signals at the band limits.

4. AVAILABLE PARTS

The printed circuit boards, semiconductors, coil formers, trimmer capacitors and kits are available from the publishers or their national representatives. Please see advertising page.

5. REFERENCES

(1) E. G. Hoffschildt: Two circuits for Automatic Bandscanning
Part 1: A simple band scanner
VHF COMMUNICATIONS 2 (1970), Edition 4, Pages 245-248

INDEX TO VOLUME 2 (1970) OF VHF COMMUNICATIONS

All copies of Volume 1 (1969) and Volume 2 (1970) are still available. The price of a complete Volume is DM 12,-- (surface mail) or DM 4,-- for individual copies.

Price List of new equipment described in VHF COMMUNICATIONS 1/1971 and miscellaneous items
For earlier equipment, see price list in edition 4/1970

DJ 4 BG 006	Speech Processor		
PC-board	DJ 4 BG 006 (with printed plan)	DM	7,--
Semiconductor	DJ 4 BG 006 (1 Ic, 2 transistors)	DM	17.80
Kit	DJ 4 BG 006 with above listed components	DM	24.80
Connectors	Siemens (13 pole) for PC-board DJ 4 BG 006 - set	DM	7.40
DL 9 FX 002	Bandscanner with stop device		
PC-board	DL 9 FX 002 (with printed plan)	DM	6.--
Minikit	DL 9 FX 002 (coilformer and trimmer se as well as semiconductors)	DM	37.15
Kit	DL 9 FX 002 with above listed components	DM	43.15
DJ 5 HD/DJ 7 JX	Synthesis VFO for 144 MHz or 136 MHz		
DJ 5 HD 001	VFO and buffer		
PC-board	DJ 5 HD 001 (with printed plan)	DM	4.50
Minikit	DJ 5 HD 001 (Airspaced trimmer, variable ceramic coilformer)	DM	19.80
Semiconductors	DJ 5 HD 001 (2 transistors)	DM	4.00
Variable capacitor	57 pF (24 x 32 x 26.5 mm)	DM	13.50
Kit	DJ 5 HD 001 with above listed components	DM	41.80
DJ 5 HD 002	Crystal oscillator, mixer, amplifier, voltage stabilizer		
PC-board	DJ 5 HD 002 (with printed plan)	DM	9.--
Minikit	DJ 5 HD 002 (coilformers, trimmers and chokes)	DM	11.50
Semiconductors	DJ 5 HD 002 (7 transistors, 1 diode)	DM	31.40
Crystal	66.500 MHz (HC-6/U) for 145 MHz VFO	DM	18.--
Kit	DJ 5 HD 002/145 with above components	DM	69.90
Crystal	62.000 MHz (HC-6/U) for 136 MHz VFO	DM	18.--
Kit	DJ 5 HD 002/136 with above components	DM	69.90
DL 8 ZX 001	70 cm transmitter with VXO		
VXO			
PC-board	DL 8 ZX 001 (with printed plan)	DM	4.--
Minikit	DL 8 ZX 001/VXO coilformer set, screening cans	DM	3.--
Semiconductors	DL 8 ZX 001/VXO 2 transistors	DM	7.80
Kit	DL 8 ZX 001/VXO with above components	DM	14.80
Crystals	27.... MHz (HC-18/U on request delivery 6 weeks)		
Transmitter			
Minikit	DL 8 ZX 001/TX 2 tube sockets, coilformer set, choke set, ferrite beads, trimmer set	DM	21.90
Semiconductors	DL 8 ZX 001/TX 6 transistors, 4 diodes	DM	34.20
Tube	EC 8010	DM	24.--
Tube	EC 8020	DM	27.--
Kit	DL 8 ZX 001/TX with above components	DM	107.10
DK 1 YZ	VFO operation from SSB transmitter 24-24.5 MHz		
PC-board	DL 7 ZR (with printed plan)	DM	8.00
Minikit	DK 1 YZ 001 (coilformer set)	DM	2.70
Semiconductors	DK 1 YZ 001 (4 transistors, 4 diodes)	DM	22.70
Kit	DK 1 YZ 001 witz above components	DM	33.40
Crystal	19.000 MHz (spezial order-HC-6/U)	DM	21.50
Special offers			
PC-board	DL 9 GU 001 with printed plan	DM	3.--
PC-board	DJ 4 BG 006 without plan	DM	5.--
Silicon diodes	400 V p.i.v./0.7 A	DM	0.30
Silicon diodes	200 V p.i.v./0.7 A	DM	0.30
Price changes			
DJ 9 ZR 001	5 W SSB transmitter		
Semiconductors	reduced to	DM	92.30
Kit price	reduced to	DM	114.80
DJ 9 ZR 005	9 MHz IF/AF portion		
Now available with chokes and transformer			
Minikit price	increased to	DM	43.20
Kit price	increased to	DM	159.30

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