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SSB / CW Transceiver For 144 MHz

Wolfgang Schneider, DJ8ES

Contents

Well this is my first issue, I have tried to ensure that the magazine is up to the normal standard. If you have any comments please let me know.

Thank you all for your support, please tell your freinds about the magazine - Andy

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FREQUENCY DIVIDER UP TO 4 GHZ

Suitable frequency dividers are often required for home-made circuits in the UHF-SHF range.

Recently, though, there have been problems procuring frequency dividers which still function at frequencies exceeding 2 GHz.

Either the integrated circuits can no longer be obtained or the prices are disproportionately high.

1. DESCRIPTION OF COMPONENTS

Thus, for example, the µPB581 and 582 pre-dividers from NEC, well-known to radio amateurs (divider: 2, divider: 4) can be used up to 3.7 GHz. But there is now almost nowhere where these advantageously priced integrated circuits can still be obtained.

Another option is represented by dividers from Plessey, which can be obtained with various divider factors and which function up to 5 GHz or 6 GHz. Unfortunately various frequency divider ICs from other manufacturers can not be supplied at all now, because they are no longer manufactured or are difficult to obtain and the prices have risen accordingly.

One very interesting alternative is the NEC divider, type µPB 1505. The µPB 1505 frequency divider is specified for up to 3 GHz, but functions up to 4 GHz and beyond, and is housed in an 8-pin SMD housing.

The sensitivity and dynamics are considerably better than in the older versions, µPB 581/582. The programmable divider factors of 64, 128 or 256 are also very interesting.

Here are a few of the frequency dividers data, taken from the manufacturers specifications:

- High actual frequency range:

  0.5 GHz to 3.0 GHz

- Low current consumption:

  Typically 14 mA at 5 V

- High divider ratio:

  : 256, : 128, : 64

- High input sensitivity:

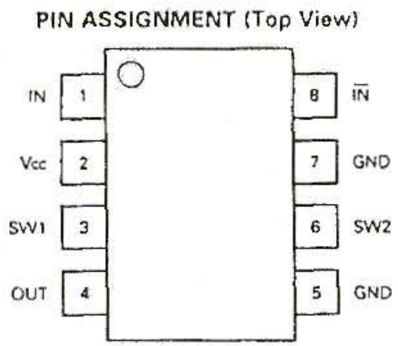


Fig. 1: Pin assignment of µPB 1505

14 to + 10 dBm (at 1.0 to 2.7 GHz)

– High output level:

1.5 Vss (CL = 8 pF load)

The desired divider factor can be set using pins, SW1 and SW2, in accordance with the following table:

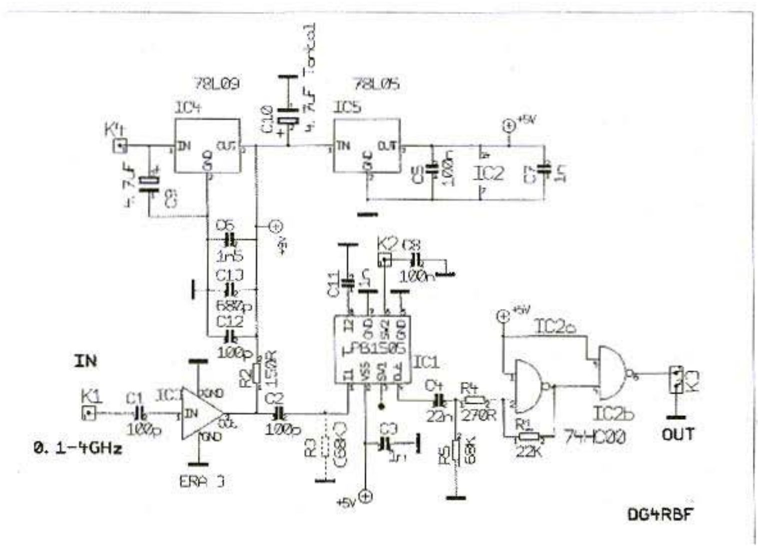
Divider factor:	Wiring:
: 256	SW1 = Low and SW2 = Low
: 128	SW1 = Low and SW2 = High
: 64	SW1 = High and SW2 = High

The following typical application shows how little it costs to expand a relatively old frequency counter to 4 GHz.

Most frequency counters which function up to approximately 1,000 MHz have a pre-divider with one of these three divider factors : 64, : 128 or : 256. These pre-dividers are usually mounted directly at the input jack on a small printed circuit board or in a separate tinplate housing. This pre-divider module is simply replaced by the new pre-divider, which has a greater operational range.

The great advantage of a replacement, as against additional series-connected

Fig. 2: Circuit diagram of pre-divider up to 4 GHz (divider factors 64,128,256)



dividers, is that the frequency to be counted is directly displayed. This dispenses with the burdensome conversion to the actual frequency necessitated by the odd divider ratio, together with additional modification measures to generate the gate time.

2.

PRE-DIVIDER CIRCUIT DESCRIPTION

The circuit essentially consists of three units: pre-amplifier, frequency divider and level converter (Fig. 2).

The pre-amplifier fulfils two requirements. Firstly, it raises the level of the input signal, which increases the sensitivity, and secondly it protects the divider against destruction due to excessive input power.

The ERA 3 from MiniCircuits was used as a pre-amplifier here. This MMIC gives a very uniform amplification of approximately 20 dB up to approximatey 2 GHz, falling somewhat as the frequency increases, though it is still approximately 13 dB at 4 GHz.

To illustrate this, see the measurement curves in Figs. 3a and 3b. They were measured before the divider IC was inserted, and show an outstandingly uniform amplification of 19 to 20 dB over the range in question.

The high amplification rather balances out the decrease in sensitivity of the pre-divider below 200 MHz, so that the latter can be used with good sensitivity even at 100 MHz (- 26 dBm).

This is followed by the divider IC, which needs practically no external circuitry.

Finally, a 74 HC00 provides the correct TTL level which is required for further processing in the frequency counter.

Fig. 4 shows the output signal for an input signal of 3.6 GHz with a division of : 256. The divider factor : 64 can not be used below 4 GHz, since the resultant output frequency is too high for the level conversion and also for the subsequent TTL stages (4,000 MHz: 64 = 62.5 MHz).

In principle, there are two ways in which the operating voltage can be fed in for MMICs:

- A: Through a resistor only
- B: Through a resistor with high-frequency chokes wired in series

Version (A) is the simplest and most unproblematic way of feeding in the operating voltage. But the maximum output is not attained, especially at low supply voltages. At low supply voltages, a correspondingly low resistance (Rbias) is used, causing a high-frequency gain loss to take place. The maximum attainable gain is therefore not available.

Regarding the high-frequency gain, version (B) is more efficient, since the additional choke blocks the high frequency better and the gain divider effect is avoided.

But this can result in having to deal with undesirable resonances, which leads to undesirable oscillations.

The curves in Fig. 5 show the readings from a test circuit with an ERA 1 (version A), with a supply voltage of

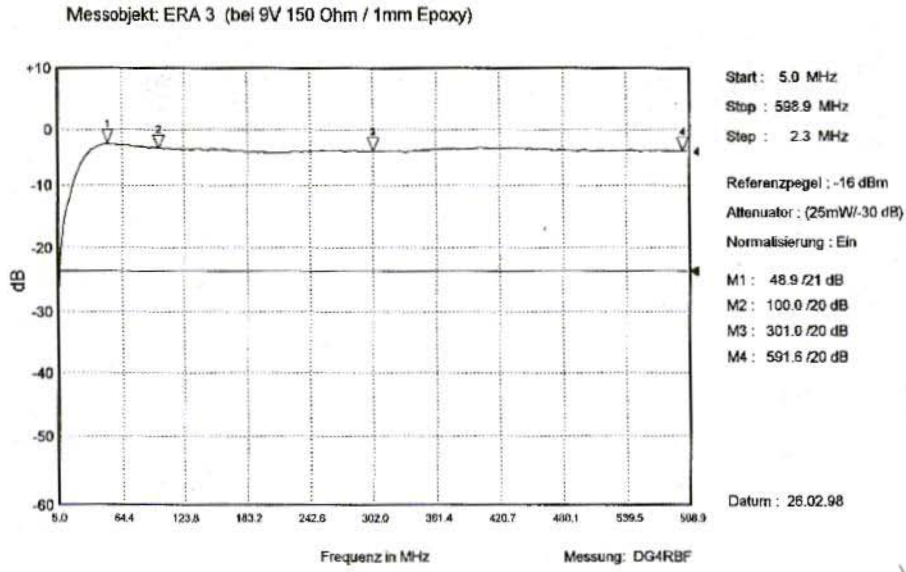


Fig. 3a: Very uniform amplification of ERA 3 of app. 20 dB

(Messobjekt = Test, Referenzpegel = Reference level, Normalisierung = Normalisation, Ein = On, Datum = Date)

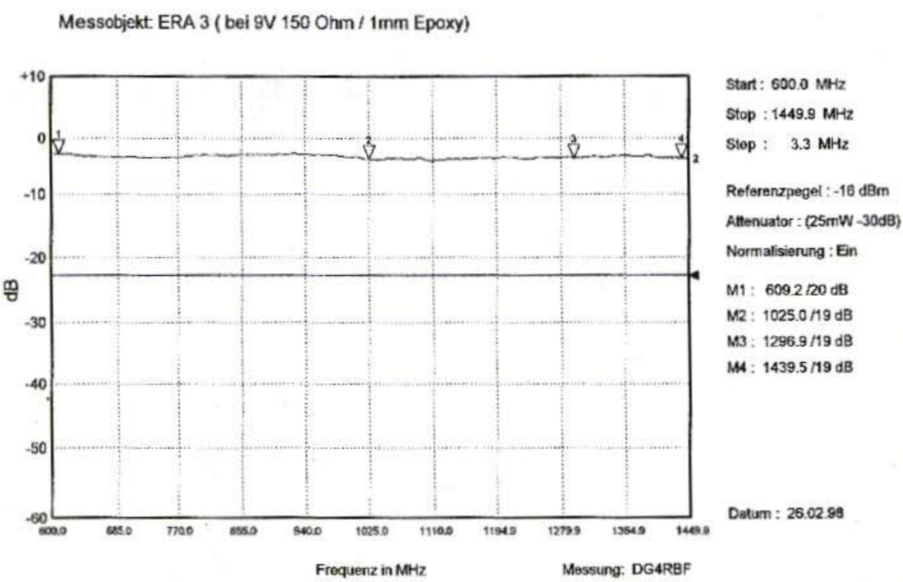


Fig. 3b: The amplification curve remains very linear up to app. 2 GHz

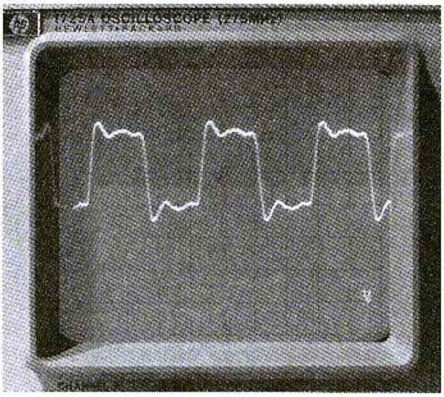


Fig. 4: Output signal of divider with TLL level, at input frequency of 3.6 GHz, divided by 256

+ 5 V or + 12 V. It can be clearly seen that the gain is lower for an operating voltage of 5 V.

Here is a simple formula to calculate the protective resistor, Rbias, for MMICs :

Rbias = (1,000 * (Vcc Vd) / Ibias

where :

- Vcc is the supply voltage,
- Vd is the MMIC voltage, and
- Ibias is the current in mA.

An example:

Vcc = 9 V, Vd = 3.5 V and I = 35 mA

R = (1,000 * (9 3.5) / 35 = 157 Ohms

Version A was selected (without choke), since the ERA MMIC types have shown themselves to be somewhat critical when powered with chokes.

3. CONSTRUCTION

The small circuit is constructed on a 1.0 mm. thick, double-sided printed circuit board made from epoxy material (Fig. 6), which naturally already represents a certain compromise for the high frequencies.

The feedthroughs are manufactured first. The best thing to use for this is small compression rivets with a diameter of approximatey 1 mm., which are well soldered to the top and bottom sides of the printed circuit board. But make sure the compression rivets do not fill up with solder! Special attention should be paid to the low-inductance feedthroughs on the divider IC. The feedthrough directly below the divider IC must be kept flat, so that it will not touch the IC when it is fitted.

The hole for the pre-amplifier IC measures 2.2 mm.. The MMIC (ERA 3) is inserted from the earth side, so that its earth connections can be soldered directly on the underside of the printed circuit board. To this end, the little connection struts at the input and output are bent up at 90 degrees and are fed through the hole for the MMIC and then soldered to the top side of the printed circuit board. If necessary, the hole must be slightly widened to do this.

The dot on the ERA 3 indicates the input. Make sure that the positive pole of the SMD electrolytic capacitor is also identified by a line or bar.

Two connection options have been provided for the high-frequency input, so that, if space is available, the circuit can be directly soldered to the input jack of the frequency counter. If necessary, it is also possible to build the circuit into a little tinplate housing.

The components are soldered on the

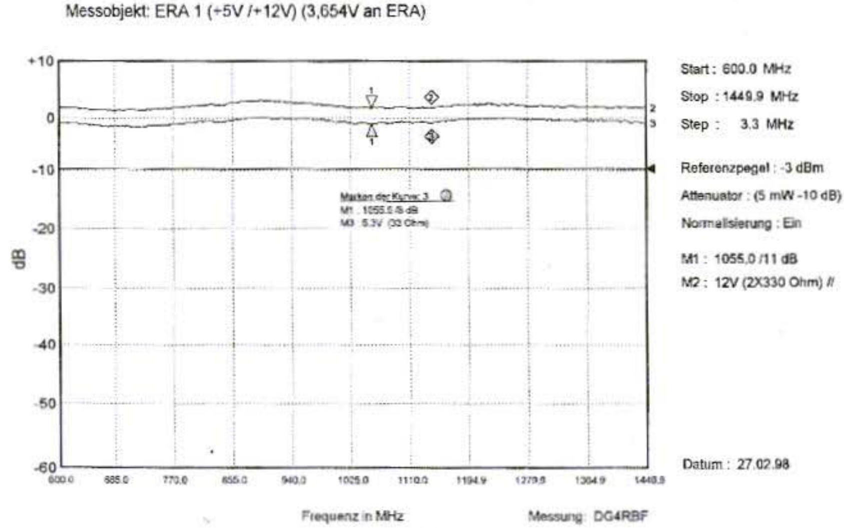


Fig. 5: Measurement curves of a test circuit with an ERA 1 with varying supply voltages from 5 V to 12 Volts

(Messobjekt = Test, Ein = On, Referenzpegel = Reference level, Normalisierung = Normalisation, Datum = Date)

layout side of the printed circuit board, with the usual precautions against static charging.

The circuit has been laid out in such a way that there are selectable options for the operating voltage.

The following types of supply are possible for the circuit.

Firstly, the circuit could be powered from the frequency counter with a stabilised voltage of + 5 V. In this case, the two fixed voltage regulators are not fitted, but are replaced by bridges. The protective resistor for the ERA 3 is chosen for a voltage of 5 Volts (Rbias for 5 V is about 39-43 Ohms).

The other option is laid out for an input voltage of approximately 10 to 12 V. Here the two fixed voltage regulators (+ 9 V and + 5 V) are required and are also mounted.

This gives the advantage that the value

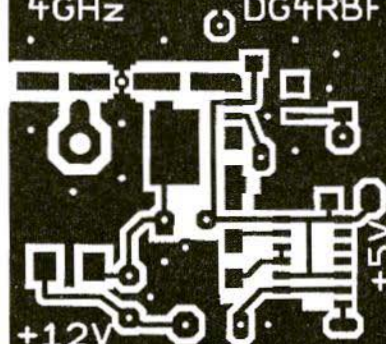


Fig. 6: Layout of pre-divider printed circuit board

of resistor (Rbias) for the MMIC can be bigger, and we can obtain approximately 2 dB more amplification (Rbias for 9 V is app. 150 Ohms).

In exactly the same way, we can also mount only the + 9 V voltage regulator which supplies the MMIC, the 5 V section being supplied from the subsequent counter.

The ERA 3 is operated with a current of 35 to 38 mA. The 5 V section of the circuit requires app. 25 mA.

The circuit is calibration-free and should function at first go.

Component list:

SMD components:

R1 22 kOhms

R2 150 Ohms

R4 270 Ohms

R5 68 kOhms

C1, C2, C12 100 pF

C3, C7, C11 1 nF

C4 22 nF

C5, C8 100 nF

C6 1.5 nF

C9, C10 4.7 µF tantalum

C13 680 pF

IC1 µPB 1505

IC2 74 HC00

IC 3 ERA 3

Wired components:

IC4 78 L09

IC5 78 L05

R3 68 kOhms

5.

CONCLUSION

Like many other pre-dividers, this one also oscillates at the frequency of its maximum sensitivity if no input signal is present (app. 2.5 GHz). But since this oscillation is unstable, it should be possible to distinguish this from the genuine input signal.

There is something which can be helpful, but which can not be recommended unreservedly.

With a resistance of approximately 68 kOhms at the input of the divider (R3), we can try to suppress the oscillation. However, a certain loss of sensitivity is also involved. The resistance must be individually matched, and should not be any lower than is absolutely necessary.

Since, in the upper frequency range in particular, this leads to a detectable loss of sensitivity (from 3 GHz), it should be possible to switch off the resistance using a switch or a small relay.

This pre-divider module is also used in a micro-controller regulated double frequency counter up to 4 GHz, which the author uses and which is described in the next article.

The small circuit (Fig. 7) was built into a frequency counter by the author, and here it replaces the internal pre-divider module and an additionally built-on pre-divider based on µPB 582.

The frequency counter is operating considerably better thanks to the modification, and has fewer problems.

The prototype is very sensitive, even in the upper frequency range.

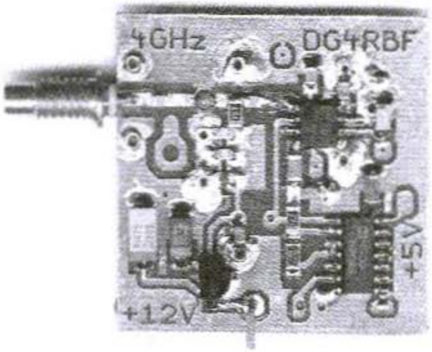


Fig. 7: Prototype of pre-divider with SMD components

Sensitivity of frequency divider with ERA 3:

MHz	dBm	MHz	dBm
50	- 19	1,800	- 43
80	- 23	2,000	- 43
100	- 26	2,200	- 44
145	- 30	2,400	< - 50
200	- 33	2,600	< - 50
400	- 37	2,800	- 44
600	- 41	3,000	- 38
800	- 42	3,200	- 36
1,000	- 43	3,400	- 34
1,200	- 43	3,600	- 30
1,400	- 44	4,000	- 26

Bernd Kaa, DG4RBF

FC 4000 MICRO CONTROLLED DOUBLE FREQUENCY COUNTER UP TO 4.0 GHZ

This is a genuine double frequency counter, which can count and display two frequencies at the same time, and which works with a precision of up to 9 places at up to 4,000 MHz.

These two characteristics justify building your own counter even today. Moreover, a counter of this nature can be a meaningful addition to a radio amateurs measuring equipment.

1. INTRODUCTION

People will undoubtedly ask why they should build a frequency counter themselves when they can buy ready-made equipment from £200 upwards. This double frequency counter is not comparable with a common or garden counter, since it can count and display two frequencies simultaneously. The operating range of such a counter for high-frequency use is very wide and, for instance, offers the inestimable advantage of being able to measure the basic oscillator and the intermediate frequency simultaneously during balancing work on high-frequency equipment such as, for example, transverters.

The double frequency counter (Fig. 1) is modular in structure and consists of the following assemblies:

- Pre-divider for channel A (100-4,000 MHz)
- Pre-divider for channel B (0.5-100 MHz)
- Micro-controller board (Uniboard C501) with control keys and LC display, and
- Frequency counter

The actual calculations are done by the processor board. The pre-amplification and pre-division of the signal to be processed take place in the pre-stages for the respective channels. The frequency counter assembly is actually a frequency counter attachment, which performs only the preliminary work

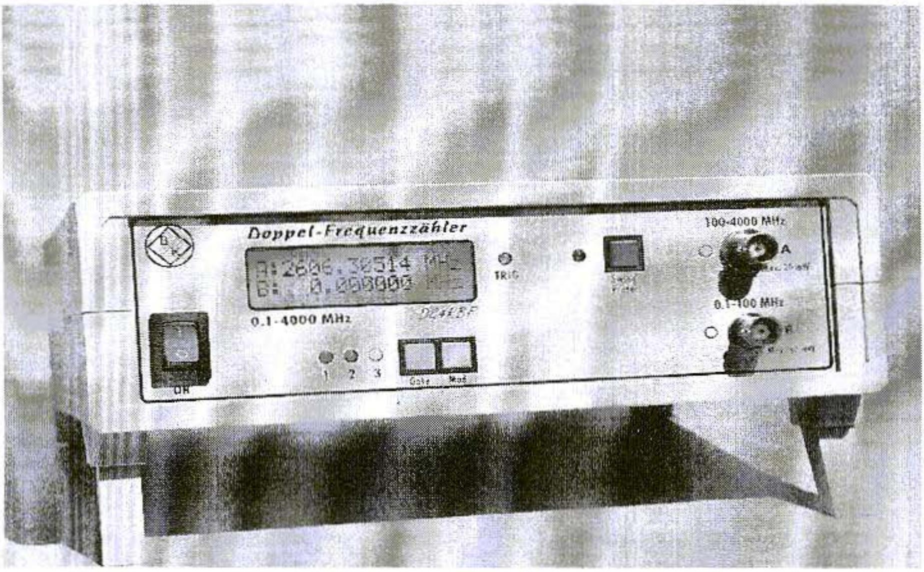


Fig. 1: Prototype Double Frequency Counter Ready to Operate

relevant to the counter and hands everything else over to the processor for processing.

2.

DESCRIPTION OF ASSEMBLIES

2.1. Divider up to 100 MHz

The input section for the 0.5 to 100 MHz frequency range (channel B) was created using 50-Ohm technology, without any special integrated circuits (Fig. 2). A type MAR 8 MMIC is used as pre-amplifier, with a high amplification of approximately 30 dB in the frequency range up to 100 MHz. There are limiting diodes at the inputs and outputs, which keep the levels within the permissible range for driving the subsequent ICs.

The level conversion and subsequent division by 4 is carried out by IC 2a and the dual D-Flip Flop IC 5.

The relatively high operating frequency of 100 MHz poses a problem for normal TTL ICs. So various ranges of IC were tested, and the combination of 74 HC 00 with 74 F 74 gave the best results. If we also use a 74 HC 00 manufactured by SGS-Thomson (ST), we can obtain app. 10 dB more sensitivity. The prototype is thus already operating at frequencies of up to 120 MHz.

The small circuit is powered by a single supply of + 12 V. Voltage regulator ICs (series 780X or 78L0X) provide internal stabilisation to + 9 V and + 5 V.

The prototypes channel B sensitivity was measured at:

- – 44 dBm at 5 MHz
- – 44 dBm at 10 MHz
- – 48 dBm at 20 MHz

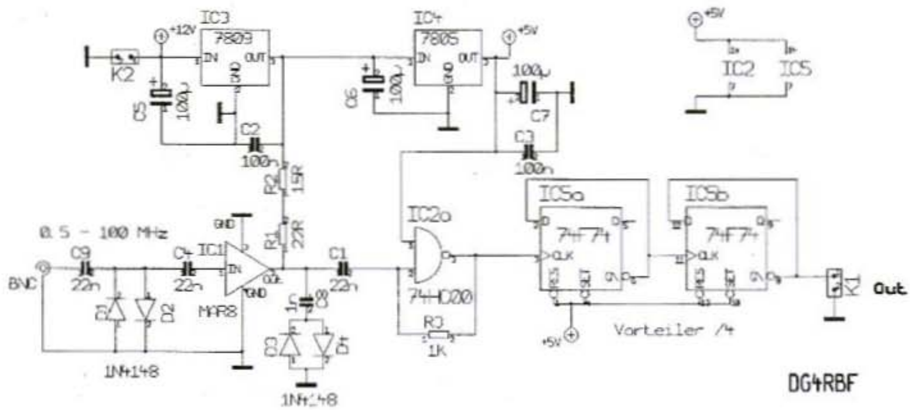


Fig. 2: Wiring Diagram of 0.5 to 100 MHz Input Section

(Vorteiler = Pre-divider)

- < 50 dBm at 50 MHz
- 41 dBm at 80 MHz
- 35 dBm at 100 MHz
- (30 dBm at 120 MHz)

2.1.1. Construction

The circuit is constructed on a one-sided printed circuit board (Fig. 3) which measures 54 mm. x 35 mm.. Fig. 4 shows the component layout.

The circuit had to be incorporated in a tinplate housing of suitable dimensions for screening purposes.

2.1.2. Pre-divider parts list

C1, C4, C9	22 nF
C2, C3	100 nF
C5 C7	100 µF
C8	1 nF

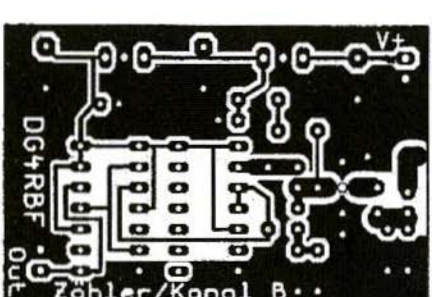


Fig. 3: Layout of Input Section

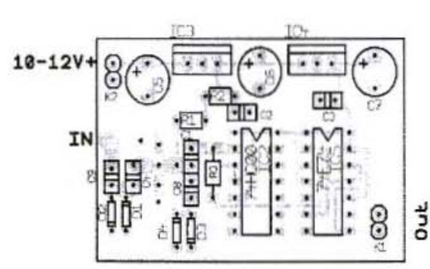


Fig. 4: Component Plan of Input Section

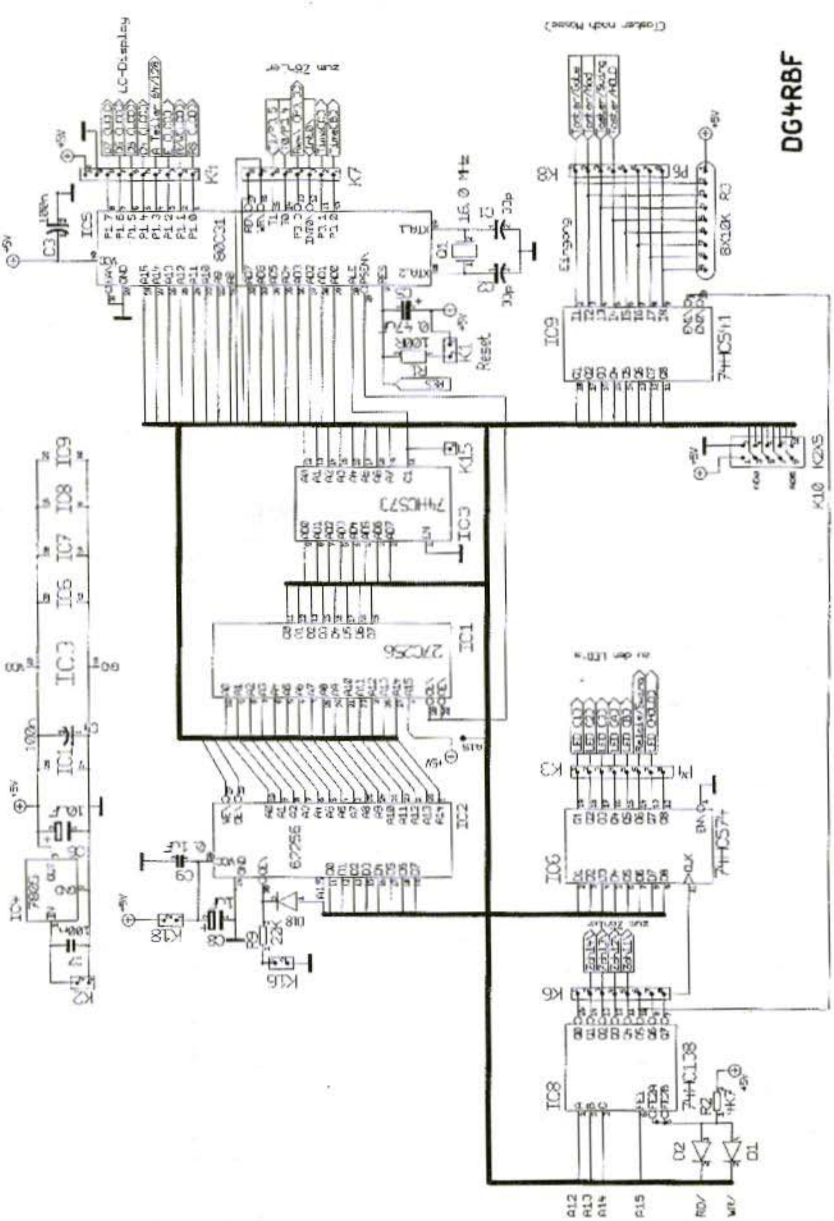


Fig. 5: Circuit Diagram of Processor Board for use in Double Frequency Counter

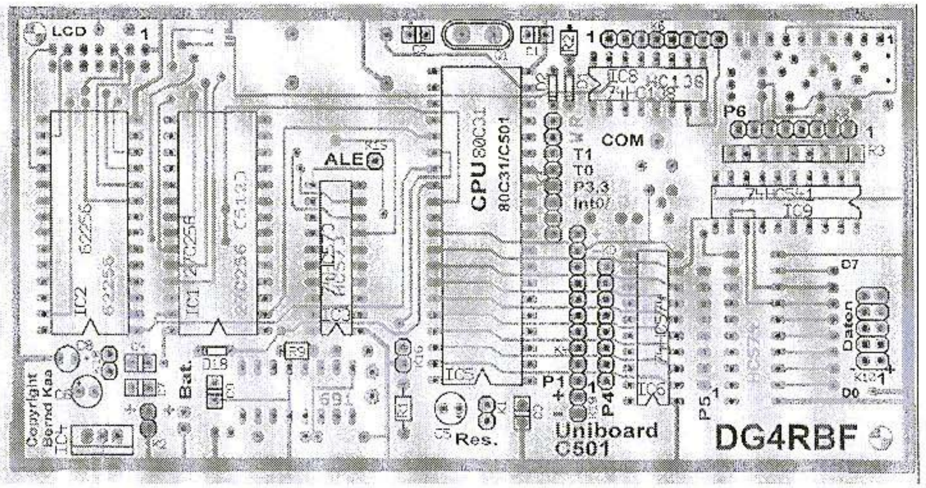


Fig. 6: Component Plan of Micro-Controller Board (not to scale)

D1 D4	1N4148	IC4	78 05, 5 V voltage regulator
IC1	MAR8		
IC2	74 HC 00	IC5	74 F 74
IC3	78 09, 9 V voltage regulator	K1, K2	1 x 2 columns
		R1	22 Ohms

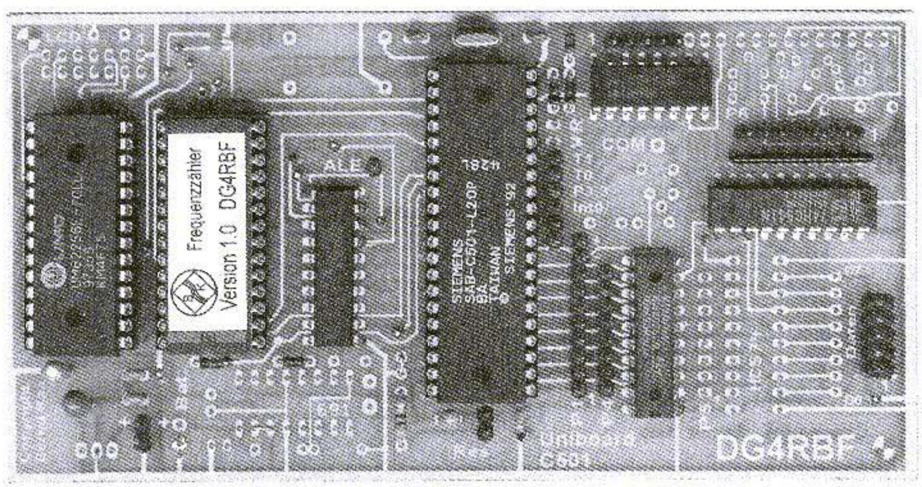


Fig. 7: C501 Prototype Uniboard

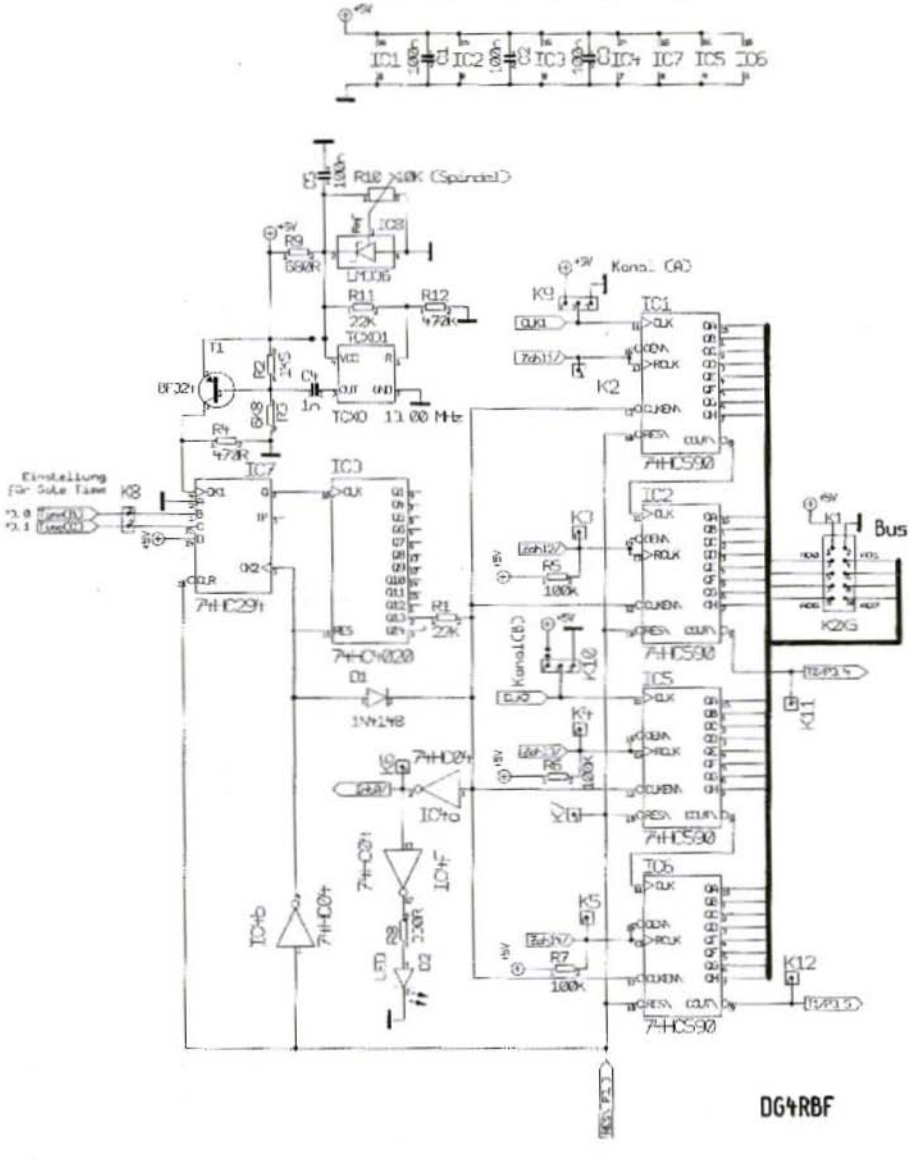


Fig. 8: Circuit Diagram of Frequency Counter Unit

(Einstellung für Gate Time = Gate time setting, Kanal = Channel, Spindel = Spindle)

R2	15 Ohms
R3	1 kOhm

2.2. Pre-divider up to 4 GHz

This pre-divider has already been described in this issue and [1]. In addition to the basic description, the following special features should be taken into account:

The pre-divider module is equipped with a 9-Volt voltage regulator for the MMIC. The 5-Volt section is supplied by the counter assembly. The switch input SW1 of the divider IC is set to High (V + of IC).

In order to obtain optimal resolution for the system, the pre-divider for channel A is driven with the low divider factor of only 64 up to a frequency of 2,450 MHz, and only above this frequency is it switched over to the factor 128. The divider factor is changed over through the micro-controller at port P1.3.

For this purpose, port P1.3 is connected to K2 (SW2 on µPB 1505) on the pre-divider printed circuit board. It should be taken into account that the control inputs of the pre-divider IC, SW1 and SW2, can be switched correctly only if the high level corresponds to the supply voltage of the IC. A difference of only 0.1 V can cause unstable switching.

Since the control voltage at the output of the micro-controller is already approximately 0.1 V lower, the 5 V distribution voltage of the pre-divider must be minimally reduced. This can be brought about, for example, by means of a 10-Ohm pre-resistor in the supply line, which brings about a reduction of approximately 150 mV. The turn-on voltage and the supply voltage should be measured as precisely as possible, e.g. with a digital multimeter.

In the prototype, the sensitivity of channel A is a splendid 26 dBm at 4 GHz, and is thus sufficient for most applications.

For screening purposes, the circuit should be built into a tinplate housing of suitable dimensions.

2.3. Universal micro-controller board

The entire control system of the double frequency counter, including the LCD module, is operated through the C 501 Uniboard (Fig. 5) from [2]. The Uniboard is not used in its fully extended version for the double frequency counter application.

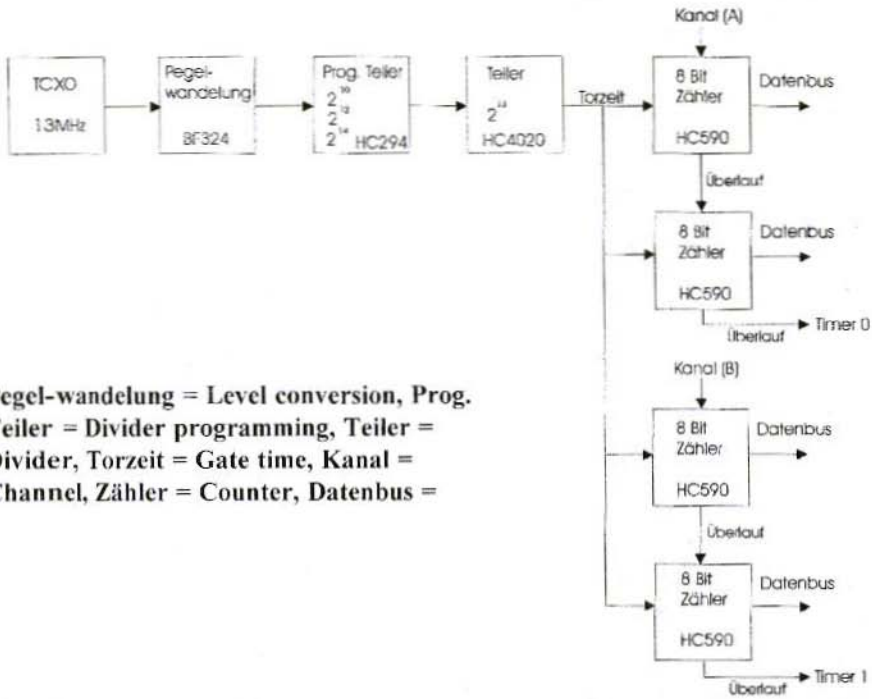
2.3.1. Construction

Fig. 6 shows the component plan. The following components are not required (as against the fully extended version) and are therefore not fitted:

K14 with diode matrix, P5 port expansion (IC7, K5), serial interface (R4, R5, D3, T1, K12), reset IC (IC10, R6, R7, R8, C10, D4, K11, R11), TTL oscillator (Q2), LCD bus connection (IC 11, K17, R10) and single-series bus connection (K9).

The keys (Gate/Mod/Swing/Hold) are here connected to K8 (pins 1-4).

The processor for this application is an 80QC 31-16, which is driven with a 16.0 MHz crystal (Q1). In addition, connections K18 and K16 should be short-circuited, since no reset IC is



Pegel-wandelung = Level conversion, Prog. Teiler = Divider programming, Teiler = Divider, Torzeit = Gate time, Kanal = Channel, Zähler = Counter, Datenbus =

Fig. 9: Block Diagram of Counter Unit

being used here. Thus the RAM receives the supply voltage and is switched into active condition.

Fig. 7 shows the processor board, the C 501 Uniboard, in the appropriate layout for the double frequency counter.

2.3.2. Components list

IC1	27C256 Eprom, FC 4000
IC2	62256
IC3	74 HC573
IC4	7805, 5-V voltage regulator
IC5	80 C31-16, processor
IC6	74 HC 574
IC8	74 HC 138
IC9	74 HC 541
D1, D2, D18	1N4148
Q1	16,000 MHz
C1, C2	33 pF
C3, C4, C7	100 nF
C5	0.47 uF
C6	10 µF, 25 V

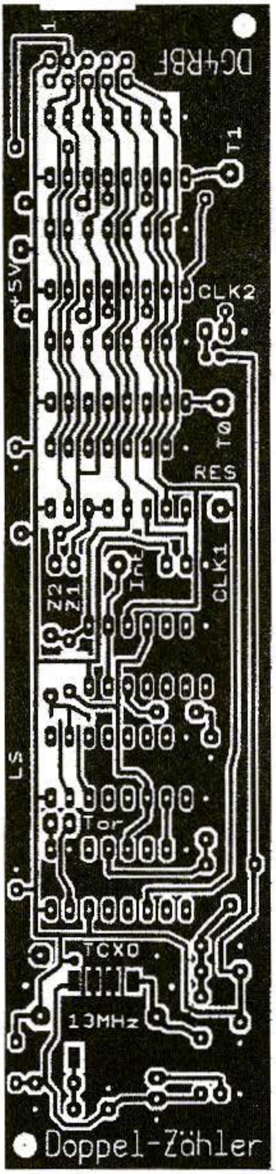


Fig. 10: Printed Circuit Board for Counter Assembly

C8	1 µF, 25 V
C9	0.1 µF
C10	4.7 µF, 25 V
R1	100 Ohms
R2	4.7 Ohms
R3	8 x 10 kOhms, array
R9	22 kOhms

K1, K2, K16, K18	1 x 2 columns
K4	1 x 10 columns
K3, K6, K7, K8	1 x 8 columns
K10	2 x 5 columns
K15	1 x 1 column

2.4. The frequency counter assembly

The circuit (Fig. 8) contains the gate time generation, together with four 8-bit binary counters, 2 of which are wired together for each input channel, and which take over the counting of the lower 16 bits (Fig. 9). The internal timer of the micro-controller is responsible for the counting at 16 bits and above.

The core of the gate time generation is a TCXO (temperature-compensated crystal oscillator), which can be set for 13.000 MHz or 26.000 MHz. The quality of the TCXO will determine the accuracy and temperature stability of the unit.

The printed circuit board here (Fig. 10) was prepared for 2 kinds of TCXO. Firstly, for a standard TCXO, which has to be tuned with a small built-in trimming capacitor, and secondly for a trimmerless precision TCXO, which is balanced with a control voltage of approximately 2.5 V. For this purpose, there is a tunable voltage reference (LM 336) on the printed circuit board, which can be adjusted using a spindle trimmer.

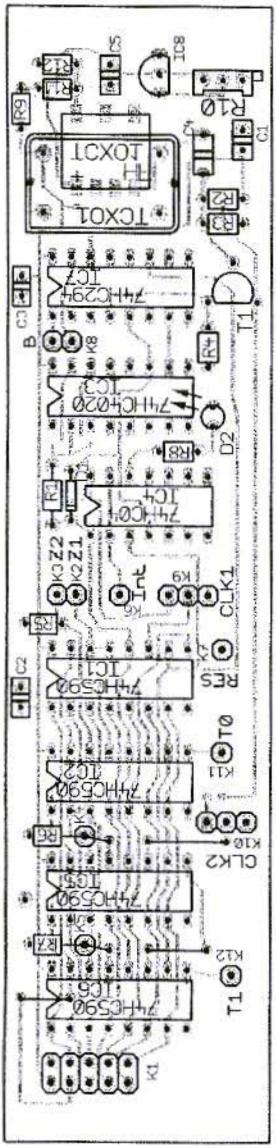


Fig. 11: Counter Assembly Component Plan

This enables a high frequency accuracy to be attained with a very precise fine adjustment.

A type BF 324 transistor brings the TCXOs signal to the correct level for the subsequent programmable binary counter (divider). This binary counter divides the signal optionally by 210/212/ or 214. The three possible gate times are selected through inputs B and C.

The divided signal then arrives at a fixed binary divider with a divider factor of 213 or 214, depending whether a 13-MHz or 26-MHz TCXO is being used.

The gate time pulse generated in this way stops the four counters (74 HC590) and triggers an interrupt (Int0/) on the micro-controller. For the micro-controller, this conveys the instruction Start a new calculation cycle immediately!.

The computer first scans the state of the external counters. For this purpose, the counters are accessed through the address decoder, sending their data to the micro-controller via the data bus.

Once all data have been read, a reset signal (RES\) is transmitted to P3.3, which inhibits and resets the gate time preparation and the four external counters. The external counters are inhibited through the diode D1 for as long as the (RES\) signal is present.

With the presence of the internal counter conditions T0 and T1, all the necessary information is now available, and the computer begins the frequency calculation. Depending on the gate time and frequency level set, the calculation is carried out for up to 9 places and the result is displayed. Since each channel (A and B) has its own counters, the two channels are measured simultaneously.

2.4.1. Construction

The equipment is assembled on a single-sided printed circuit board with

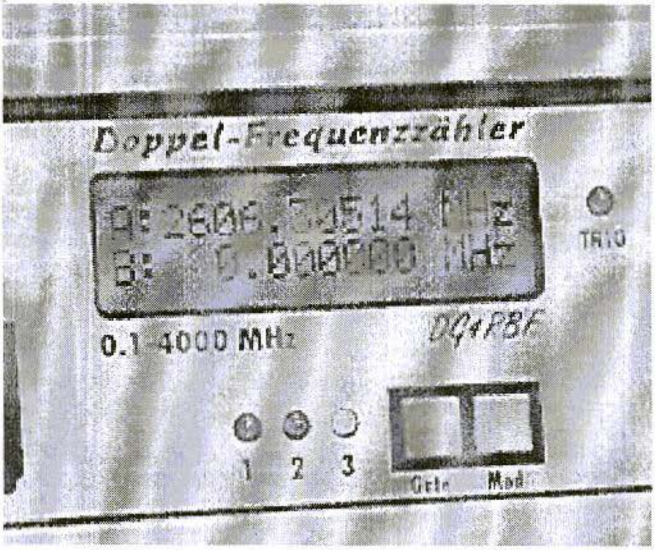


Fig. 12: Two-Line LCD Display in Prototype

dimensions of 146 mm. x 35 mm., corresponding to the component plan in Fig. 11.

A recess should be provided on the front of the printed circuit board for the ribbon connection, so that the cable can run down to the micro-controller.

The wire bridges must be fitted before the other components.

For reasons of space, there is no direct soldering point for one R6 connection. Instead, the direct soldering connection goes to K4, and then on to pin 13 of IC 5. The same applies to R7, K5 and IC6.

The channel A pre-divider is connected to [CLK1] (K9). The + 5 V are also available at K9. The channel B pre-divider is connected to [CLK2] (K10). The + 5 V connection is not used here, since this pre-divider is powered entirely from outside.

2.4.2. Component list

IC1, IC2, IC5, IC6	74 HC590
IC3	74 HC4020
IC4	74 HC04
IC7	74 HC294
IC8	LM336-2.5
C1, C2, C3, C5	100 nF
C4	1 nF
D1	1N4148
D2	LED
T1	BF324
TCXO	13.0 MHz (26.0 MHz)
K1	2 x 5 columns
K9, K10	1 x 3 columns
K2, K7, K11, K12	1 x 1 column
K8	1 x 2 columns

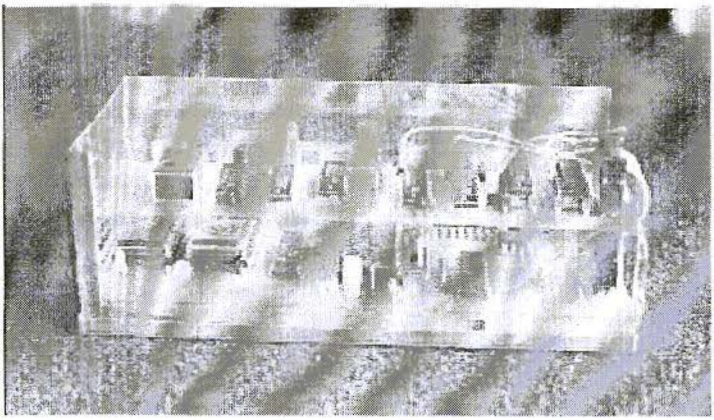


Fig. 13: Counter and Processor Printed Circuit Boards are mounted Piggyback in Tinplate Housing

R1	22 kOhms
R2	1.5 kOhms
R3	6.8 kOhms
R4	470 Ohms
R5 R7	100 kOhms
R8	330 Ohms
R9	680 Ohms
R10	10 kOhms (spindle trimmer)
R11	22 kOhms
R12	470 kOhms

2.5. The LC display

An LCD dot-matrix module with 2 x 16 characters is used for the display. Fig. 12 shows the representation of the two frequencies, each shown in one line of the display.

The display is driven through port 1 of the micro-controller. The connection diagram was taken from [2].

3. ASSEMBLY

The micro-controller and counter assemblies are incorporated together into a standard tinplate housing measuring 74 mm. x 148 mm. x 50 mm. (Fig. 13), with the counter printed circuit board located above the micro-controller printed circuit board.

The simplest way to handle the various data bus connections is to connect them using a 10-pin ribbon cable with column plug connectors. Please make sure that pin 1 also comes onto pin 1.

4. OPERATION OF COUNTER

The operation has been kept as simple and clear as possible.

One of the three possible gate times is selected via the (Gate) key. The currently active time is displayed through the corresponding LED. (Gate times: app. 0.3/1.2/6 sec.)

The desired operating mode is selected via the (Mod) key. Here you can choose whether the channel (A) and channel (B)

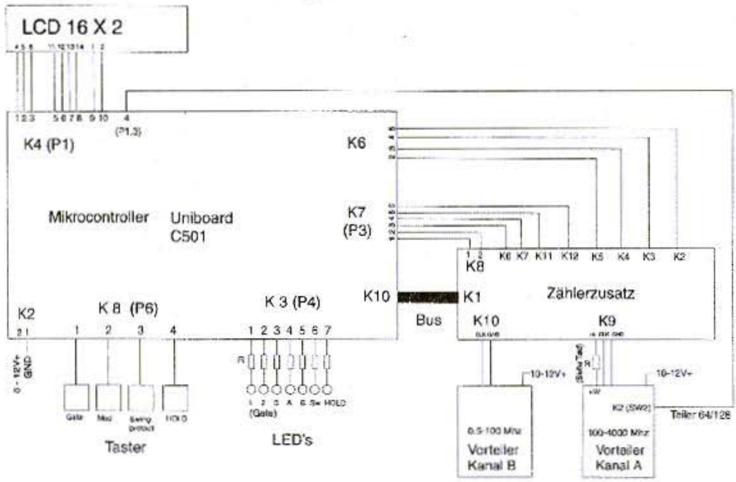


Fig. 14: Inter-connection of Individual FC 4000 Assemblies

(Taster = Keys, Zählerzusatz = Counter attachment, Vorteiler = Pre-divider, Kanal = Channel, Teiler = Divider)

frequencies are to be displayed simultaneously.

If only one of the two channels is selected, and if therefore only one line is required to display the frequency counted, the second line displays the period for the active channel.

The visual display showing which channel is active is again provided through two light-emitting diodes.

If desired, an additional key (Swing Protect) can be connected. Using the associated output, it is then possible to trigger a relay which influences the pre-divider (channel A). On this subject, see instructions in [1].

A holding function is also possible if an additional (Hold) key is connected to earth at pin 4 of K8.

In this condition, the current frequency display is frozen, the counter is stopped, the word Hold is displayed, and the corresponding LED is activated.

5.

FAULT-FINDING

Problems on micro-controller:

- Is K16 short-circuited?

  (Earth at pin 20 of RAM)
- Is K18 short-circuited?

  (+ 5 V at pin 28 of RAM)
- Check all soldering with a magnifying glass! (Usually its just a simple soldering error!)
- Are all ICs and diodes correctly set?
- Is the contrast setting of the IC display correct?

- For most displays, the connection for the contrast setting is earthed directly or through a resistor. But there are also displays which require negative voltage to display the text. As a minimum, the bar of the first line must be visible.
- Is the reset capacitor (C5) in order? (replace with 1 μF if necessary)
- The R11 resistor (shown as dotted line) should not be used!
- Check following points using oscilloscope:
- Is the ALE signal present at K15 (square wave signal)?
- Do the address and data bus lines have TLL levels? (intermediate values indicate a short-circuit!)
- Fault: Only half the frequency is displayed for gate time 3 (long)!
- Origin: Turn-on voltage at SW2 of divider is not connected (P1.3) or is lower than supply voltage!

6. CONCLUSION

The prototype has been very successfully in use for some months. The technical data in particular, those relating to accuracy of measurement and temperature drift are entirely capable of standing comparison with industrially produced frequency counters (£200 - £500).

7. LITERATURE

[1] Frequency Divider up to 4 GHz

Bernd Kaa, DG4 RBF

VHF Reports 1/98, Pp. 23-30

[2] C 501 Uniboard Universal Microcontroller Board

Bernd Kaa, DG4 RBF

FAQ on the Web Site

I would like to start an FAQ (Frequently Asked Questions) section of the VHF Communications Web site. This would be especially for those readers who are either constructing projects from the magazine or using the information published and are having difficulties. Email or write to me and I will put your questions on the web site followed by any replies or information that I receive form other readers. As the editor I will use my discretion when putting information onto the Web site.

If you don't have access to the internet you can still write to me and I will respond back to you by paper mail - Andy

http://www.vhfcomm.co.uk

Helmut Neidel, DL 1 IN

5.7 GHZ ATV CONVERTER

The 200 MHz wide 6-cm. amateur radio band in the 5.7 GHz range offers ideal conditions for narrow-band and broad-band transmissions. One type of transmission of this nature is the ATV mode, for which a down-converter to the SAT intermediate frequency is described here.

1.

INTRODUCTION

To receive ATV signals at 5.7 GHz a converter is needed which converts the whole of the 6-cm. band into the range of the normal SAT intermediate frequency. Any standard commercial SAT receiver can then be used.

The technical data of the 5.7 GHz ATV converter are:

- Input frequency: 5.65-5.85 GHz
- Output frequency: 1.4-1.6 GHz
- Noise factor: < 1 dB
- Transmission amplification: App. 40 dB
- Image attenuation: App. 50 dB
- Operational voltage/current: 10-12V/ 0.26 A
- IN connection: SMA jack
- OUT connection: SMC jack

In the planning phase, the question of a suitable oscillator was bound to come up. Layouts with ceramic resonators (coax or DRO) often founder on the rocks because of obtaining these components, particularly in small numbers. The use of a crystal oscillator, as in narrow-band converters, creates undesirable harmonics in the 200 MHz wide intermediate-frequency and reception range. The use of SAW resonators offers an interesting alternative. They have outstanding characteristics, but are, of course, available only in a few fixed frequencies. A frequency of 423 MHz was selected, which does not cause harmonics either in the reception range or in the interme-

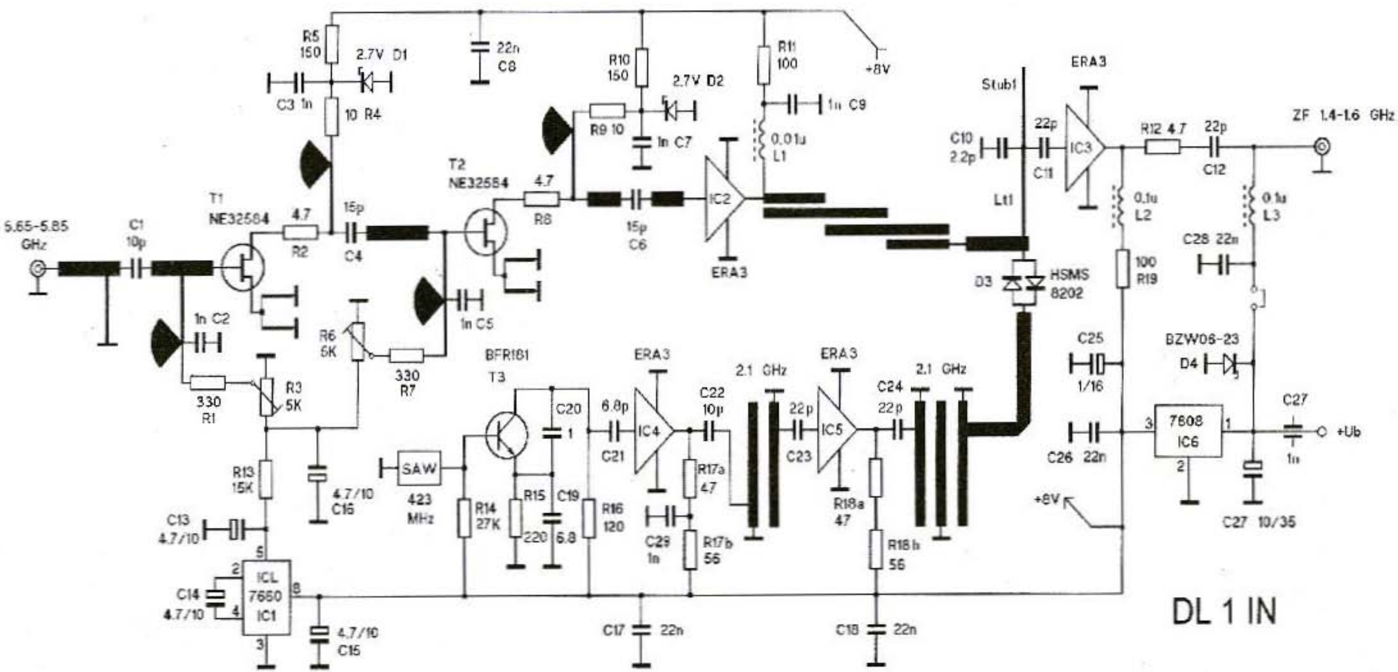


Fig. 1: Complete Wiring Diagram of 5.7 GHz ATV Converter with SAW Oscillator and Stripline Filters

diate frequency range.

The SAW oscillator also has very little phase jitter, which is comparable only with good crystal oscillators. Only the temperature stability is lower than for a real crystal.

2. CIRCUIT DESCRIPTION

The circuit of the ATV converter for 5.7 GHz is shown in Fig. 1, including the internal voltage regulator.

The circuit consists of a 3-stage amplifier, a sub-harmonic mixer and the SAW oscillator.

Immediately next to the high-frequency input there is a short-circuited lambda/4 line for protection against static charges on the aerial cable.

The first two amplifier stages are each equipped with an NEC HEMT (type NE 32584), which creates a noise factor less than 1 dB. The subsequent amplifier, with an ERA-3 from Mini Circuits, balances the attenuation of the 5.7 GHz filter (image frequency) and the mixer.

An HP double diode (type HSMS 8202) acts as a sub-harmonic mixer. Together with the filter input resistances, the conduction components on the mixer create the impedance conditions required for the mixing diodes.

Even while the printed circuit board was being developed, appropriate matching structures were provided. Thus, together with its connecting line, the 5.7 GHz filter branch forms a lambda/4 component for 2.1 GHz, while with its feed to the double diode the LO filter supplies a

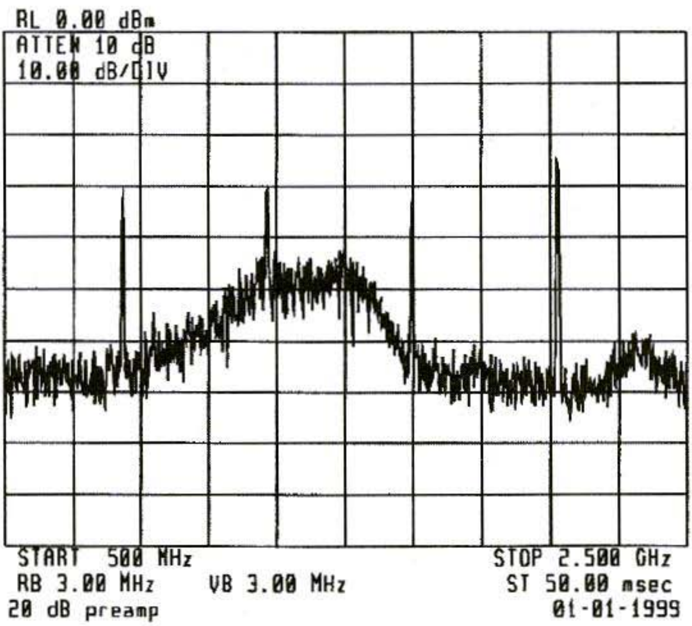


Fig. 2: Intermediate Frequency Spectrum of 5.7 GHz Converter without Input Signal

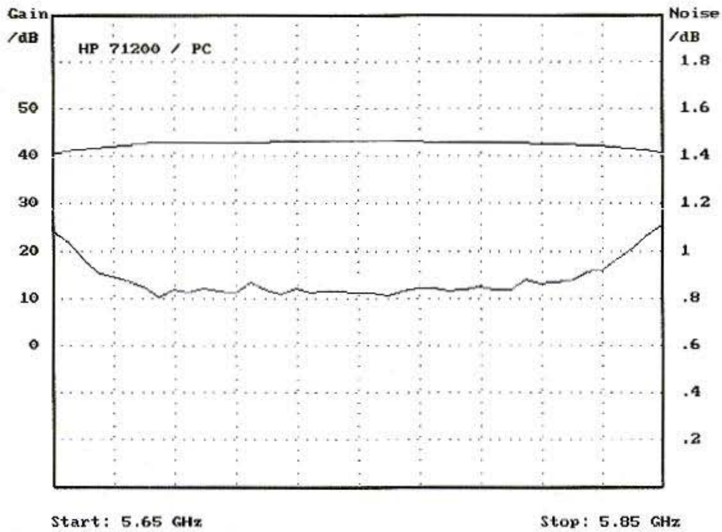


Fig. 3: Typical Curves for Amplification (top) and Noise Factor (bottom) of 5.7 GHz Converter

short-circuit there for 5.7 GHz. For the intermediate frequency, reactive impedances arise on both sides of the diode which, together with the conduction component Lt 1 (approximately lambda/4 for 5.7 GHz) and the input circuit of IC 3 (stub 1, C 10) form a low-pass filter for the intermediate frequency. IC 3 acts merely as an intermediate frequency amplifier, through which the LO is additionally attenuated using stub 1.

A Colpitts circuit was selected for the SAW oscillator [1], which oscillates at 423.2 MHz..

The output spectrum of IC 4 contains a large number of harmonics [2], of which the 2.1 GHz signal is brought to approximately 3 mW by means of selective amplifier stages with IC 5. By increasing the R17b resistance (56 Ohms), the LO power can be reduced, if applicable, to optimise the noise.

Fig. 2 shows the intermediate frequency spectrum without an input signal. The external oscillator harmonics and the attenuation of LO obtained (2.1 GHz) can clearly be seen.

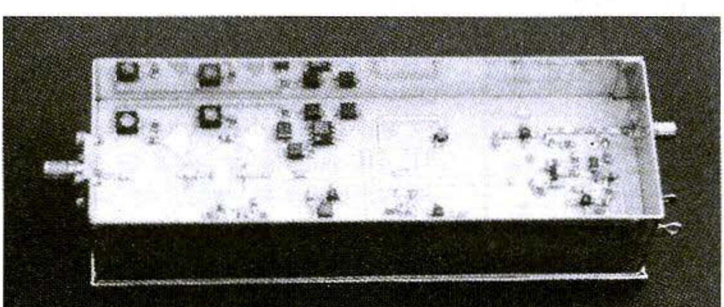


Photo of ready to operate 5.7 GHz Converter; the Track Structures are very easily recognisable

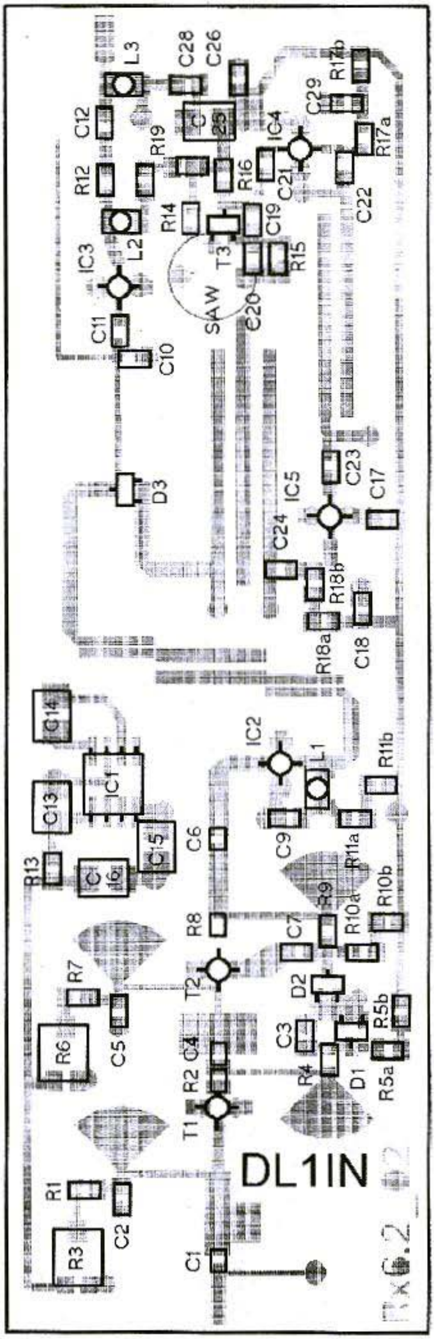


Fig. 4: Components Plan with SMD Components on Foil Side

Power for the converter can be supplied optionally through the intermediate frequency cable or separately through a 1 nF feedthrough capacitor. The suppressor diode D 4 is intended to provide protection against excessively high voltages and reverse connections.

8 V was selected as the internal operational voltage for the converter. The voltage multipliers for the ERA amplifier are each made up of two parallel SMD resistances, in order to attain the necessary rating.

The layout of the input stages has been optimised using the simulation software Silver Star from Eagleware, for minimal background noise and the largest possible amplification under conditions of absolute stability (K < 1, B > 0). Fig. 3 shows a typical curve for the circuits noise factor and transmission amplification.

3. ASSEMBLY

The printed circuit board, made from 0.5 mm. thick Rogers material RO4003, is soldered into a tinplate housing measuring 30 mm. x 37 mm. x 111 mm.. All the SMD components are on the foil side (Fig. 4).

Essentially, SMD format 0805 is used. Only on the drain connections of HEMT T1 and T2 was format 0402 needed for R2, R8 and C4, in order to attain the desired values for sensitivity and stability with the pre-set line lengths.

The SAW resonator and a wire strap to the voltage regulator are on the back of the printed circuit board. The 8-V fixed voltage regulator is soldered directly to the housing for better heat dissipation.

Just a tip from personal experience because some of the SMD components for this circuit are especially small, this article is addressed only to experienced DIYers with a very steady hand.

This project can therefore also be obtained as a complete ready-to-operate module.

4. LITERATURE

[1] RF Monolithics data book

[2] DUBUS 2/98, P. 32

High-Order Frequency Multipliers using MMIC Devices

[3] Eagelware Corporation, Genesys, version 6

Simulation Manual

[4] NEC data sheet NE 32584

Matjaz Vidmar, S53MV

Correction to Marker Counter for Spectrum Analysers in 4/1999

Page 234 of issue 4/1999 contained Fig 2 which was titled Prescaler. It was in fact a copy of Fig 1 on page 231. The diagram shown on this page is the correct Fig 2.

Thanks to Matjaz for sending the correct diagram in time for this issue.

Policy on Errors

Every effort is made to ensure that there are no errors in this publication, but it is always possible that one or two will get missed. If you spot a mistake please either write or email the editor and if possible a correction will be published in the next issue.

Where possible the error will also be published on the VHF Communications web site so that keen constructors won't have to wait three months to find out why their new project is not working properly !

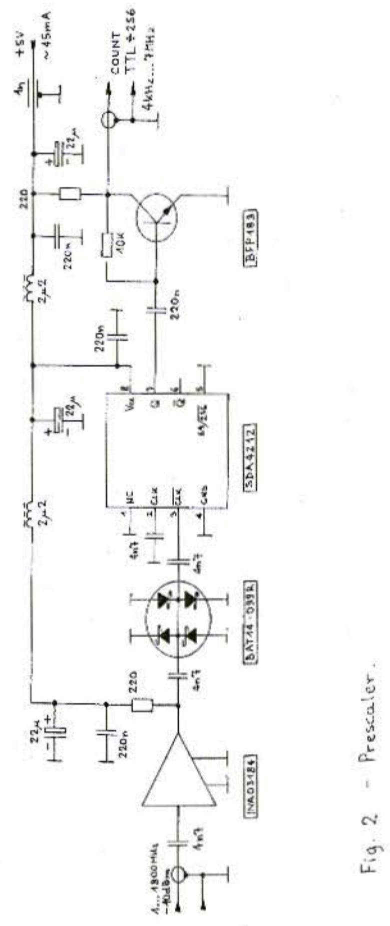


Fig 2 : Prescaler

Index of Volume 31 (1999)

23 cm BAND

3 cm BAND

MEASURING TECHNOLOGY

FUNDAMENTALS & NEW TECHNOLOGY

WEATHER SATELLITE RECEPTION

MISCELLANEOUS

Wolfgang Schneider, DJ8 ES

SSB/CW TRANSCEIVER FOR 144 MHZ

Building a complete transceiver yourself still represents a big challenge for a radio amateur. Technology has changed over the years, but so have the demands which will be made on equipment of this nature, irrespective of whether it is a transceiver for short-wave signals or for the VHF/UHF bands.

This article describes how an SSB/CW transceiver for the 2-m. amateur radio band can be constructed.

The possibility of using this as a control transceiver (add-on) for GHz transverters has been considered at all stages of development.

1. INTRODUCTION

The research I have carried out leads me to the conclusion that all the articles published on this subject in the last 30 years can be counted on the fingers of my two hands. Let them be represented by the SSB transceiver for the 2-m. band from DC6 HL [1], the 2-m./70-cm. transceiver according to DJ7 QY [2], and the zero-IF transceiver for the GHz bands from S53 MV [3].

In the concept laid out below, special importance has been given to modular structure, reproducibility and simplicity of operation. A DDS oscillator was selected, which has already been described in detail in this review [4], and the advantages of which, among others, include the smallest possible step size of 1 Hz.

2. THE ASSEMBLIES

The block diagram (Fig. 1) shows the structure of the complete SSB/CW transceiver for 144 MHz. The individual functional units are described in greater detail below.

2.1. The DDS oscillator

With present-day technology, it is relatively simple to create a DDS oscillator (DDS = Direct Digital Synthesiser) (Fig. 2) and it is also a genuine alternative to standard oscillators in terms of price. The technical advantages for such modules cannot be ignored. Special advantages, in particular,

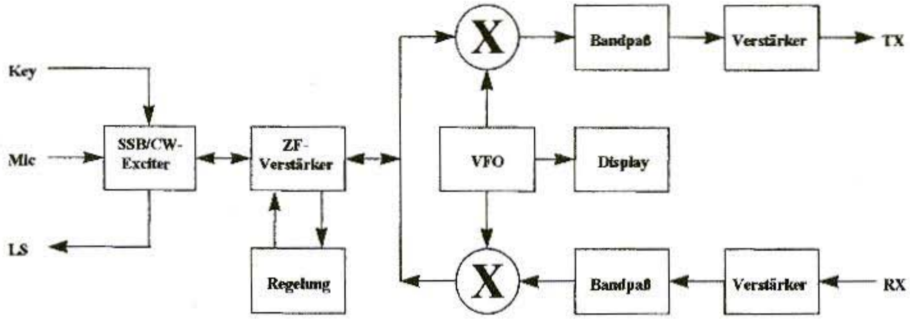


Fig. 1: Block Diagram for SSB/CW Transceiver

(ZF-Verstärker = Intermediate-frequency amplifier, Regelung = Adjustment, Bandpaß = Band pass, Verstärker = Amplifier)

are the high frequency stability, the clean output signal, the wide tuning range (which covers the entire frequency range desired without any problems), the ease of assembly and relatively low cost.

2.1.1. DDS oscillator circuit description

The core of the circuit is the integrated AD 9850 DDS module from Analog Devices. It supplies a sinusoidal output voltage at 50 Ohms. The usable fre-

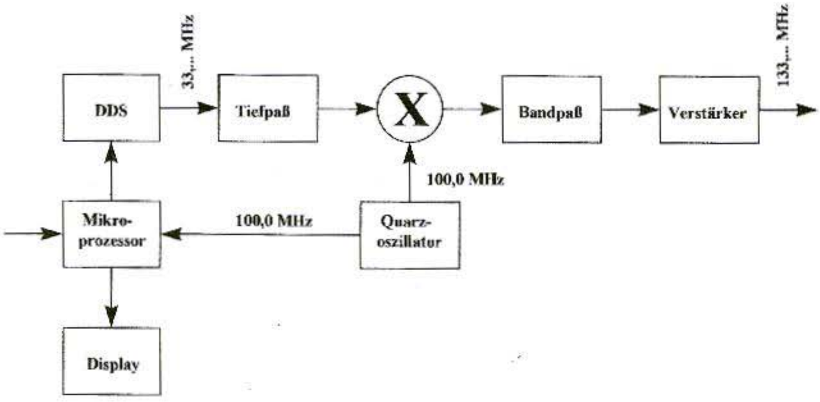


Fig. 2: DDS Oscillator with Mixer after 133 MHz

(Mikro-prozessor = Micro-processor, Tiefpaß = Deep pass, Quarz-oszillator = Crystal oscillator, Bandpaß = Band pass, Verstärker = Amplifier)

quency lies in the range between 0 Hz and approximately 33% of the clock frequency. Thus, for a 100 MHz clock oscillator, the maximum usable frequency is approximately 33 MHz. The background to this restriction is the output spectrum of a DDS module which, in addition to the desired frequency (fundamental wave) also generates alias products such as: clock frequency + fundamental wave and clock frequency fundamental wave. The same applies to the clock frequency x 2, the clock frequency x 3, and so on. This again results in an infinite quantity of mixed products.

The spectrum can be restricted only by a high pass filter with flanks as steep as possible at 30 to 40% of the clock frequency. The required parameters can be achieved by using a 7 pole Butterworth high pass filter which has been characterised for 50 Ohms. All values are normalised to standard values; the limiting frequency is approximately 40 MHz.

The DDSs output signal of 33.3 to 35.3 MHz is mixed up to the required 133.3 to 135.3 MHz in the subsequent mixer (NE 612). The mixing signal for this comes from the existing reference oscillator (100 MHz).

The 2 stage band pass filter is followed by a broad-band amplifier module (type MSA 0104), which raises the output signal to approximately 0.5 mW (- 3 dBm) (Fig. 3).

The DDS module receives frequency data from a serial input. To this end, the serial data, W Clock (Word Clock) and FQ UP (Frequency Update) lines are fed out through Teflon bushings to the C501

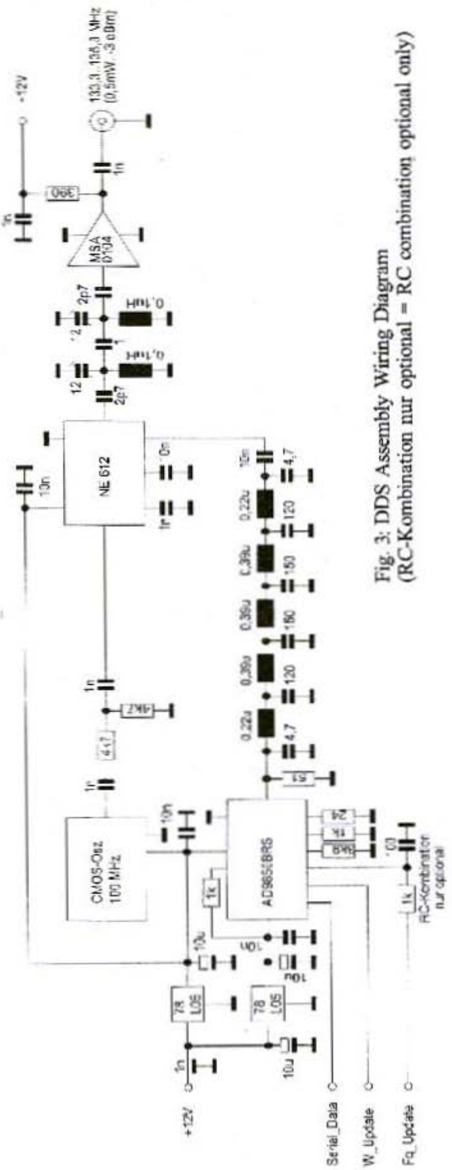


Fig. 3: DDS Assembly Wiring Diagram (RC-Kombination nur optional = RC combination optional only)

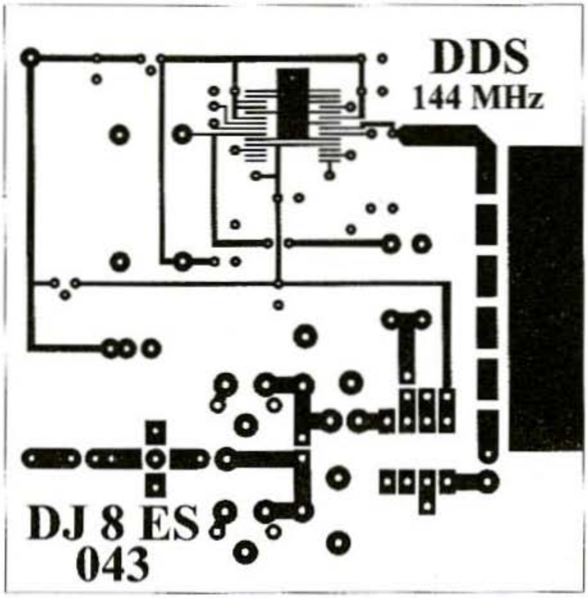


Fig. 4: Layout of DJ8ES 043 DDS Printed Circuit Board

micro-controller Uniboard connection of DG4RBF (4).

2.1.2. Assembly instructions

The circuit for the complete DSS oscillator is mounted on a double-sided epoxy printed circuit board measuring 72 mm. x 72 mm. (Fig. 4). The printed

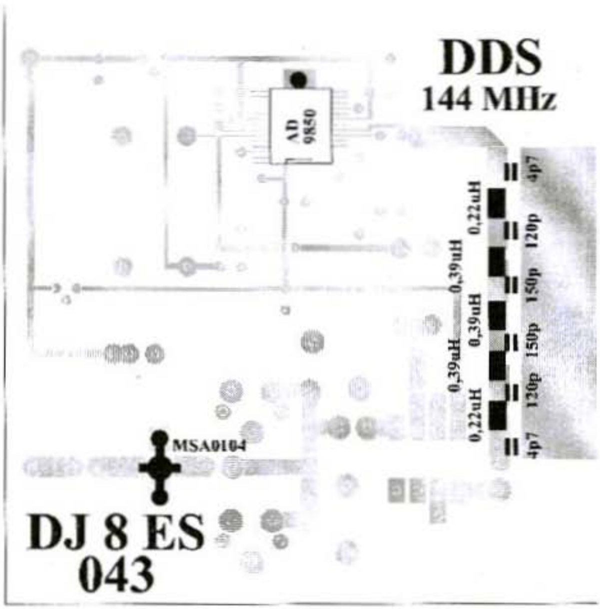


Fig. 5: Foil Side with DDS Components and other Components

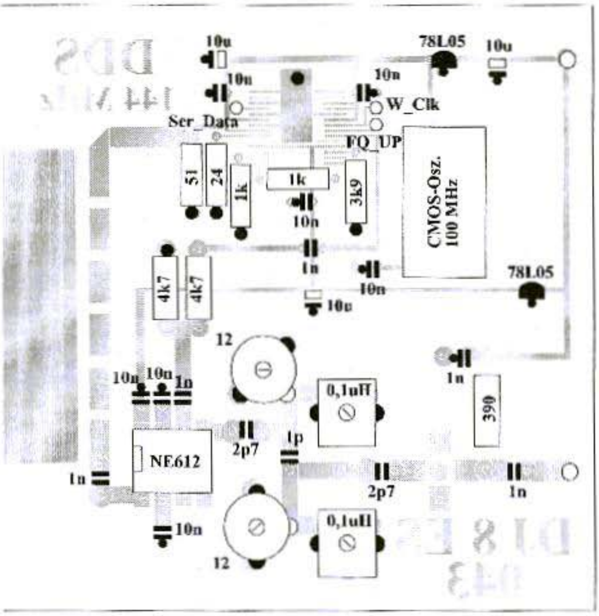


Fig. 6: Components Side of DDS Assembly for 144 MHz

circuit board fits into a standard tinplate housing measuring 74 mm. x 74 mm. x 30 mm..

First, the earth connection for the AD 9850 is created using a compression rivet. It makes sense to fit the relatively expensive DDS module last (Fig. 5). The AD 9850 DDS module is soldered on the foil side. This is an IC in a SMD housing, with a half screen interval of only 0.65 mm.! For assembly, use a very fine soldering iron tip and a magnifying glass.

All other components are inserted from the components side as usual (Fig. 6) and then soldered. Earth connections are soldered on both sides.

2.1.3. DDS components list

1 x AD 9850BRS, DDS

1 x MSA 0104, MMIC

1 x NE 612, mixer IC

2 x 78L05, voltage regulator

1 x CMOS 100.0 MHz crystal oscillator

2 x BV5061, Neosid 0.1 µH ready-made coil

2 x 12 pF foil trimmer, yellow

3 x 10 µF, 25 V tantalum electrolytic capacitor

1 x 390 Ohms, 0.5 W

1 x tinplate housing, 74 x 74 x 30 mm.

1 x 1 nF DF-Kond, solderable

3 x Teflon bushing

1 x SMA flanged bush

1 x SMA connector

1 x 4 mm.soldering tag

4 x compression rivet

1 x DJ8 ES 043 printed circuit board, DDS oscillator

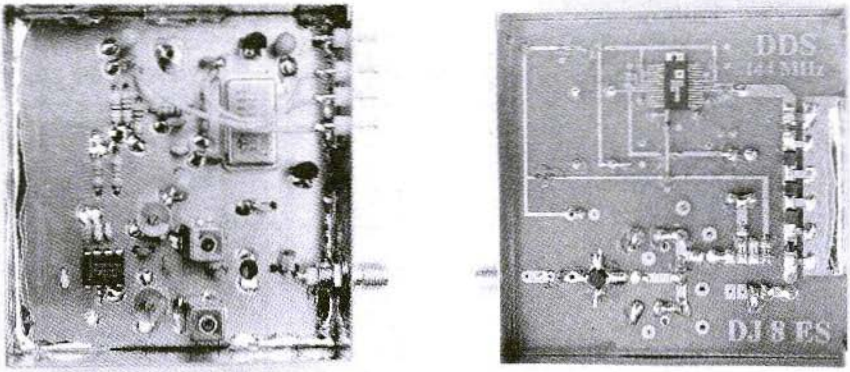


Fig. 7: Prototype of DDS for 144 MHz, a) Top b) Bottom

1 x 24 Ohms, 0.1 W; RM 10 mm.

1 x 51 Ohms, 0.1 W; RM 10 mm.

2 x 1 kOhms, 0.1 W; RM 10 mm.

1 x 3.9 kOhms, 0.1 W; RM 10 mm.

1 x 4.7 kOhms, 0.1 W; RM 10 mm.

1 x 1 pF, ceramic wafer-Cs, EGPU

2 x 2.7 pF RM 2.5 mm.

6 x 1 nF,

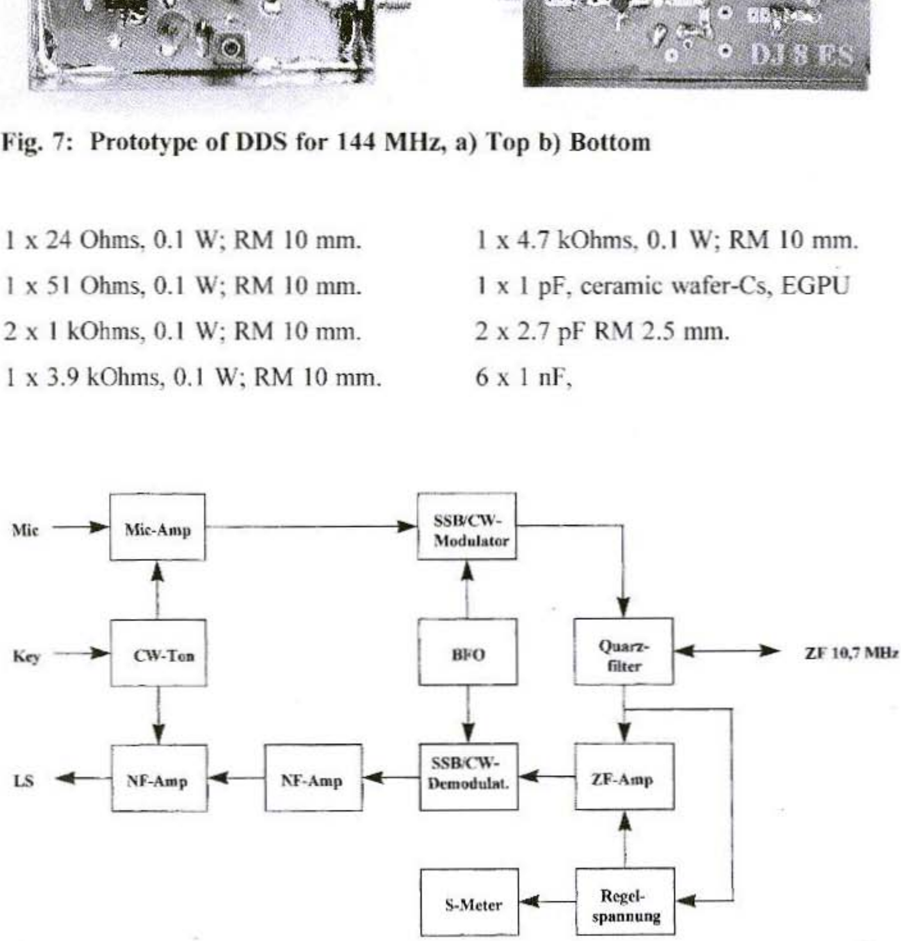


Fig. 8: Block Diagram for SSB/CW Preparation with Intermediate-Frequency Amplifier

(CW-Ton=CW tone, NF-Amp=Low-frequency amplifier, Quarz-filter=Crystal filter, ZF-Amp=Intermediate-frequency filter, Regel-spannung=Control voltage)

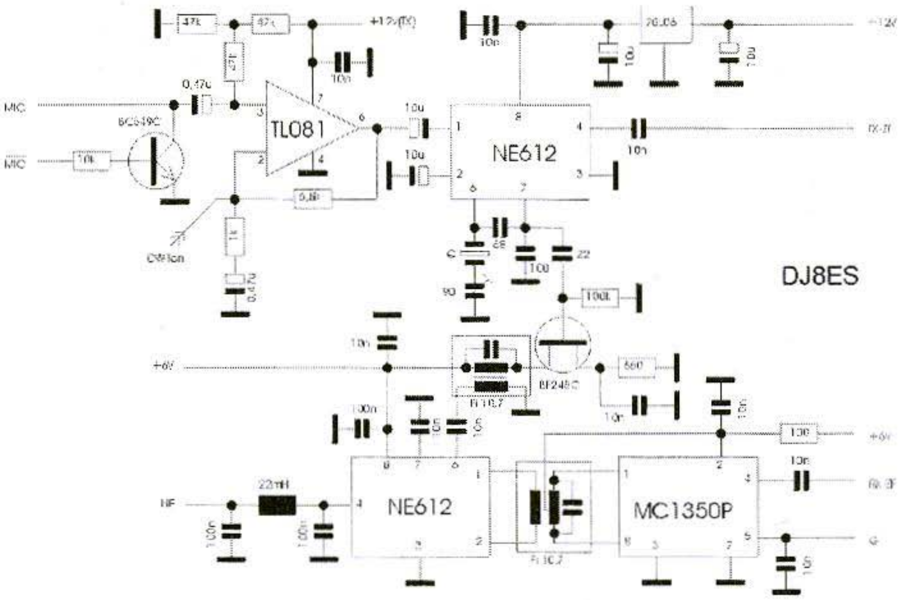


Fig. 9: Wiring Diagram for Microphone Amplifier, Mixer and Intermediate-Frequency Amplifier Stages

5 x 10 nF,

2 x 0.22 µH, SMD choke

3 x 0.39 µH, SMD choke

2 x 4.7 pF, SMD-C

2 x 120 pF, SMD-C

2 x 150 pF, SMD-C

2.1.4. Putting DDS into operation

To put the DDS into operation with the AD 9850, the assembly is connectd to the operating voltage + 12 V (150 mA) and joined up to the micro-controller. For a more detailed description, see the article by Bernd Kaa [4].

The two 12 pF foil trimmers in the 2-circuit band filter are the sole balancing elements. They should be reciprocally set to the maximum output power.

The output frequency of the DDS module starts at 133.3 MHz and goes up to a maximum of 135.3 MHz. Thus the entire 2-m. amateur radio band is covered, plus the intermediate frequencies from 10.7 MHz. The output power is approximately 0.5 mW (- 3 dBm).

2.1.5. DDS control

The DDS assembly and other functions of the SSB/CW transceiver are controlled through the C501 Uniboard micro-controller board [4]. The operating software is housed in an EPROM. Certain parallels with the KW4 QRP short-wave transceiver will have struck the attentive reader [5].

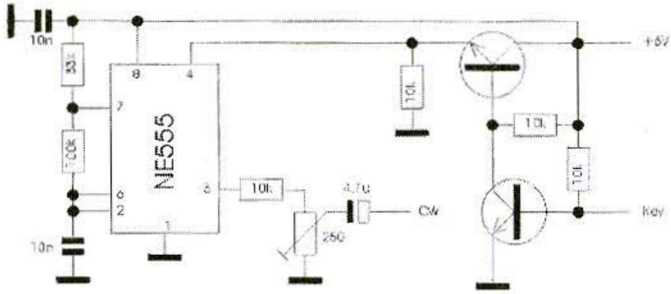


Fig. 10: Tone Generator for Morse Keys

2.2. SSB/CW exciter

The preparation of the SSB/CW involves all the stages required for the modulation or demodulation of a SSB or CW signal, including the low-frequency section. Thus a microphone, a loudspeaker and a Morse key can be connected directly here. In addition, the intermediate-frequency amplifier with a crystal filter for 10.7 MHz, the regulator voltage generation and the S-meter are constituent elements of this assembly.

The interaction of the individual functional units in the SSB/CW exciter is shown in the block diagram in Fig. 8.

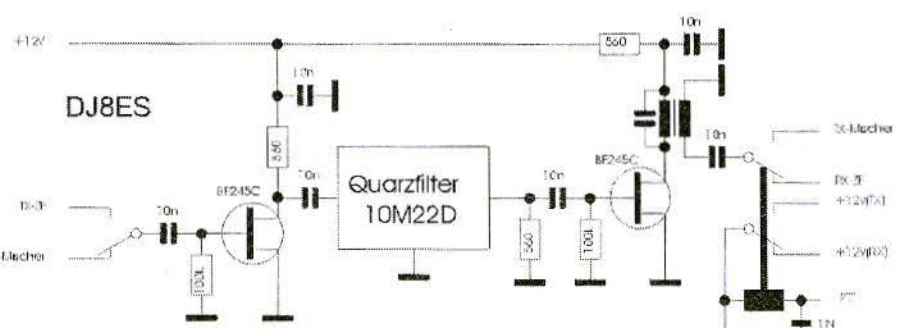


Fig. 11: Wiring Diagram for Crystal Filter Assembly with Transmission/ Reception Change-over

(Quarzfilter = Crystal filter, Mischer = Mixer)

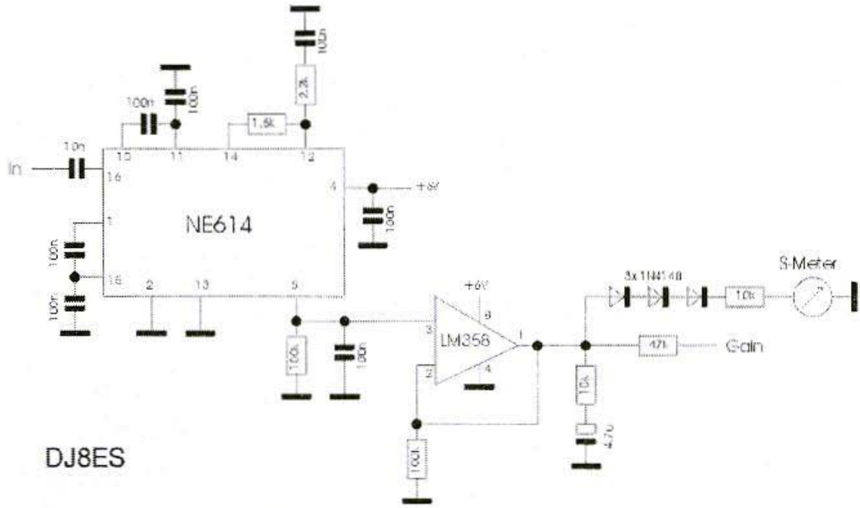


Fig. 12: Control Voltage Generation for S-Meter

2.2.1. SSB/CW exciter circuit description

The microphone signal is first amplified by a factor of 8, using a low-noise operational amplifier (TL 081) (Fig. 9). The subsequent mixer (NE 612) is thus still not overloaded. The amplification is fixed by means of the feedback resistors, and thus a MIC gain control can be dispensed with!

The CW tone of approximately 800 Hz is also fed in through the microphone amplifier. It is generated through an NE 555 timer IC (Fig. 10). The frequency is determined by the RC combination 33 kOhms / 100 kOhms / 10 nF. The CW signal is coupled through a 250 Ohm trimmer to set the level.

The CW key (LOW-active) is connected to the HIGH-active trigger input of the generator IC through a transistor stage

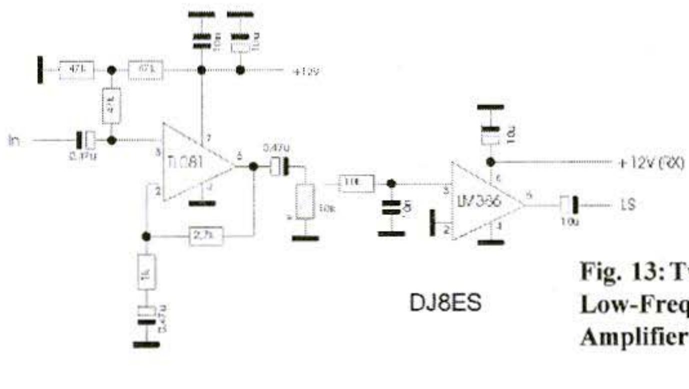


Fig. 13: Two-Stage Low-Frequency Amplifier

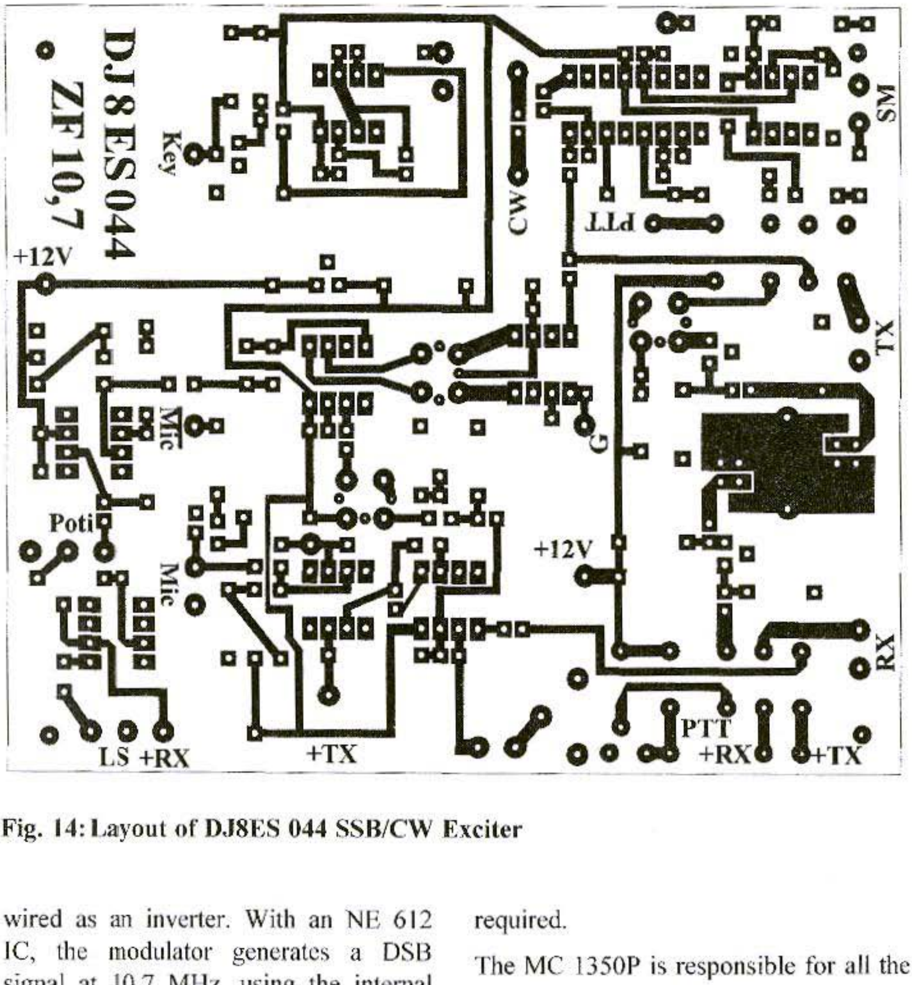


Fig. 14: Layout of DJ8ES 044 SSB/CW Exciter

wired as an inverter. With an NE 612 IC, the modulator generates a DSB signal at 10.7 MHz, using the internal oscillator. The crystal frequency is 10.6985 MHz (sideband crystal for USB).

A crystal filter suppresses the unwanted sideband, together with the carrier frequency (Fig. 11). At the output, the USB transmission signal, with a level of approximately 0.5 mW (- 3 dBm), is available to drive the transmission mixer. The crystal filter is used bi-directionally and is switched over when required.

The MC 1350P is responsible for all the intermediate-frequency amplification required in receive mode. Depending on the control voltage, this IC amplifies to maximum 60 dB. The control voltage (Fig. 12) is obtained from an integrated intermediate-frequency amplification module (NE 614 intermediate-frequency IC) with field strength output immediately behind the crystal filter. Following the necessary level matching, a sensitive moving coil instrument (e.g. 100 µA) displays the received field strength as an

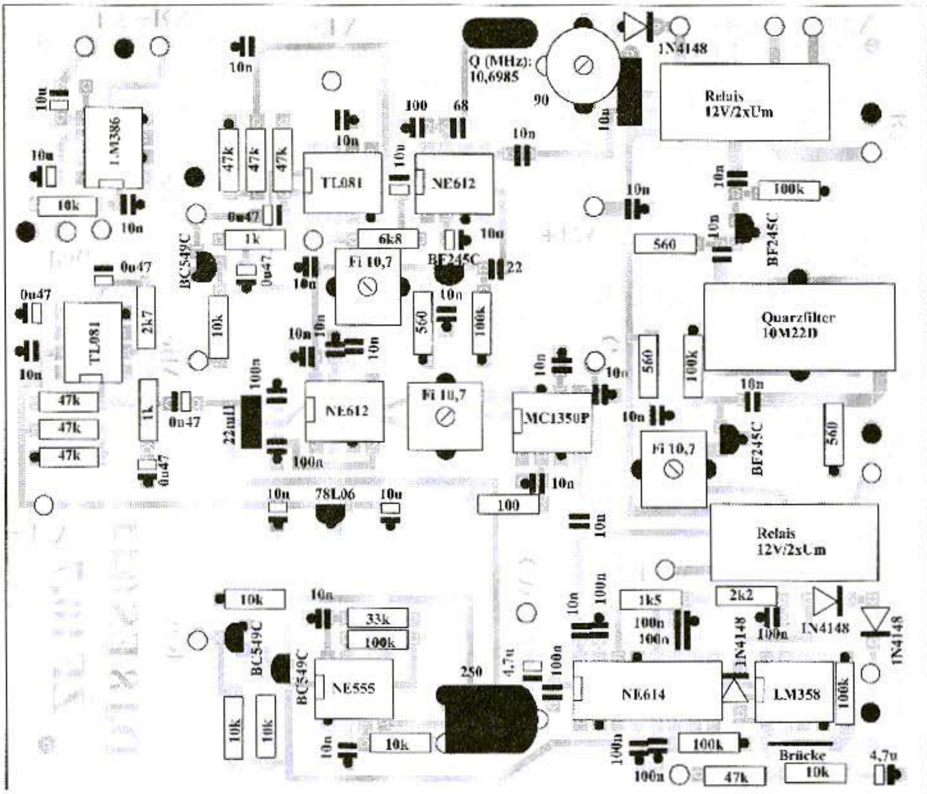


Fig. 15: Component Plan of SSB/CW Exciter (Relais = Relay, Quarzfilter = Crystal filter, Brücke = Bridge)

S-meter.

An NE 612 mixer IC is again used as demodulator. However, here the side-band oscillator is powered externally from the modulator IC. The demodulated reception signal runs through a low pass filter to remove the high frequency signals. The low frequency amplifier has two stages (Fig. 13). The first stage, with V = 4, acts merely as a pre-amplifier. The final amplifier is an LM 386 fed through the volume control (10 k Ohms). With an amplification of max. x 200, this low-frequency IC supplies an output power of app. 0.5 W at 8 Ohms.

2.2.2. Assembly instructions for SSB/CW exciter

The SSB/CW exciter element (DJ8 ES044) for the 144 MHz transceiver is assembled on a double-sided coated epoxy printed circuit board measuring 100 mm. x 120 mm. (Fig. 14). The componet side is not etched. This guarantees good earthing conditions.

First the holes are drilled for the components (0.8 mm.). The earth surface can then be taken away around the

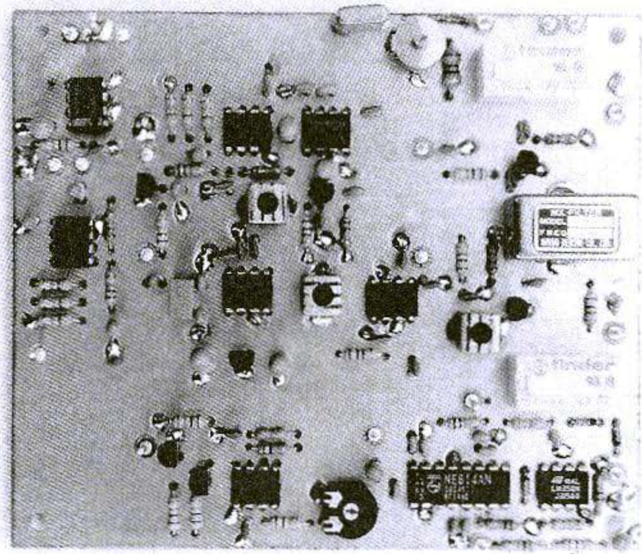


Fig. 16: Plan View of Assembled Prototype of SSB/CW Exciter

holes on the component side, using a 2.5-mm. drill. N.B.: The earth surface around the holes must remain for all earth connections! The individual component is later soldered directly on the earth surface.

The position of the components is shown on the component plan (Fig. 15).

2.2.3. SSB/CW exciter components list

2 x NE 612, integrated mixer circuit

1 x NE 614, log amplifier

1 x MC 1350P, intermediate-frequency amplifier

1 x LM 386, low-frequency amplifier

1 x NE 555, timer

1 x LM 358, OP

2 x TL 081, OP

3 x BC 549C, transistor

3 x BF 245C, FET

1 x 78 L06, 6-V voltage regulator

4 x IN 4148, Si diode

6 x 0.47 µF, 25 V, tantalum electrolytic capacitor

2 x 4.7 µF, 25 V, tantalum electrolytic capacitor

6 x 10 µF, 25 V, tantalum electrolytic capacitor

1 x 250 W, horizontal trimmer potentiometer, RM 5/10 mm.

1 x 10 kW linear potentiometer, 6 mm. axis

1 x 90 µF, foil trimmer, red, RM 5/10 mm.

1 x 22 mH vertical choke, RM 5 mm.

1 x 10 µH horizontal choke, RM 10 mm.

1 x DJ8 ES044 SSB/CW exciter printed

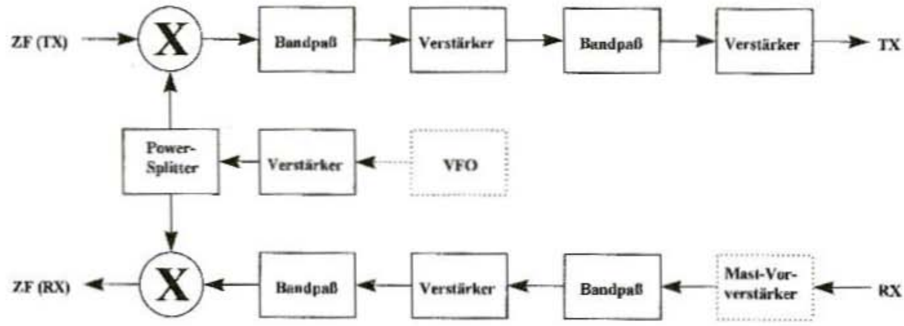


Fig. 17: Block Diagram of 144 MHz/10.7 MHz Transmission/Reception Mixer

(Bandpaß = Band pass, Verstärker = Amplifier, Mast-Vor-verstärker = Masthead pre-amplifier)

circuit board

1 x 10.6985 MHz crystal (USB side-band crystal)

1 x 10M 22D crystal filter, alternative 10M 22C

3 x 10.7 MHz LC ready-made filter, green, RM 5 mm.

2 x relay 2 x UM, 12 V

27 x 1.3 mm. soldering stud

1 x 100 Ohms, each 0.1 MW, RM 10 mm.

4 x 560 Ohms

2 x 1 kOhm

1 x 1.5 kOhms

1 x 2.2 kOhms

1 x 2.7 kOhms

1 x 6.8 kOhms

7 x 10 kOhms

1 x 33 kOhms

7 x 47 kOhms

6 x 100 kOhms

1 x 22 pF, ceramic wafer-Cs, EGPU

1 x 68 pF, RM 2.5 mm.

1 x 100 pF

21 x 10 nF

9 x 100 nF

2.2.4. Putting SSB/CW exciter into operation

Following a visual check of the fully equipped printed circuit board (Fig. 16), the operational voltage of + 12 V can be applied. The functioning of the sideband oscillator can easily be checked using an oscilloscope at the 10.7 MHz filter pot (secondary side on 10 nF capacitor). The coil core can be used to adjust to the maximum output level. The precise frequency of 10.6985 MHz is set by fine adjustment of the 90 pF trimmer.

The microphone can now be connected, and + 12 V can be fed into the

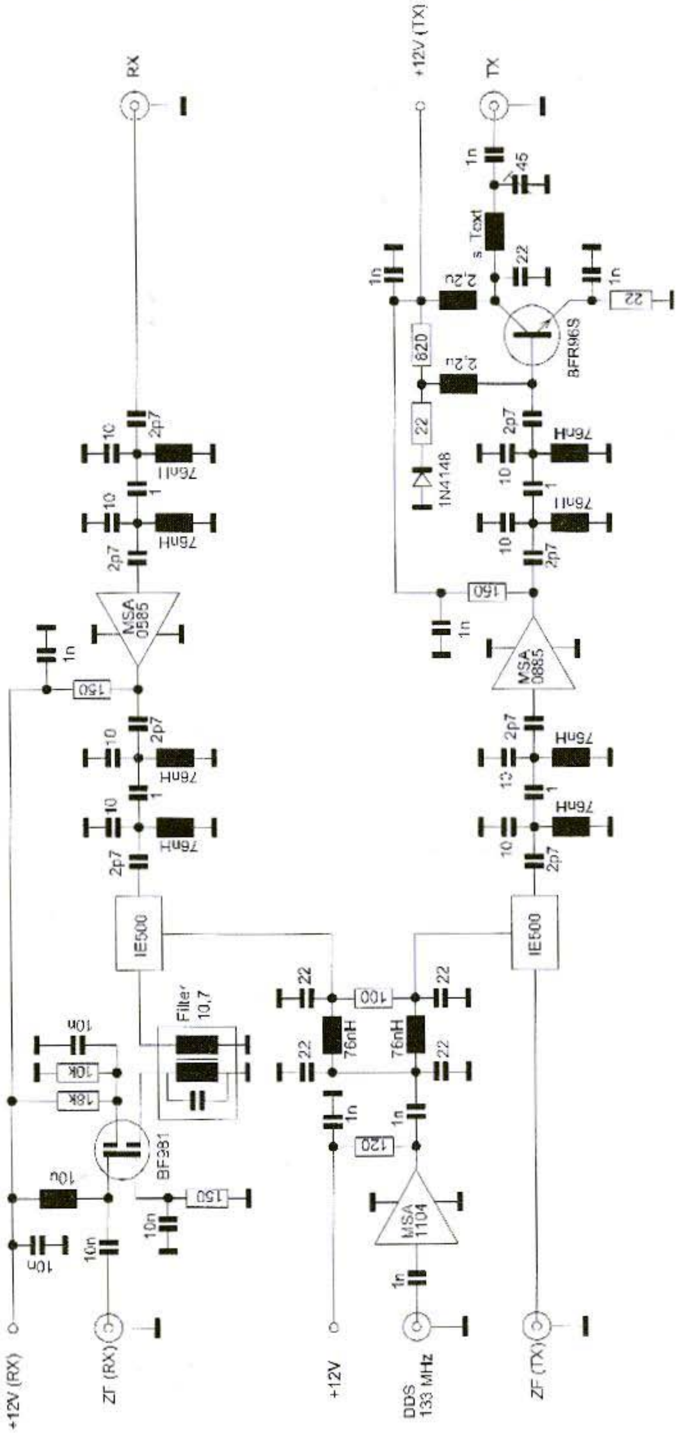


Fig. 18: Wiring Diagram of Transmit/Receive Mixer with IE 500 Ring Mixer

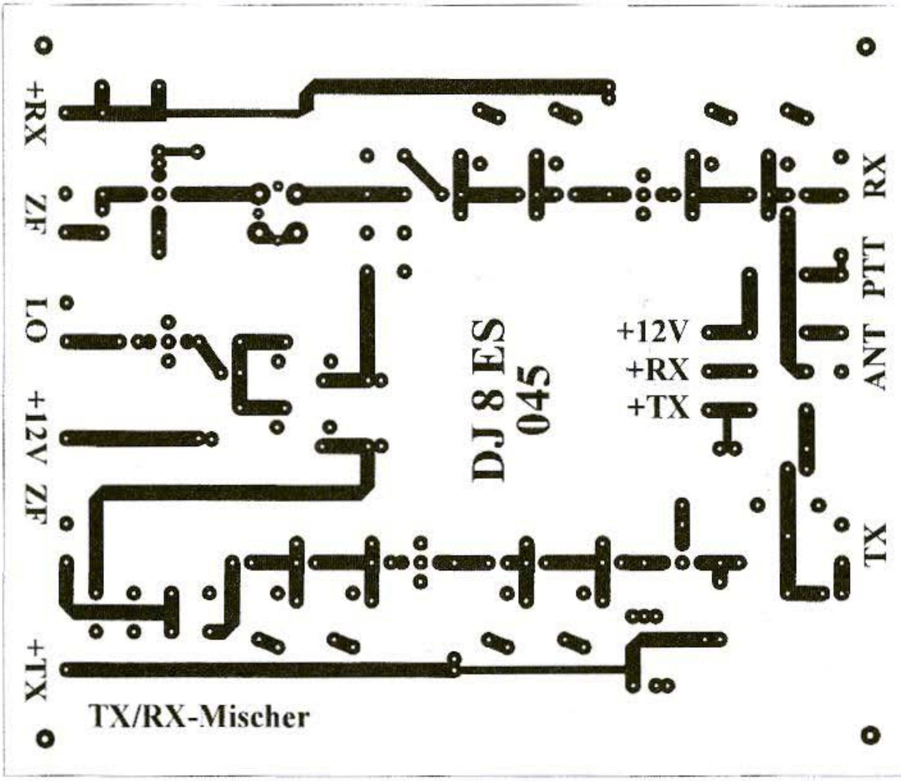


Fig. 19: Layout of DJ8ES 045 Transmission/Reception Mixer (Mischer = Mixer)

microphone amplifier (TL 081, pin 7). The signals (low-frequency and high-frequency signals) can be tracked stage by stage. Measurement points are, for example, the input or output of the TL 081 microphone amplifier, the output of the NE 612 modulator, and the input and output of the crystal filter. N.B.: Do not forget that the PTT must be connected to earth for receive.

If a loudspeaker is now connected and the low-frequency amplifier (TL 081 and LM 386) is powered at the operational voltage (+ 12 V), the equipments own transmission signal becomes audible on the 10.7 MHz intermediate-frequency band. The functioning of the demodulator and the low frequency amplifier can likewise be assumed. A connected S-meter shows a corresponding movement of the needle when modulation is applied.

Checking the functioning of the CW tone generator is also very simple. Connect up Morse keys and check the signal at the CW output using an oscilloscope. There must be a square-wave voltage here, with a frequency of approximately 800 Hz.

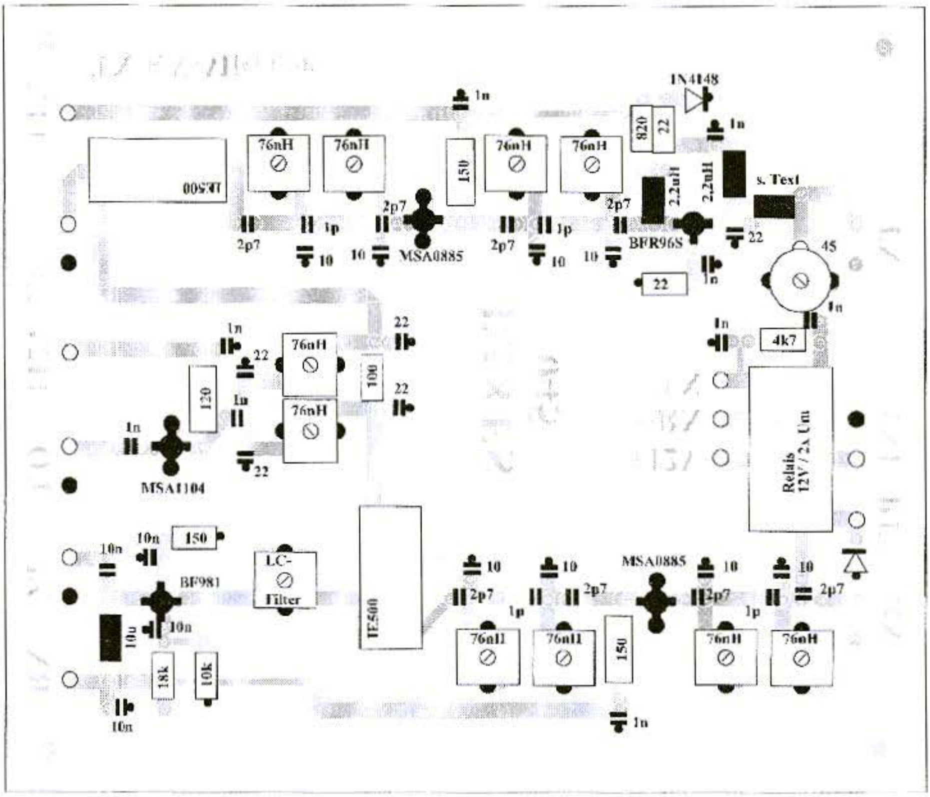


Fig. 20: Component Plan of Transmit/Receive Mixer (Relais = Relay)

2.3. TX/RX mixer

The TX/Rx mixer converts the 10.7 MHz intermediate frequency signal directly to the 2-m. amateur radio band (Fig. 17). The DDS module described controls the frequency by micro controller control [6].

In accordance with the overall concept, as a control transceiver for GHz transverters, an output power of approximately 100 mW is sufficient here. The receiver input is designed for good high-level signal behaviour.

For possible use as a station transceiver, the TX/RX mixer can easily be supplemented by an additional power amplifier and a reception pre-amplifier.

2.3.1. TX/RX mixer circuit description

The DDS oscillator signal is amplified to approximately 20 mW using an MSA 1104 MMIC. The discretely assembled Wilkinson hybrid divides the oscillator level uniformly into transmission and reception branches. The necessary signal

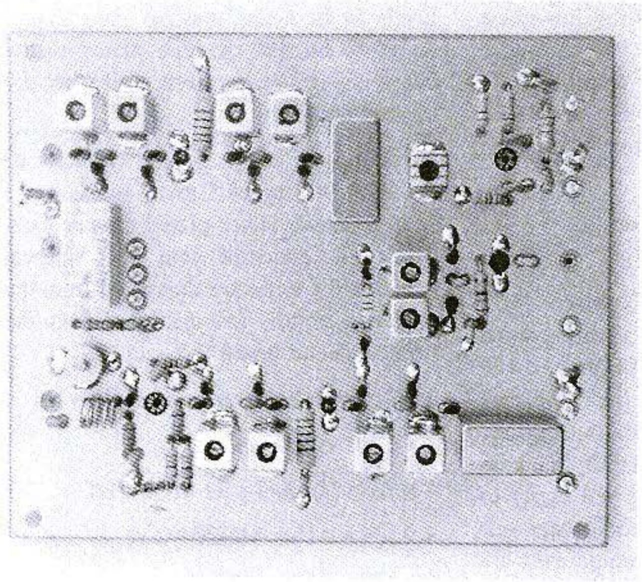


Fig. 21: Fully Assembled Prototype of TX/RX Mixer

level is thus available to both IE 500 ring mixers.

In the transmission branch, the mixer is fed, not only by the oscillator (133.3 to 135.3 MHz), but also by the SSB/CW exciter assembly, at 10.7 MHz.

The usable signal at 144 MHz is filtered out through a 2 stage filter. The values have been chosen to attain the suppression of oscillator and signal frequencies. A second 2 stage filter suppresses the oscillator and signal frequencies further.

The subsequent amplifier stage is assembled using an MMIC (monolithic microwave integrated circuit), type MSA 0885, which supplies approximately 30 dB amplification at 144 MHz for a maximum output power of 10 mW. Be especially careful here to mount the components neatly, using short connecting wires, otherwise there will be a tendency to oscillate.

And finally, the transistor stage amplifies the transmission signal to the desired value of approximately 100 mW with a BFR 96S. This allows direct feeding of either transverters for the GHz range or power amplifiers [6] for the 2-m. amateur radio band.

The reception branch attains its high selectivity, in particular, through the 2 stage band pass filter directly at the input. Since the entire transverter is strictly orientated around the standards of 50-Ohm technology, this filter is structured like the one already described in the transmitter.

Before the reception signal is mixed down to 10.7 MHz, it first runs through an amplifier stage (MSA 0885) and the second band pass filter. A type IE-500 ring mixer is used in the reception branch as well.

The mixed-down reception signal is coupled through the ready-made filter for 10.7 MHz and fed to the low-noise amplifier stage with a BF 981 dual-gate MOS FET. This stage amplifies the signal somewhat to 20 dB, and thus guarantees the level required for feeding the SSB/CW exciter.

2.3.2. TX/RX mixer assembly instructions

The board for the TX/RX mixer (DJ8 ES045) is a double-sided epoxy printed circuit board measuring 100 mm. x 120 mm. (Fig. 19). When the soldering points have been drilled (0.8 mm.), they are countersunk from the earth side with a 2.5-mm. drill. This does not apply to the earth connections, which are soldered on both sides. All components are mounted from the fully-coated side (Fig. 20).

The stripline transistors (BF 981, BFR 96S) and the MMICs (MSA 1104, MSA 0885) are inserted into the board. Appropriate holes should be drilled for this purpose: for the MMICs, 4 mm. or 2.5 mm., and for the transistors 5 mm. These techniques provide suitable mounting for high-frequency equipment, with short connecting wires. This guarantees stable operational behaviour and makes the equipment easy to copy.

All band pass filters, both ring mixers and the foil trimmer are also each soldered to the earth surface at two points.

One piece of advice here if another type of ring mixer is to be used as an alternative to the IE 500 ring mixer proposed (for example, SRA-1 or SBL-1), the technical data may indeed be comparable, but it is possible that the earth connections will not connect firmly to the metal housing. They should therefore be through-hole plated to the board using compression rivets, as described earlier.

The coupling coil L on the collector of the BFR 96S has 4.5 turns and is made from 0.8 mm. silver-plated copper wire. The coil diameter and the interval between the turns are measured from the soldering points. The clearance from the printed circuit board is 1 mm..

2.3.3. TX/RX mixer components list

1 x BFR 96S, transistor

1 x BF 981, dual-gate MOS FET

1 x MSA 1104, MMIC

2 x MSA 0885, MMIC

2 x 1N 4148, diode

2 x IE 500 ring mixer (SRA-1 or SBL-1)

10 x BV 51 4630, 0.076 uH Neosid ready-made filter

1 x LC ready-made filter, 10.7 MHz, green, RM 5 mm.

1 x 45 pF foil trimmer, violet

2 x 2.2 mH choke, RM 5 mm.

1 x 10 mH choke, RM 5 mm.

1 x 120 Ohms, 0.5 W, carbon film, RM 12.5 mm.

2 x 150 Ohms, 0.5 W, carbon film, RM 12.5 mm.

1 x relay, 2 x Um, 12 V

1 x coil, 4.5 turns, CuAg wire, 0.8 mm.

11 x soldering studs, 1.3 mm.

8 x compression rivets

1 x DJ8 ES045 TX/RX mixer board

Fig. 22: Frontplate of Specimen 2-m. Transceiver

1 x 10 Ohms, each 0.1 W, RM 10 mm.

1 x 22 Ohms

1 x 100 Ohms

1 x 150 Ohms

1 x 820 Ohms

1 x 4.7 kOhms

1 x 10 kOhms

1 x 18 kOhms

4 x 1 pF individual ceramic wafer-Cs

8 x 2.7 pF, EGPU with RM 2.5 mm.

8 x 10 pF

5 x 22 pF

9 x 1 nF

4 x 10 nF

2.3.4. Putting TX/RX mixer into operation

Following a successful visual check, the assembly can be put into operation in stages. The supply voltage for all components is + 12 V. This gives zero signal currents (i.e. without input) of 15 mA (LO), 45 mA (RX) and 100 mA (TX). At full drive, the current in the transmission section rises to 160 mA.

With input using a CW signal at 10.7 MHz, only the two band pass filters need to be set to maximum output power (100 mW), using the coil cores and the 45-pF foil trimmer at the output. A loud warning signal should immediately be heard in the receiver. Here too, the only adjustable elements are the two 2 stage filters.

3.
INTER-CONNECTION AND PUTTING INTO OPERATION

High-frequency assemblies, of whatever type, should essentially be incorporated in a screening housing (metal housing). This simultaneously prevents the re-radiation of undesirable frequencies and also the penetration of external interference into the equipment.

One of the biggest interference sources is in the equipment itself. The micro-controller produces a spectrum of interference radiation covering the entire

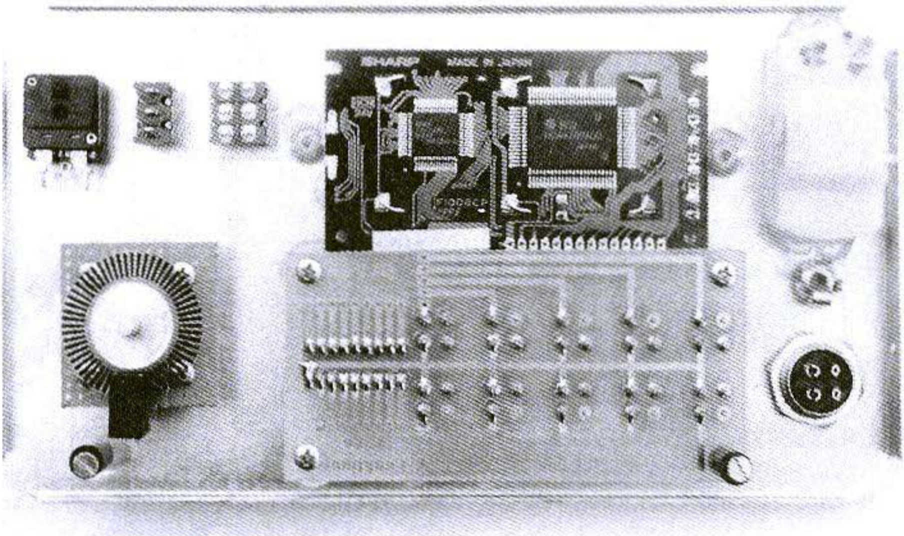


Fig. 23: Arrangement of Individual Elements on Back of Frontplate

VHF range. This printed circuit board must be mounted in a separate tinplate housing measuring 74 mm. x 146 mm. x 30 mm.. All connections here can be fed through a 25-pin SUB-D connector (or 9 pins, for the LC display). These connectors can be supplied in a special electro-magnetically compatible version. A 1 nF solderable feedthrough capacitor is used for the supply voltage.

There are no further pre-conditions for the layout of the remaining assemblies or boards of the transceiver. However, unnecessarily long cable connections should be avoided here. In addition, unimpeded access to the assemblies should be possible for adjustment work.

3.1. Operating controls and connections

The number of operating controls and connections for the 144 MHz SSB/CW transceiver has been reduced to what is necessary. The only luxuries are the frequency storage keys, F1 to F4, on the front of the equipment.

3.1.1. Function keys

The function key assembly (DJ8 ES042) has already been used in the article on the 4-band QRP short-wave transceiver [5]. Here there are pressure keys for specific control functions such as band selection, RIT and frequency storage. The key control operates in a low-active manner i.e. all the keys switch to earth.

The switching outputs for the PTT switchover (including the sequencer) for operation with a powerful final stage and a masthead pre-amplifier, or as control transceiver for transverter mode, are available on the board at the same time.

The ULN 2803 is used as the integrated

driver circuit. Its switching outputs can cope with a current of max. 500 mA. The outputs pins 11 to 18, and the corresponding input is opposite. Thus, for example, if the input is pin 1, the output is pin 18, etc..

The same applies to the voltage supply: earthing at pin 9 and + 12 V at pin 10 of ULN 2803 integrated driver circuit. The function key printed circuit board (DJ8 ES042) consists of single-sided copper-coated epoxy material measuring 50 mm. x 100 mm..

3.1.2. Elements of front plate

In the prototype, the microphone jack and the connection for a headset are on the left-hand side of the front plate (Fig. 22), with the S-meter display above them.

The LC display always shows the current condition of the transceiver. Thus the status regarding VFO or storage mode, TX/RX and clarifier is always displayed.

The frequency is adjusted using the large tuning knob in the bottom right-hand corner (accuracy of display 10 Hz).

All operating controls are either screwed to the front panel directly or else fastened by means of glued-on M3 blind nuts. The adhesive used is two-component adhesive. The photo (Fig. 23) shows the layout of the components on the back of the front panel.

More effort is involved in mounting the shaft encoder. With the favourably-priced variant of the incremental transmitter used here from Sharp (type GP1 A70R), the hybrid light barrier and the dividing plate must be mounted to a spindle and a mounting plate (Fig. 24). Alternatively, enclosed models of shaft encoder can also be sought. In the end, this is merely a matter of price.

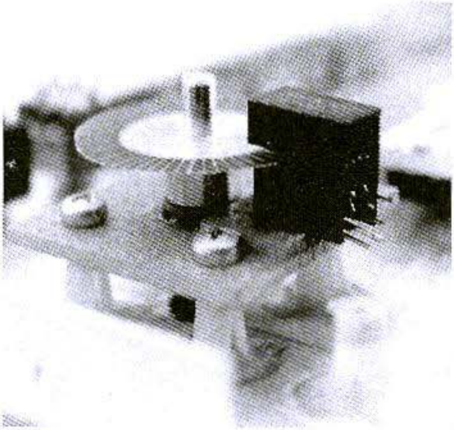


Fig. 24: Structure of Hybrid Light Barrier with Dividing Plate

3.2. Components list for assembly

1 x housing, 200 mm. x 100 mm. x 250 mm.

1 x LC display, 2 lines, each with 16 characters

1 x front frame for LC display

1 x 4-pin microphone jack

3 x 3.5 mm. jack plug

2 x flip switch, single-pole Um

1 x 10 kOhms (linear), potentiometer with switch

1 x S-meter, 100 µA

1 x turning knob, 15 mm.

1 x turning knob, 28 mm.

1 x PL jack (SO 239)

3 x chinch jack

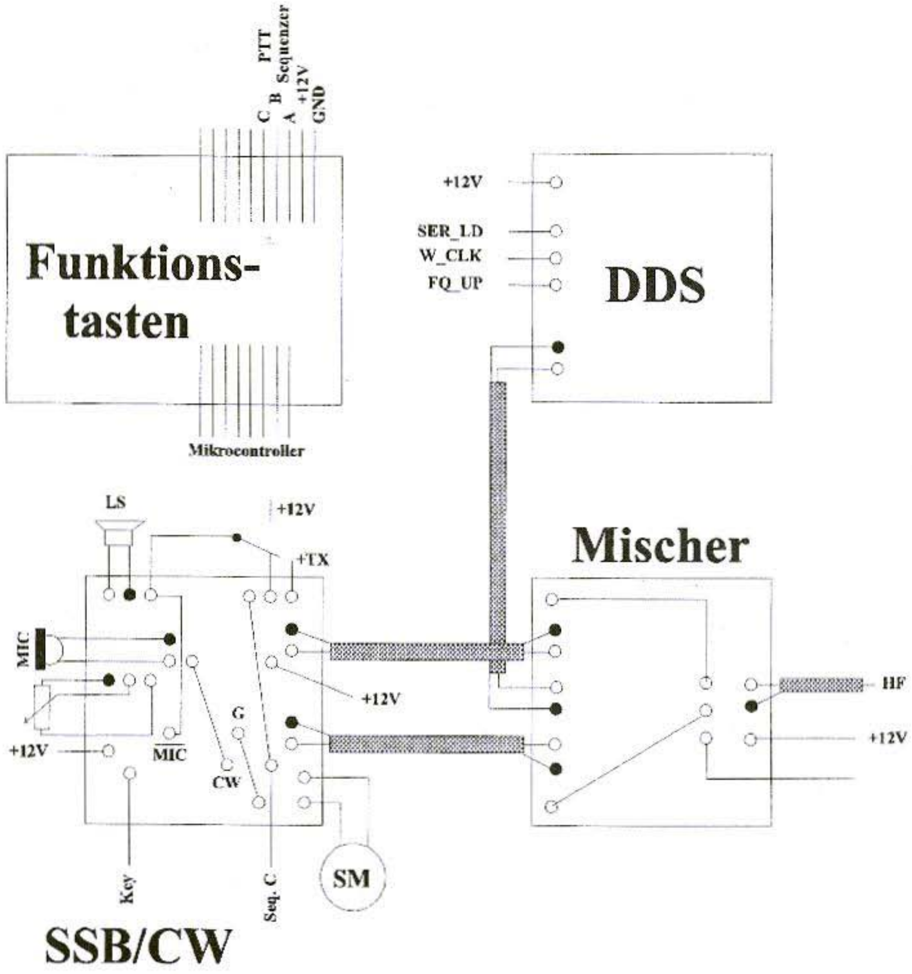


Fig. 25: Wiring Diagram of Assemblies of 2-m. Transceiver

(Funktions-tasten = Function keys, Sequenzer = Sequencer, Mikrocontroller = Micro-controller, Mischer = Mixer)

1 x fuse holder

1 x 2A fine-wire fuse

10 x pressure key

2 x pin jack, red or black

1 x breadboard

1 x SUB-D plug-type connector (elec-

tro-magnetically compatible), 9-pin

1 x SUB-D plug-type connector (electro-magnetically compatible), 25-pin

1 x incremental transmitter (e.g. GP1 A7OR, Sharp)

2 x flange sleeve

1 x breadboard

1 x 4 mm. axis

And in addition, miscellaneous installation material:

Ribbon cable

Stranded hook-up wire

RG 174 coax cable

M3 blind nuts

M3 screws with nuts

3.3. Wiring of assemblies

The SSB/CW transceiver for 144 MHz consists of 5 assemblies in all. The individual components are wired up to each other in accordance with the general plan in Fig. 25.

In detail, the following cable material is used for the internal wiring:

RG 174 coax cable for high-frequency connections

Screened low-frequency flexes for microphone, loudspeaker and volume control

Stranded hook-up wire for power supply

Switches, S-meters, etc.

Ribbon cable for connections to micro-controller

The article by Bernd Kaa, DG4 RBF, contains further instructions regarding the micro-controller, including the control lines and the operating software required for the 2-m. transceiver.

3.4. Putting into operation

Following the complete wiring up of all the VHF transceivers assemblies, the transceiver can be put into operation for the first time.

As far as possible, the individual stages should already have been tested and pre-set. Thus, for example, the functioning of the DDS oscillator can be checked in isolation.

When the equipment has been switched on and the switching on routines have been run through, check the display to see whether the micro-controller is functioning satisfactorily; this should show 144.300.00 MHz.

If an aerial is connected, signals from a strong station should now already be audible at 2 m.. For this purpose, the reception frequency is tuned using the shaft encoder. Even if absolutely no signal should be audible, still at least the loudspeaker should hiss!

It is simplest if the precise balancing of the band pass filter is carried out in transmission mode (CW). Thus, the amplitude of the individual frequencies can be displayed and tuned to the maximum, using an oscilloscope. During this phase, the transmitter should be connected to a wattmeter fitted with a 50-Ohm dummy load. The 250-Ohm potentiometer for the CW level is in the mid-position.

4.

OPERATING EXPERIENCES

The SSB/CW transceiver for 144 MHz has been developed as an add-on for GHz transverters. Special features such as, for example, PTT switching via coax cable, are naturally taken into account here.

The transmission section in the transceiver supplies approximately 100 mW at 144 MHz. This output can easily be adapted for various transverters.

The design of the receiver ensures high input sensitivity and high signal strength performance. Thus the first stage is the input 2 stage band pass filter, and only after this do we find an amplifier stage. With this design, the noise factor is approximately 5 dB. Since the amplification for standard transverters is approximately 20 dB, the entire system possesses the necessary receiver sensitivity.

The output power of approximately 100 mW is sufficient for driving a power amplifier. There are essentially two options here either a conventional two-stage or three-stage transistor amplifier or a modern hybrid module is used (e.g. M 57727 from Mitsubishi). This makes it simple to attain outputs of 20 to 50 Watts.

It is normal nowadays for VHF DX stations to use a masthead pre-amplifier to improve the reception sensitivity of the 2-m. SSB/CW transceiver.

5.

LITERATURE

[1] SSB Transceiver for the 2-m. Band DC 6HL VHF Reports, Seventies issue

[2] 2-m./70-cm. Transceiver DJ7QYDU-BUS, issue

[3] Zero Intermediate-Frequency Transceiver for GHz Bands S53MV From years 1996-1997

[4] Bernd Kaa, DG4 RBF C501 Uniboard Micro-Controller VHF Reports 3/98 Verlag UKW-Berichte, Baiersdorf

[5] Wolfgang Schneider DJ8ES: KW4 (QRP) 4-Band QRP Short-Wave Transceiver VHF Reports 3/98 and 4/98 Verlag UKW-Berichte, Baiersdorf

[6] Wolfgang Schneider DJ8ES Hybrid Amplifier for 144 MHz VHF Reports 2/93 Verlag UKW-Berichte, Baiersdorf

Bernd Kaa, DG 4 RBF

CONTROL OF SSB/CW TRANSCEIVER (VHF 2 M) FOR 144 MHZ

An additional control printed circuit board with a micro-controller and operational software is required for the 2-m transceiver project with DDS from Wolfgang Schneider, DJ8ES [1]. Here too, the C501 [2] Uniboard comes into use.

The software for the SSB/CW transceiver (VHF 2 m) in version 2.0 was prepared using a new compiler which was still more efficient, which led to a few changes in the hardware and software. However, many points are the same as in the description for the KW4(QRP) [3], so that only the points where there are discrepancies and the changes are dealt with here.

1. HARDWARE

1.1. The micro-controller board

The C501 micro-controller board comes into use here in the same assembly stage as for the KW4(QRP) shortwave transceiver [3]. The only change is reset capacitor C5, which is changed to 1 µF-1.5 µF. For the sake of completeness, the component plan is shown in the version for 144 MHz TRX.

1.2. Shaft encoder for frequency adjustment

The VHF2m operational software in the 2.0 version confers a marked advantage in terms of speed, which mainly makes itself noticeable in frequency adjustment using the shaft encoder. For this reason, we were also able to dispense with the progressive programming of the shaft encoder. The shaft encoder here should be on ball-bearings so that it moves easily, and to make rapid tuning possible.

1.5 Connections

Important changes take place concerning the display connection:

The LC display is driven at port 1. In software version 2.0 it is important that pin 5 (R/W) of the LC display is connected to earth. Pin 2 at K4 (port 1.1) remains free.

The table shows the connection of the LC display at port 1 in software version 2.0.

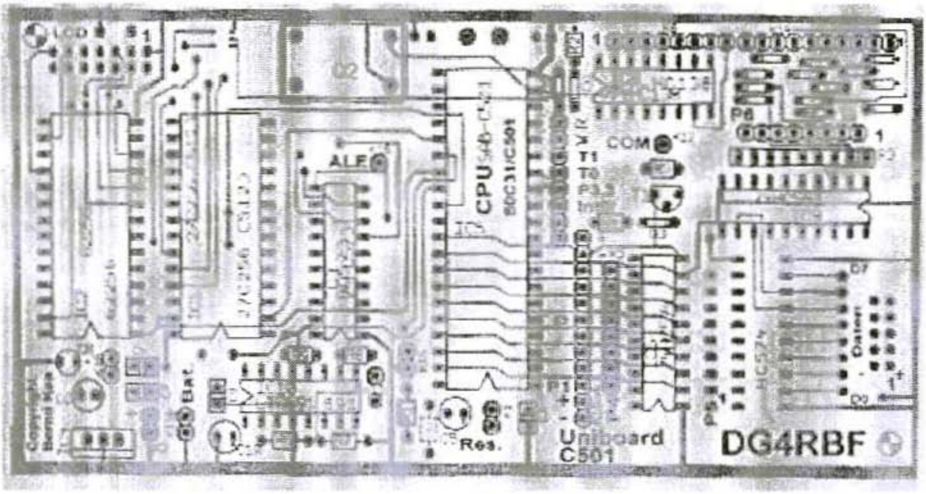


Fig. 1: Component Plan of Uniboard C 501 Micro-Controller Board in Version for SSB/CW Transceiver for 144 MHz

Table: LC Display Connections

Display pin	Signal	Pin on K4	Port	Comment
Pin 1	Gnd	9 or 1 on K19	-	Gnd
Pin 2	+5v	10 or 2 on K19	-	+5v
Pin 3	Contrast	-	-	Depnds on module
Pin 4	RS	1	P1.0	Reg Select
Pin 5	R/W	-	-	Gnd
Pin 6	E	3	P1.2	Enable
Pin 7	D0	-	-	Gnd
Pin 8	D1	-	-	Gnd
Pin 10	D2	-	-	Gnd
Pin 11	D4	5	P1.4	Data
Pin 12	D5	6	P1.5	Data
Pin 13	D6	7	P1.6	Data
Pin14	D7	8	P1.7	Data

Plug K7 / port 3

P 3.0 = Channel B shaft encoder

P 3.1 = Connect to K12 (COM) serial interface

P 3.2/Int0 = Channel A shaft encoder

P3.3 DDS = FQ Update

P3.4 DDS = Serial Data

P3.5 DDS = Word Clock

Plug K14 (input)

E1 = Memory 1	E2 = Memory 2
E3 = Memory 3	E4 = Memory 4
E5 = Memory 5	E6 = VFO/CLR (out from memory!)
E7 = Fast / Slow	E8 = Up (Frq. Step)
E9 = Down	E10 = PTT

Plug K8 (input)

P6.4 = Function (menu)

P6.5 = CLAR (clarifier)

2. SOFTWARE

2.1. Operation

Up / Down (Frq. Step):

The [UP] and [DOWN] keys can be used to adjust the frequency in specific steps. The step width can be adjusted in the system menu using the STEP Up/ Down menu option.

Basic settings with menu system:

Activating the [Function] key takes you into the menu. Here you can select the following menu options using the shaft encoder:

1. Crystal	2. QRG
3. FRQ Trim	4. STEP Up/Down
5. Sequencer	6. End

In order to implement the selected menu option, activate the [Function] key.

To leave the menu system, select option <END>.

– 1. Crystal:

Here the clock oscillator frequency is adjusted. It is adjusted using the shaft encoder, in 10-Hz steps, or using the Up/Down keys in 100-kHz steps. To adjust the frequency, press the [Function] key.

Default setting = 10000000 Hz (100.000 MHz)

– 2. QRG:

Since the SSB/CW transceiver (VHF 2m) has been specially laid out for transverter mode for higher bands, the bands listed below can be selected directly. Thus, when operating with the corresponding transverter, the correct frequency is always displayed.

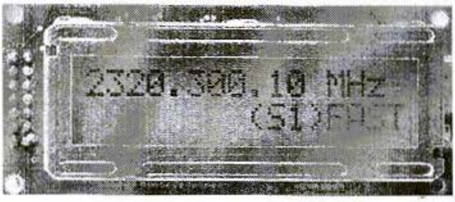


Fig. 2: LC Display during Operation with Settings for 13-cm. Band

2 m (1)	70 cm (2)
23 cm (3)	13 cm (4)
9 cm (5)	6 cm (6)
10 GHz (7)	24 GHz (8)
47 GHz (9)	

Fig. 2 reproduces the LC display when the 13-cm. band is selected.

– 3. FRQ. Trim:

Should the clock oscillator used not oscillate at precisely its rated frequency, a fine correction can be made here using the shaft encoder. Very fine frequency correction below 1 Hz is possible in version 2.0 of the programme.

During the setting itself, the frequency is re-calculated and immediately transferred to the DDS, so that when a frequency counter is connected up the current output frequency can be measured without delay.

To store the corrected frequency again, use the [Function] key.

– 4. Step Up/Down:

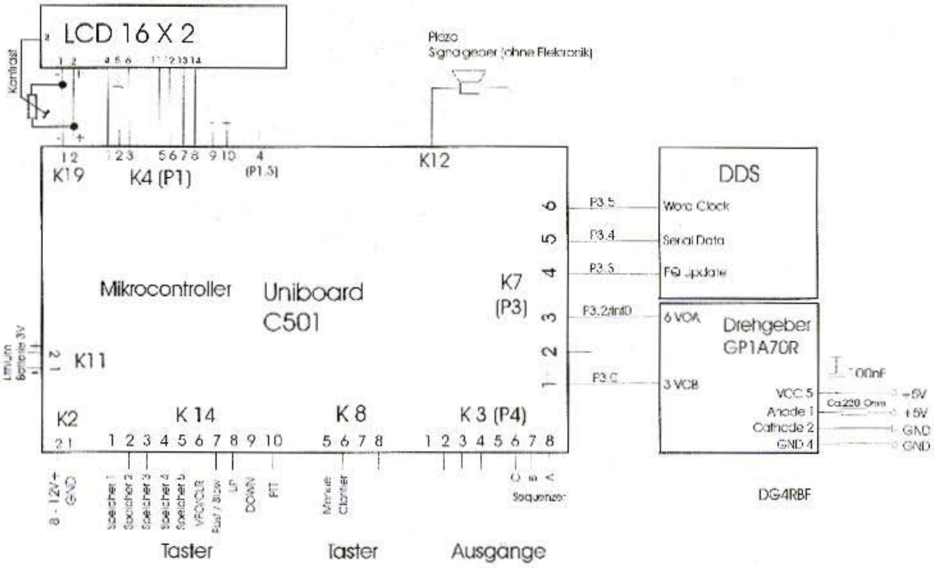


Fig. 3: External Wiring for Uniboard C501 Micro-Controller Board for SSB/CW Transceiver for 144 MHz (VHF 2m)

(Kontrast = Contrast, Batterie = Battery, Speicher = Memory, Menue = Menu, Mikrocontroller = Micro-controller, Piezo Signalgeber (ohne Elektronik) = Piezo signal transmitter (without electronics), Drehgeber = Shaft encoder, Sequenzer = Sequencer, Taster = Key, Ausgänge = Outputs, Wichtige Änderungen für = Important changes for, Reset-Kondensator = Reset capacitor, Ändern auf = Change to, Pin 5 (R/W) des LCD wird auf Masse gelegt und Port 1.1 am MC bleibt frei = Pin 5 (R/W) of LCD is earthed and port 1.1 at MC remains free)

Here the step width for the Up/Down keys is set in kHz. The default setting is 5 kHz.

– 5 Sequencer:

Here the delay time for the sequencer can be set in stages of 1-250. The default value is 35.

– 6 End:

Use this option to leave the menu.

All settings activated remain stored in the RAM of the micro-controller printed circuit board even when the equipment is switched off, provided the 3 V lithium battery is built-in.

2.2. Additional functions during switch-on

If a key is pressed during switch-on, specific set-up functions can be carried out.

Thus, for example, no micro-controller system should be without a reset function with which a defined initial condition can be re-established.

Press key 6 [VFO/CLR] to carry out a reset function and re-establish all settings.

The following set-up functions are also available:

Key (1) S1 = Band limit = 144-146 MHz (default)

Key (2) S2 = Band limit = 140-150 MHz

Key (7) Fast/Slow = Info on program version

2.3. Putting equipment into operation:

The first time the equipment is switched on, a warning signal is heard and the message Data lost! is displayed, since the RAM memory contains no meaningful data as yet.

During subsequent switch-on procedures, a check function determines whether correct data are present in the RAM, and the message System OK should be displayed.

3. LITERATURE

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SSB/CW Transceiver for 144 MHz

VHF Reports 1/1999, Pp. 9-30

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Uniboard C501 Universal Micro-Controller Board

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