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for the Radio-Amateur

Especially Covering VHF,
UHF and Microwaves

VHF communications

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Editorial

Satellite News

As many of our readers will know, TIROS-N also failed in late 1980. This means that there were three major setbacks on the satellite scene in 1980: METEOSAT and TIROS-N failed in Orbit, and OSCAR 9 was destroyed when the Ariane rocket crashed into the sea. However, there is good news on the way, since ESA seems to have solved its rocket propulsion problems, which means that the launch of METEOSAT II is fairly certain for June 1981. A replacement satellite for TIROS-N (afternoon orbit) is scheduled for launch in May 1981 according to the latest NOAA information. With regards to OSCAR 9: ESA has agreed to take the phase III B spacecraft aboard Ariane L 7, which is scheduled for launch in February 1982. This means that we have just enough time to those antennas and tracking systems ready, and to optimize our stations with suitable low-noise preamplifiers, etc.

DJ 0 BQ / G 3 JVQ

SSB on the 10 GHz Band

Part 2: Waveguide Modules

by H. Fleckner, DC 8 UG and
G. Börs, DB 1 PM

Part 1 of this article described the modules for generating a 2268 MHz local oscillator signal. By altering the oscillator frequency, it is possible for this local oscillator to be used for a first intermediate frequency of 144 MHz or 432 MHz. The associated crystal frequencies are given in the appendix. Part 2 is now to describe the waveguide modules as given in Figures 1 and 2 of Part 1 (VHF COMMUNICATIONS, Edition 3/1980).

The description is to assume a first intermediate frequency of 1296 MHz, since only a few modifications must be made for operation with a lower intermediate frequency. These will then be described in Part 3. These mainly deal with the filter and the input and output coupling for the intermediate frequency.

The described modules should not be classed as a final conception, but more as a contribution to the development of a narrow-band, crystal-controlled 10 GHz portable station that is easily to construct. The version using a waveguide switch can be used together with a GaAs-FET preamplifier by modifying the oscillator frequency coupling. The price of a low-noise X-band FET is at present in the order of approximately $ 100.—.

The version using a through-mixer is especially designed for portable operation and represents a compromise between output power and sensitivity in favor of a simple construction. All modules are made from WG 16- (R 100-) waveguide and are usually shown in the drawings without flange.

4. OPERATION AND CONSTRUCTION OF THE MODULES

4.1. Subharmonic Transmit Mixer

The subharmonic mixer whose operation was described in (1) works as an up-converter in the transmit mode and supplies the oscillator signal for the receive mixer in the receive mode. The circuit of this mixer is given in **Figure 17**.

This is one application of the module, which can, according to the diode used, be operated as a pure multiplier, for example for FM-stations, or beacons, as well as an up and even down-converter.

Storage diodes are best used for operation as frequency multiplier, and the reasons for this were given in (2) and (3). In the case of an up-converter, varactors can be used whose characteristic exponent γ is between 0.3 and 0.5, and whose conversion losses are less than 5 dB. Diode type DH 636 manufactured by Thomson-CSF fulfills this demand.

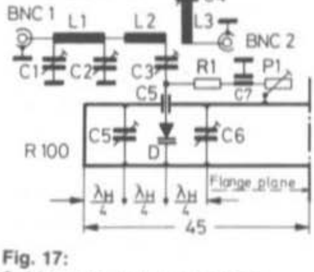

Fig. 17:
Subharmonic transmit mixer

As can be seen in Figure 17, the 2268 MHz signal is fed via a Pi-circuit into the mixer chamber and is coupled from there with the aid of a series-circuit to the diode located within the waveguide.

The Pi-circuit matches the local oscillator signal to the mixer in conjunction with the line length. For this, the cable lengths between the times-6 multiplier and mixer should be kept to even multiples of λ/2, since the input impedance is not real, and is also drive-dependent.

The solution using the Pi-circuit is a recommendation with which a line transformation can be used to match the local oscillator signal to the mixer by varying the output coupling of the frequency multiplier. Other types of coupling were tried, but provided less satisfactory results. This is because the more concentrated components that are used, the larger will be the losses.

One achieves this aim best when using line transformation, possibly in the form of a stripline. In this case, the local oscillator signal is fed via a BNC-flange connector to trimmer C 3 and the line shortened in steps of λ/8 until the maximum is reached.

The drive of the local oscillator signal is adjusted with the aid of C 3, and the operating point is set with the aid of P 1. The IF-signal from BNC 2 is coupled into the chamber with the aid of a series-circuit.

The waveguide operates in the same manner as a high-pass filter, which means that only waves in excess of its lower cut-off frequency can be propagated. Oscillations lower than this frequency cannot be propagated, however, they can be generated as well as coupled in and out. The high-pass behaviour of the waveguide has a favorable effect on the spectral purity of the signal.

The chamber is brought to resonance at 10 368 MHz with the aid of C 5. In this case, the frequency 1296 MHz and 9072 MHz (= 4 x 2268 MHz) are added in the waveguide. The mixer is aligned for maximum conversion gain.

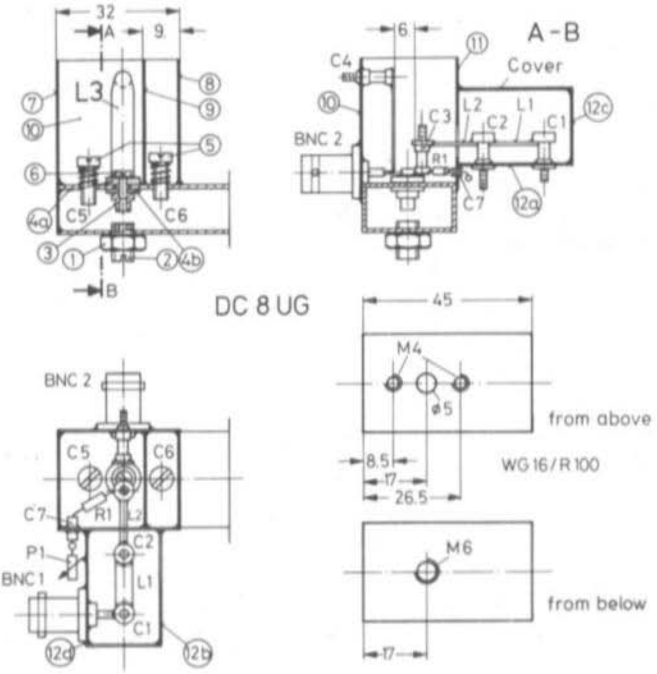

Fig. 18:
The most important dimensions for the transmit mixer

4.1.1. Electrical and Mechanical Components of the Mixer

Figure 18 shows the mechanical construction of the mixer, and **Figure 19** the required mechanical pieces.

The following further components are required:

C 1, C 2:	0.5 - 3 pF ceramic tubular trimmer, large type
C 3, C 4:	0.5 - 3 pF ceramic tubular trimmer, small type
C 5, C 6:	M 4 x 15 mm, brass screw with locking spring
C 7:	Feedthrough capacitor, solder mounting, approx. 1 nF
R 1:	10 kΩ, 1/8 W
P 1:	100 kΩ, 1/4 W
L 1:	12 x 5 x 0.5 mm, brass plate, fitted between C 1 and C 2
L 2:	1 mm dia. silver-plated wire, 8 mm long
L 3:	Brass plate, 0.5 mm thick, 6 mm wide, 30 mm long, bend up 5 mm !
D :	Varactor diode DH 636, (Thomson-CSF)

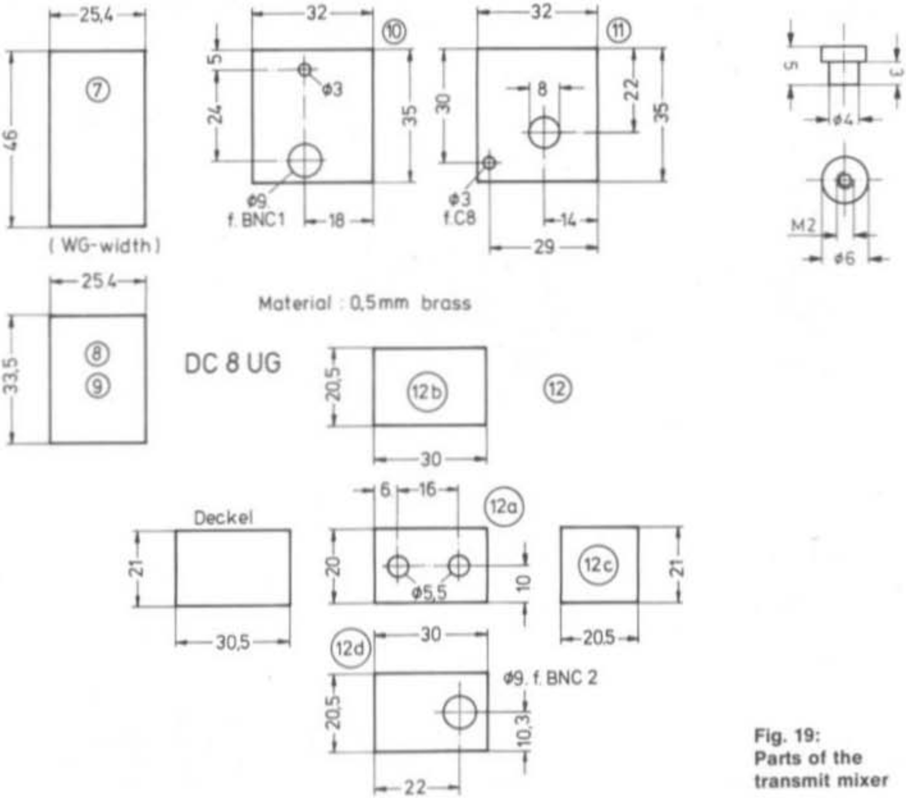

Fig. 19: Parts of the transmit mixer

Part 1: M 6-counter nut
Part 2: M 6 x 10 mm with 2 mm hole
Part 3: Diode plunger, s.Fig.19
Part 4: PTFE-disk, 9 x 1 mm, with 2 mm hole
Part 5: PTFE-disk, 9 x 2 mm, with 2 mm hole
Part 6: M 2 x 6 with U-disk

4.2. Through-Line Mixer

The straight-through mixer shown in **Fig.20** is only used straight-through with the 10368 MHz signal in the transmit mode; the subsequent filter for the 9072 MHz signal will block it in the receive mode. Attention was paid when interconnecting with the transmit mixer that the diode is spaced an odd multiple of λ/4 from the short-circuit panel so that the signal is reflected back to the diode at identical phase.

The tuning screws between the transmit mixer and the receive diode (see **Figure 21**) improve the matching in the transmit mode. The tuner in front of the filter matches the waveguide to the filter.

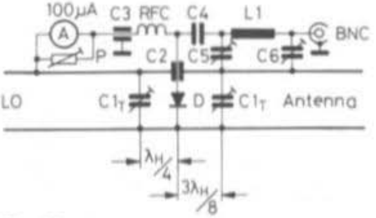

Fig. 20: Circuit diagram for the through-line mixer

The IF-signal is fed via a RF-trap and a subsequent Pi-circuit and directly coupled to the first, low-noise IF-stage **(Figure 22)**. The Pi-circuit ensures the required noise-matching at the IF-side of the diode together with DC-voltage load.

The diode can be mounted with the aid of a M 10-nut soldered to the waveguide, and a shortened screw. It is, however, advisable to use a specially made mount from brass, having a fine thread. For those readers having a certain amount of mechanical skill, it is possible for the mount to be made so that the diode can be shifted within it, so that a further matching can be made.

It is important that only the ceramic parts of the diode are within the waveguide, and that it has a good ground contact.

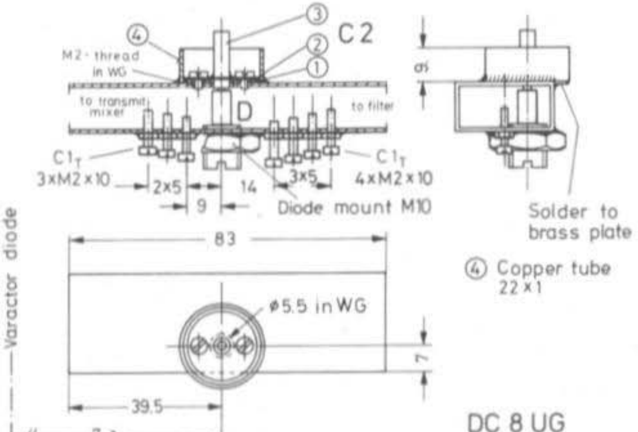

Fig. 21: The most important dimensions for construction of the through-line mixer

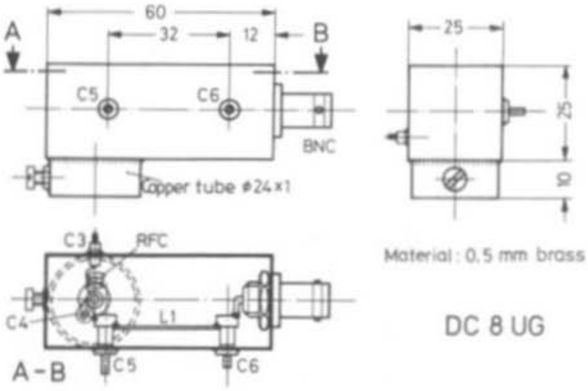

Fig. 22:
The most important dimensions of the matching stage

4.2.1. Components for IF-Matching and for the Through-Line Mixer

Figures 20 to 23 show circuit and details of the mixer and matching stage. The most important components are now to be given. Capacitor C 2 is to be found in a copper tube of 22 x 1 mm, which is soldered to the waveguide. The IF-matching stage is then fitted so that its 24 mm ring is placed over the tube, after which C 4 and the choke are soldered to the center pin.

Sliding-pin tuner 1: 3 pcs. M 2 x 10 mm screws spaced λ/8 from another and provided with counter nuts.

Sliding-pin tuner 2: 3 to 4 pcs. M 2 x 10 mm screws, spaced λ/8 from another with counter nuts.

C 2:	Disk-shaped feedthrough capacitor as shown in Fig. 23 (with 23 cm IF, the TEFLON disk can be 1.5 to 2 mm thick)
C 3:	1 nF feedthrough capacitor
C 4:	12 pF ceramic disk capacitor
C 5, C 6:	0.5 pF - 5 pF ceramic tubular trimmer
L 1:	30 x 5 x 0.5 mm, brass plate, fitted between C 5 and C 6
RFC:	3-4 turns of 0.5 mm en. copper wire, wound on a 3 mm former, self-supporting
P :	500 Ω - 1 kΩ, according to diode and meter
D :	1 N 23 E, F or BAW 95 E,F,G. The BAW 95 is recommended for the through-line mixer.

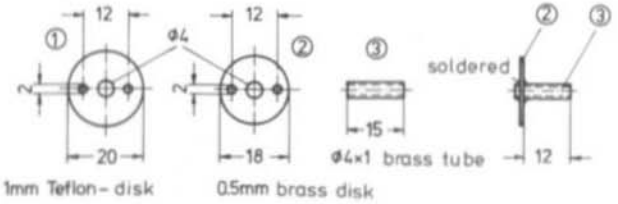

Fig. 23:
Parts for the feedthrough capacitor

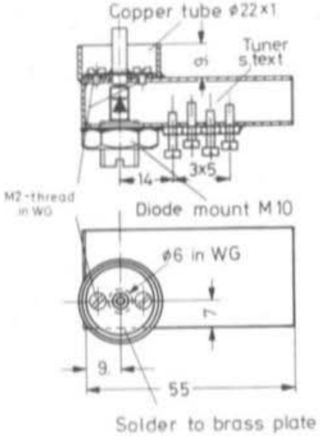

Fig. 24:
The most important dimensions for the reflection receive mixer

4.3. Reflection Receive Mixer

In the case of the receive mixer shown in **Figure 24**, the received signal is reflected with identical phase by the shortcircuit with a $\lambda/4$ spacing behind the diode. This results in a gain of the signal voltage at the diode. The components of the IF-feedthrough, matching, and the diode mount are identical to those of the through-line mixer.

In the case of both mixers, the receive diode is to be found in the vicinity of the edge of the waveguide, which means that it is coupled at low impedance. This is an advantage in the case of the through-line mixer, since the diode is not subjected to the full RF-voltage of the oscillator, and will also not load the line to any great extent.

The author would like to take this opportunity of mentioning that although diodes type 1 N 23 do have a power dissipation of 325 mW, they, however, possess a relatively low junction voltage. Furthermore, they are sensitive to electrostatic charge and shock. Schottky diodes such as BAW 95 are not so sensitive, and also have a higher power dissipation, but require a larger conversion current to obtain the same noise figures.

4.4. Cavity Switch

The system shown in Figure 1 of Part 1 uses an E-planar cavity switch for transmit-receive switching, which is shown in more detail in **Figure 25**. The switch consists of two V-shaped pieces of waveguide, in which a trap-door (part 8) has been placed at the intersection for selecting each

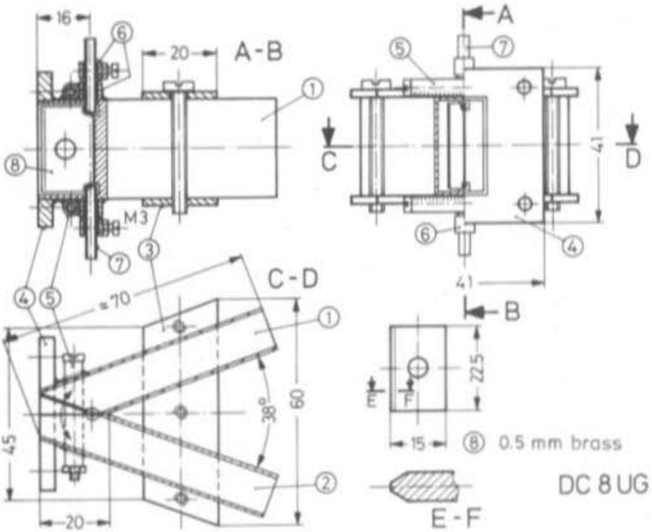

Fig. 25:
Waveguide switch, with most important dimensions

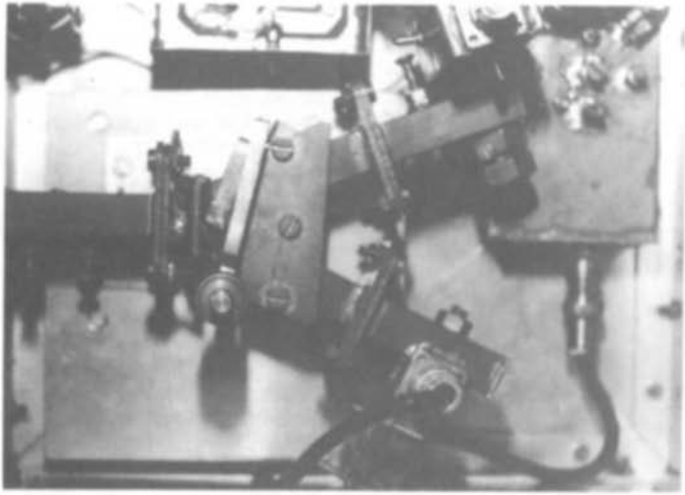

Fig. 26: E-planar cavity switch with transmit and receive mixer

branch. The common input must be provided with a home-made flange constructed from 3 mm brass plate (part 4), since available flanges are too wide.

This flange is only soldered with one WG-piece, which means that the switch can be removed, and the trap-door easily installed and detached. This may be necessary, for instance, to alter the coupling hole, through which the oscillator signal is coupled into the receive branch. The size of this hole is dependent on the available oscillator power. In the present application, it corresponds to 4 to 5 mm.

The two branches are mounted together using two threaded bolts and secured into position with the aid of two mounting plates.

The switching is carried out according to the requirements: Either manually, or electrically, for instance, using a model servomotor.

The switching devices should not load the trap-door mechanically, but should ensure that it is depressed onto the edge of the waveguide. **Figure 26** shows the cavity switch with transmit and receive mixer.

4.4.1. Parts List of Cavity Switch

Part-No.	Designation, Material, Dimensions
1, 2	Waveguide pieces R 100 (WG 16), prepared for the given angle
3	Mounting plates, 2 pcs., 2 mm thick, held together with three M 4 x 40 mm screws
4	Flange for cavity switch made from 3 mm thick brass plate
5	Mounting tubes, 4 pcs., brass, 5 x 1 x 14 mm long
6	Bearings, 4 pcs., brass tube 5 x 1 x 5 mm long
7	Shaft, 2 pcs., 3 mm brass tube, 20 mm long, slots for accommodating the trap-door
8	Trap-door, 0,5 mm thick brass plate

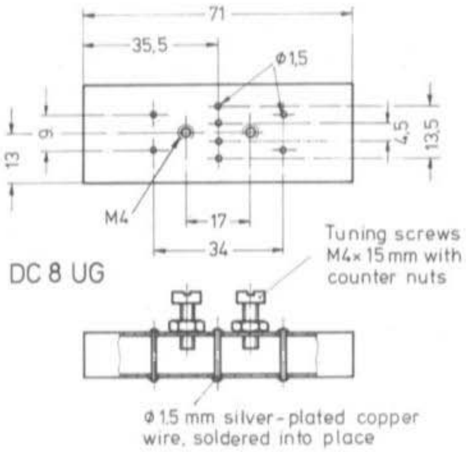

Fig. 27:
The most important dimensions of the filter (without flanges)

4.5. Filter

A filter is used in both systems, which was already described in (1) and (4). If these are made carefully, they exhibit excellent values. These are a two-stage filter with an insertion loss of less than 0.5 dB with a bandwidth of approximately 120 MHz.

The mechanical dimensions are given in **Figure 27**.

A filter was described in (5) that exhibited even better specifications and is suitable for use with an intermediate frequency of 144 MHz. It will be described with some modifications in Part 3 of this article.

5. CONSTRUCTION AND ALIGNMENT

5.1. Subharmonic Transmit-Mixer

The transmit-mixer can be made in the following order:

1. Prepare the waveguide with all holes and threaded bushings.
2. Solder on the flange
3. Make the diode mount and install into place. The diode is then placed temporarily into position to ensure that it will not be damaged.
4. Solder the mixer cavity into position.
5. Prepare the matching cavity and solder into place.
6. If the mixer is constructed without π-circuit, a BNC-flange connector should be soldered into place instead of the matching cavity and the pin connected to the trimmer capacitor C 3.

The alignment of the transmit mixer is always made in conjunction with the filter, which must be previously aligned to 10368 MHz. This can be carried out with a Gunn-oscillator whose frequency is exactly known.

If a power meter or spectrum analyzer for this frequency range is not available, a diode probe can be used for power indication, such as the reflection receive mixer. Attention should be paid during alignment that difficulties can occur easily during coupling to reactance stages without directional coupler due to the reflected power. For this reason, the standing wave ratio should be checked and the mixer aligned with the aid of C 1 to C 4 for maximum conversion gain with an injected 1296 MHz signal of 0.2 to 0.3 W.

The DC-operating point remains fixed at first. If a signal is observed, C 5 and C 6 are then aligned for maximum output power. It is necessary for the process to be carried out several times to optimize the adjustment, and P 1 is also adjusted during this process.

The line length between multiplier and mixer is now shortened in steps of λ/8 in order to obtain the best possible matching. This is especially valid when transformation is only made with the aid of the line and the coupling capacitors.

The IF-signal should not have the full level during the preliminary alignment, in order to ensure that the mixer is not overdriven.

For caution, it should be mentioned that all tuning elements of the mixer and the multiplier must be adjusted during the fine alignment, and that the whole alignment process requires patience and considerable experience with multipliers and mixers.

The given power values were obtained using the diode DH 636. Diodes type BXY 38 and BXY 41 resulted in values that were up to 10 dB less. However, it is felt that further experiments could lead to more favorable values.

In the case of the system with through- line mixer, the transmit mixer is aligned in conjunction with the receive mixer. This results in several slight corrections in the tuning of C 6 in conjunction with the tuner adjustment. The tuned mixer provides an oscillator sum power in the receive mode that is less than the transmit power.

5.2. Reflection Receive Mixer, and Through-Line Mixer

M 2 threaded holes are provided axially in the waveguide with the given spacings, which are for accommodating the tuning screws of tuner 1 and tuner 2. In order to provide a better guide of the screws, one should additionally glue M 2-nuts to the waveguide with the aid of epoxy-resin adhesive. The screws can be secured with a spring, or counternut. According to the SWR, either one or the other screw will have a larger effect on the matching.

In the case of the through-line mixer, the alignment for the most favorable 9072 MHz level with the frequency-dependent tuners can cause a loss of transmit power, however, will bring an improvement of at least 10 dB in receive sensitivity. The diode current should be in the order of 0.5 to 1.5 mA.

5.3. Filter

M 4-nuts are soldered into place in addition to the threaded holes in the waveguide, in order to mechanically stabilize the filter tuning. The screws are then secured using counternuts.

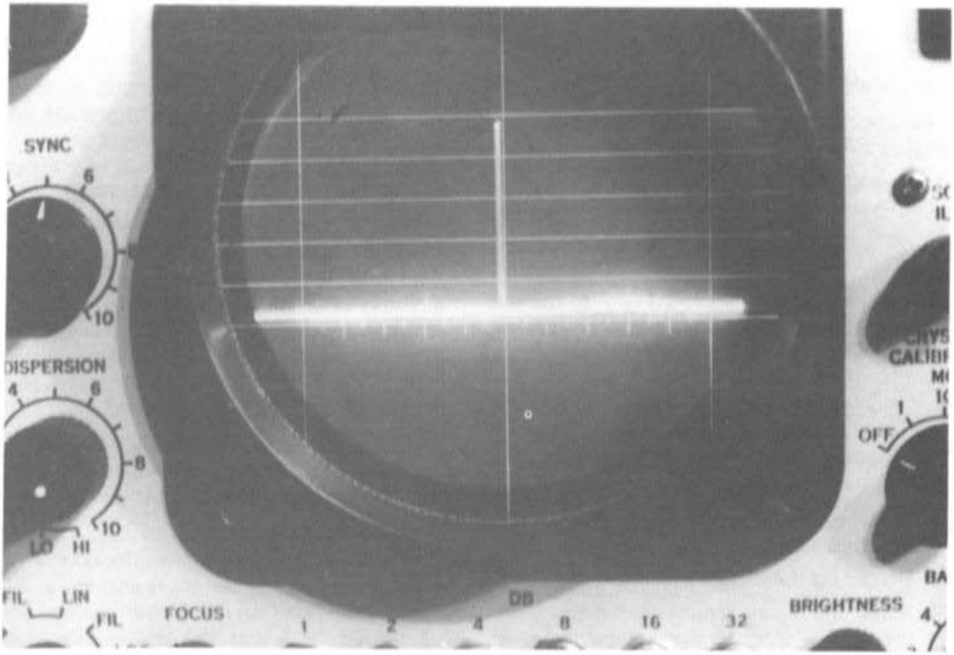

Fig. 28: Spectrum of the 10 GHz signal. Hor.: ± 50 MHz, Vert.: 10 dB/line

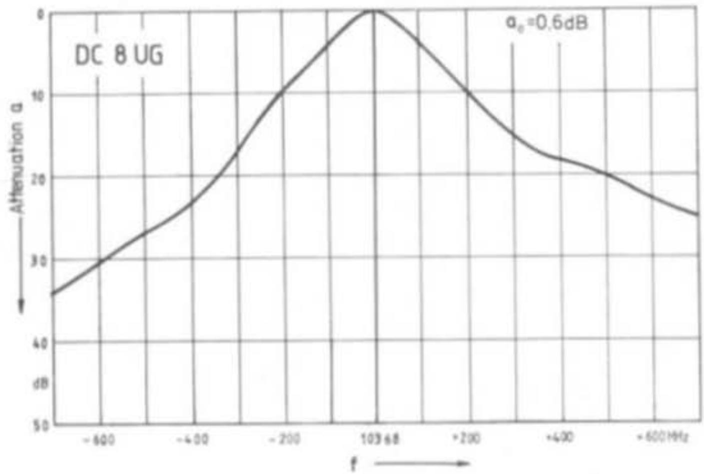

Fig. 29:
Passband curve of the filter

6. MEASURED RESULTS

The author would like to thank F. Edinger, DL 5 FAU, and F. Eichhorn, DJ 8 QL for the power and noise figure measurements.

6.1. Transmit Mixer

The transmit mixer generates a power of 25 mW into 50 Ω. This was selectively measured using a HP 435 RF-power meter. The output spectrum is clean down to – 40 dB, as can be seen in **Figure 28**.

6.2. Receive Mixer

Poorly matched receive mixers usually achieve noise figures in the order of 20 dB inspite of good diodes, and low-noise IF-stage. For this reason, a careful matching is required on the RF and IF side. This allows an SSB-noise figure of 10 to 12 dB to be obtained. The most optimum values between 7 and 10 dB cannot be achieved with the 23 cm IF used here, since an extensive low-pass filter would be required.

Due to the simple construction, and since the RF-trap is sufficient at a lower IF, this was not changed.

6.3. Cavity Switch

The cavity switch was examined in conjunction with a swept-frequency oscillator (694 D) and power meter (HP 432 A). The insertion loss was less than 0.2 dB. The oscillator is coupled into the receive branch at – 8 dB using a 3 mm coupling hole.

In the transmit mode, – 28 dB of the transmit power will be fed into the receive branch. These values were determined using a power level of 10 mW from the swept-frequency oscillator.

6.4. Filter

Figure 29 shows the measured passband curve of the filter used. The insertion loss was in the order of 0.5 dB with both prototypes.

7. APPENDIX

The crystal frequencies and degrees of multiplication are now to be given for intermediate frequencies of 144 MHz and 432 MHz. The previously mentioned systems operate in the meantime with a 144 MHz IF using a 85.2 MHz crystal. This is also at an output power of 10 mW, and increased sensitivity (see **Table 1**).

IF (MHz)	Oscillator Frequency (MHz)	Multiplication	Multiplier	Mixer
144	85.2	x 4	x 6	x 5 + IF
144	102.24	x 4	x 5	x 5 + IF
144	(106.5)	x 4	unfavourable	x 4 + IF
432	99.36	x 4	x 5	x 5 + IF
432	(103.5)	x 4	unfavourable	x 4 + IF

In the case of the crystal frequencies 102.24 and 99.36 MHz, the multipliers operate times five with idler circuits on the second and third harmonics. Generally speaking, that crystal frequency is most favorable whose high-energy third harmonic of the local oscillator signal is below the cut-off frequency of the waveguide. This is valid with 85.2, 102.24, and 99.36 MHz. In the case of 106.5 and 103.5 MHz, the injection frequencies will already be too high, which means that the multiplier efficiency is too poor.

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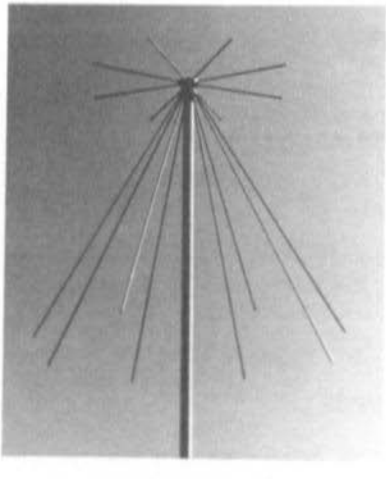

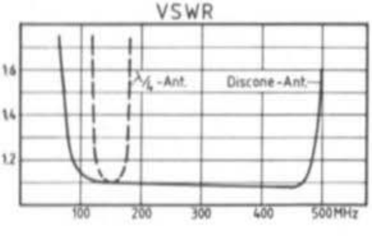

SSB on the 10 GHz Band

Part 3: Intermediate Frequencies in the 2 m or 70 cm Band

by H. Fleckner, DC 8 UG, and
G. Börs, DB 1 PM

Part 1 and 2 described two 10 GHz, narrow-band systems for a first intermediate frequency of 1296 to 1298 MHz (23 cm band). The advantages of this high, first IF are the higher RF-efficiency of the transmit mixer, and the low losses of the relatively wideband 10368 MHz filter. The disadvantage is that one does not always possess a (portable) 23 cm system, and furthermore the somewhat difficult noise matching of the mixer diode to the IF-amplifier.

Part 3 is now to give the required modifications to allow operation of the systems with a first intermediate frequency in the 2 m, or 70 cm band. In addition to this, a very low-noise selective preamplifier is to be described for the 23 cm band.

9. OPERATION WITH AN IF OF 2 m OR 70 cm

The required modifications are mainly to the filter, and the IF-input and output coupling. In addition to this, the differences that are caused by the different crystal frequencies are to be discussed.

9.1. Crystal Oscillator

Several details were given in Part 2 of this article regarding suitable crystal frequencies, as well as the required frequency multiplication factors. Table 2 summarizes these, and also gives values for capacitors C 1 and C 2. These values belong to the oscillator circuit given in **Figure 30**, which

IF (MHz)	Crystal (MHz)	C 1 (pF)	C 2 (pF)	Oscillator module	Multiplier	Mixer
144	85.20	6.8	47	x 4	x 6	x 5 + IF
144	102.24	5.6	47	x 4	x 5	x 5 + IF
144	106.50	5.6	47	x 4	x 6	x 4 + IF
432	103.50	5.6	47	x 4	x 6	x 4 + IF
432	99.36	5.6	47	x 4	x 5	x 5 + IF
1296	94.50	5.6	47	x 4	x 6	x 4 + IF

Table 2

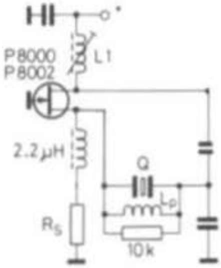

Fig. 30:
Low-noise crystal oscillator for approximately 100 MHz

represents an extract from Fig. 3 in Part 1. The stable oscillator frequency of this circuit is always somewhat lower than the nominal frequency.

9.2. Frequency Plan

When using a crystal frequency of 106.5 MHz, it is possible for the resonant circuits comprising L 4, L 5, and L 6 to be shortened by 10 % on board DC 8 UG 001; in the case of a crystal frequency of 85.2 MHz, however, they need to be lengthened by approximately 10 %. The high-pass filter can be matched to the actual crystal frequency by bending inductance L 8.

9.3. Power Amplifier

No modifications are required to this module (Fig. 8 of Part 1).

9.4. Multiplier

This module is operated as a 5-times, or 6-times multiplier according to Table 2. If 4 x 85.2 MHz = 340.8 MHz is to be used, L 2 should then be increased to 3 turns. In the case of a crystal frequency of 106.5 MHz, the brass tubes of L 6 and L 7 should be shortened to 21 mm in order to provide a high efficiency. This means that all width dimensions (Fig. 12) are changed by 3 mm.

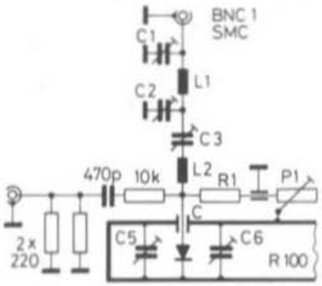

Fig. 31:
New, aperiodic IF-injection to the transmit mixer

It should be noted here that a Philips BXY 28 or BXY 38 can be used instead of the DH 110 (Thomson-CSF).

9.5. Transmit Mixer

Attention must be paid in the sub-harmonic transmit mixer, as with all UHF/SHF circuits, that the shortest possible connections are made between the connectors and components, even when this was not made in the drawing (Figure 18 of Part 2) for clarity. By the way, a SMC-connector for single-hole mounting is recommended for feeding in the local oscillator signal instead of the BNC-connector UG-1094/U.

Trimmer capacitors C 1 and C 2 should be small types having a commencement capacitance of 0.3 pF; inductance L 1 should not be longer than 11 mm. If a local oscillator frequency of 2556 MHz is used, it will then be absolutely necessary for L 1 to be shortened by 10 % to 10 mm in length.

The transmit signal at 144 MHz or 432 MHz is fed in aperiodically, as can be seen in **Figure 31**. This circuit is a modified extract from Figure 17 of Part 2. The main component of the drive power (400 to 500 mW) is converted to heat in the two, parallel-connected 220 Ω resistors (1/4 W, low-inductive !); approximately 10 % are reflected, and the remaining 10 to 20 mW is mixed with the local oscillator frequency.

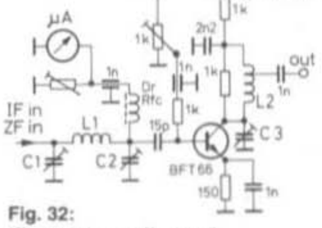

Fig. 32:
IF-output coupling and low-noise preamplifier

Table 3

IF (MHz)	C 1 (pF)	L 1	C 2 (pF)	C 3 (pF)	L 2
144	30	5 turns 1 mm silv.wire 6 mm dia.	22	22	as for L 1 tapped 1 turn from cold end
432	22	3 turns 1 mm silv.wire 6 mm dia.	10	10	as for L 1 tapped ½ turn from cold end

9.6. Receive Mixer

Figure 32 gives a very low-noise first IF-amplifier stage for the receive mixer shown in Figures 20 to 24 of Part 2. It is only necessary for the frequency-dependent components to be selected according to Table 3 for the selected intermediate frequency.

The circuit can be built up on any small board and installed in the case of the matching stage of the 1296 MHz IF (Fig. 22 of Part 2).

It was already mentioned in Part 2, that the IF-noise matching could be improved using a coaxial low-pass filter. **Figure 33** shows a suitable construction. The filter insert is placed in a PTFE-collar and depressed to the connection pin of the mixer diode with the aid of a spring. The diode should be fitted tightly on both sides.

According to the author's experience, a series-circuit as given in Figure 32 is sufficient for coupling to the IF-preamplifier.

9.7. Filter and Matching Networks

The simplest way is to use a single-stage as shown in **Figure 34** between the transmit mixer and waveguide switch. In the case of an IF of 144 MHz, the frequencies 10224 MHz and 10368 MHz will be within the passband range of this filter, whereas all other harmonics will be suppressed.

A narrow-band filter described by DB 6 NT in (1) is given in **Figure 35**. Instead of the one matching screw as shown in Figure 34, three matching screws are to be found on both sides of the filter having a spacing of λ/4. This allows the filter to be matched at the input and output to any waveguide.

The insertion loss is in the order of 1 dB, and the oscillator frequency (10224 MHz with a 144 MHz IF) is already suppressed by more than 20 dB, and the image by approximately 30 dB.

Finally, **Figure 36** shows a simple matching network with which matching can be made

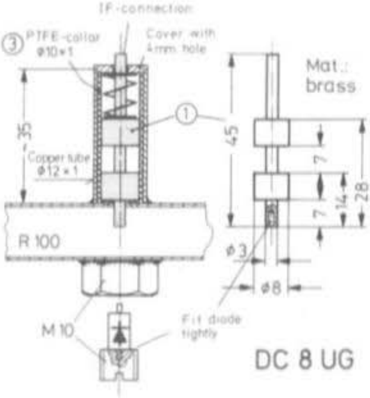

Fig. 33:
Recommended IF-output coupling in conjunction with a coaxial lowpass filter

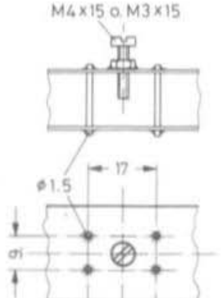

Fig. 34:
Single-stage waveguide filter

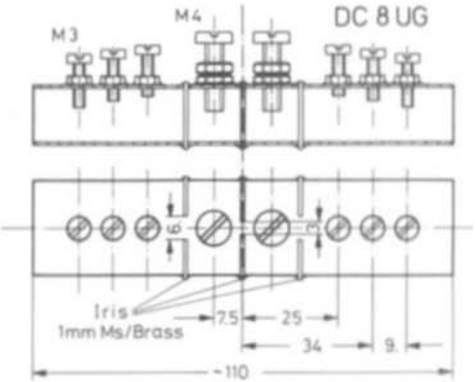

Fig. 35:
A narrow-band filter with input and output matching

according to amount and phase in the frequency range of 10 GHz. It is advisable for this to be used after varactor or Gunn diodes, or in front of radiators or receive mixer diodes.

10. 23 cm PREAMPLIFIER

A very low-noise, selective preamplifier has been designed for systems having a first intermediate frequency in the 23 cm band. The circuit of this preamplifier is given in **Figure 37**. The components for the amplifier are:

T 1:	NE 645 35 (NEC)
C 1, C 4:	12 to 50 pF (value uncritical) ceramic disk capacitor
C 2, C 3:	0.3 - 3 pF ceramic, tubular trimmer

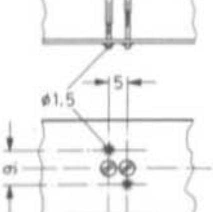

Fig. 36:
Simple matching network for amount and phase

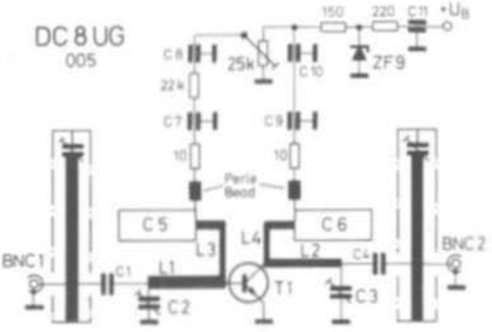

Fig. 37:
Low-noise, selective 23 cm preamplifier

C 5, C 6:	printed capacitances
C 7 - C 11:	approx. 1 nF feedthrough capacitors
L 1 - L 4:	printed inductances

The components are mounted on a double-coated PC-board whose dimensions are 70 mm x 55 mm (see **Figure 38**). As has already been mentioned by other authors, it is necessary for the two emitter connectors of the transistor to be »through-contacted«, using a 1 to 2 mm wide copper foil strip between the component and ground side of the board.

The resonant input and output circuits are made coaxially and arranged in a metal-plate case of 70 mm x 55 mm (25 mm high) so that the amplifier board is used as a cover. If the PC-board is to be screwed into place, it will be necessary for spring-contact strips to be used at all points. Of course, it is also possible for it to be soldered into place, as shown in Figure 38. It is important, that the coaxial circuits are sealed RF-tight. The inner conductors of the coaxial circuits are screwed tight to the soldered M 4 nuts.

Transistor NE 645 35 is adjusted to an operating point of $U_{CE} = 8$ V; $I_C = 7$ mA. A noise figure of 2 dB was determined using this configuration. Further details regarding the matching, and operating point adjustment were given in (2).

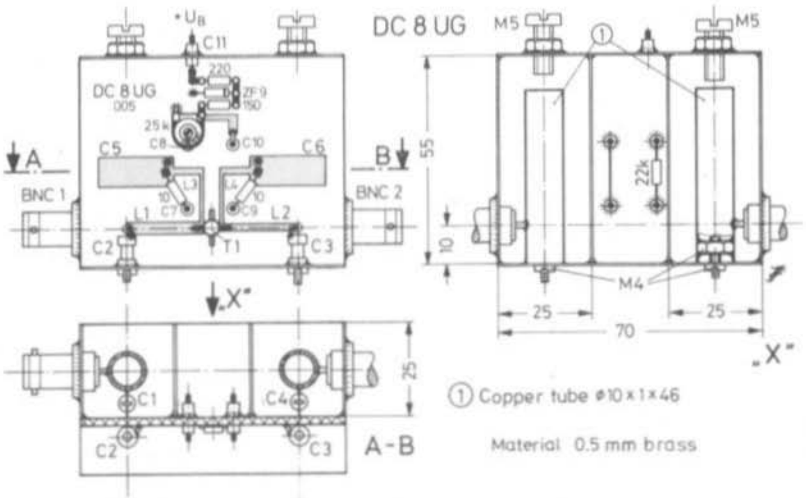

Fig. 38: The preamplifier board is used as cover for the coaxial circuits

11. EXPERIENCE AND PERSPECTIVES

The conversion from an intermediate frequency of 23 cm to one of 2 m brought no disadvantages, with the exception of the 2 to 3 dB lower transmit power (approx. 10 mW are available). This is not very important in practical operation. No experience was gained in conjunction with an intermediate frequency of 70 cm, however, it is not expected that there will be any difference than when using a 2 m IF.

Experience has shown that matching problems will occur with power-conversion using local oscillator frequencies in excess of approximately 2.5 GHz, and that these are usually not to be solved with amateur means. An increase of the output power in this manner is therefore not recommended, since one must match at least 1 W at low reflection in order to achieve a transmit power of 18 dBm.

Transistor amplifiers for the output frequency of 10368 MHz seem to be better, and DC 8 UG will be making experiments with these in the near future. It is, for instance, possible when using GaAs-FETs such as the MGF 1400 for power amplifiers with a maximum output power of 18 dBm and a gain of 9 dB to be realized in this frequency range. The sensitivity of the system can be increased by approximately 6 dB by using 2 to 3 of such stages, and aligning them for most favorable noise figure. Finally, if one combines a transmit amplifier and receive-preamplifier with a hybrid mixer, one will obtain a transceiver in micro-stripline technology, as we know them from the lower microwave bands.

To conclude, the author would like to thank all radio amateurs that have helped him with advice and tips. The author and editors would like to hear from other interested amateurs regarding their own experience, and any further developments in this area.

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A Portable Home-Made Yagi Antenna for the 70 cm Band

by H. J. Griem, DJ 1 SL

The task set by the author was to develop and construct a directional antenna for operation over amateur radio satellites. Furthermore, this antenna should be just as suitable for terrestrial communications. The author selected a YAGI antenna with a second set of elements mounted at right angles in order to receive signals with horizontal and vertical polarization. After taking the spacing between the two Yagis into consideration, and calculating the correct phasing, it would also be possible to obtain any required polarization such as circular polarization, but this is not to be described in this article (editorial notes: experience has shown that it is virtually impossible to switch polarization in conjunction with a 70 cm antenna due to irregularities of the velocity factor of the feeders used).

It is, of course, possible for signals of unknown polarization to be processed separately by feeding the signal from each antenna plane to a separate receiver tuned exactly to the same frequency (possibly with a common oscillator). The IF-signals from both receivers can then be observed on an XY-oscilloscope and compared according to their amplitude, ratio, and phase position.

SELECTION OF THE ACUTAL ANTENNA

The design of the antenna was made according to (1). For various reasons, 9 elements were selected for each antenna plane. The dimensions for one plane are given in **Figure 1**.

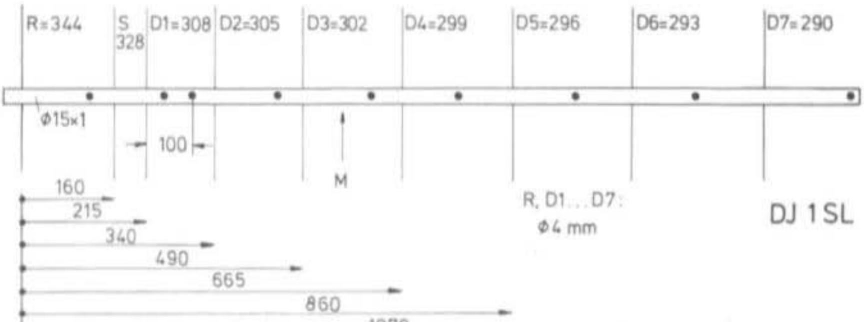


Fig. 1: A 70 cm crossed Yagi antenna; the 2nd plane is staggered by 100 mm with respect to the given plane. M = Mount

FEED PROBLEM

The first problem to be solved was the type of feeding and matching the selected coaxial cable to the radiating element. Sinec an existing 60 Ω cable was to be used, the impedance of the overall system was to be designed for this impedance.

It was assumed that the good characteristics of the antenna would only be present when the dimensions given in (1) were maintained. For this reason, it was decided not to shift the radiator along the boom in order to reduce the VSWR.

The feed of the radiator should be completely balanced in order to avoid any »squint« of the radiation characteristic, and to avoid any unwanted coupling between the vertical and horizontal Yagi; (Ed.: It is also important to avoid unwanted radiation on the sheath of the coaxial cable). A well-known, conventional balun constructed from coaxial cable was selected for balancing.

MEASURING SYSTEM

Figure 2 shows the measuring system used together with a TV-swept frequency generator, which could be adjusted down to approximately 415 MHz. This allowed the matching characteristics to be observed in a frequency range of 415 to 445 MHz. The crystal-controlled calibration markers allowed the frequency to be calibrated every 5 MHz.

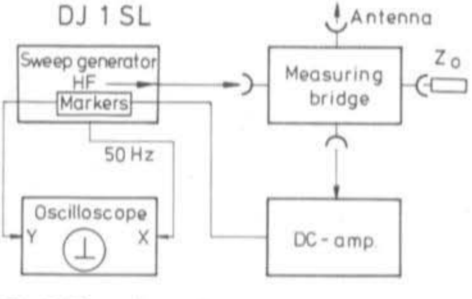


Fig. 2: Measuring system

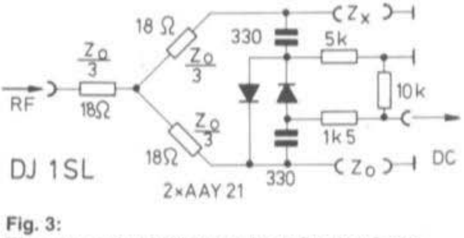


Fig. 3:
The measuring bridge for the reflection factor exhibits matching at all three connections

The measuring bridge for the reflection factor measurement was home-made, and was similar to that described in (2). The special feature of this circuit **(Figure 3)** is that it is theoretically ideally matched at all three RF-ports. This is valid, of course, only for one, selected impedance Z_0. However, in order to carry out measurements in both 60 Ω and 50 Ω systems, the terminating resistor Z_0 was made exchangeable. Details regarding the mechanical construction of the measuring bridge are given in (2).

EXPERIMENTS

The following possibilities are to be examined with respect to the matching of the coaxial cable to the antenna, either alone or in combination with another:

1. Fixed folded dipole having different element-diameters
2. Folded dipole with identical element-diameters, but variable length of the folded dipole
3. Balun transformer, whose electrical length differs from λ/2.

A folded dipole designed for 433 MHz should have a length of 2 x 32.8 cm, and the balun transformer should be 22.8 cm long (Ed.: Varies according to the velocity factor of the cable used). The following dimensions were examined in the case of the combination of 1 and 3:

Folded dipole:

Mechanical length (without sides) = 31 cm
Center-to-center spacing = 1.5 cm
Diameter of the fixed radiator = 4 mm

Diameter of the variable radiator: d_1 = 1 mm, d_2 = 2 mm, d_3 = 3 mm, d_4 = 4 mm.

Balun transformer: 60 Ω cable, ε = 2.3

Mechanical length of the balun: b_1 = 28 cm, b_2 = 26 cm, b_3 = 24 cm, b_4 = 21.5 cm, b_5 = 19 cm.

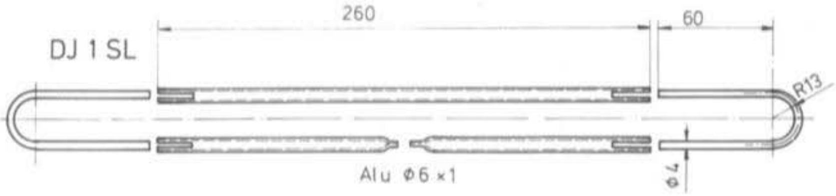


Fig. 4: A variable folded dipole was used for the experiments

The measured results were only observed on the oscilloscope, but not recorded. They showed that the lowest reflection factor was exhibited when using the same diameter for the folded dipoles. For this reason, the combination of 2 and 3 was then examined in more detail.

This was achieved by constructing a dipole whose length could be varied continuously between 30 and 39 cm **(Figure 4)**. This radiator was mounted exactly at the calculated position in the antenna. The parts used during these experiments are shown in **Figure 5**.

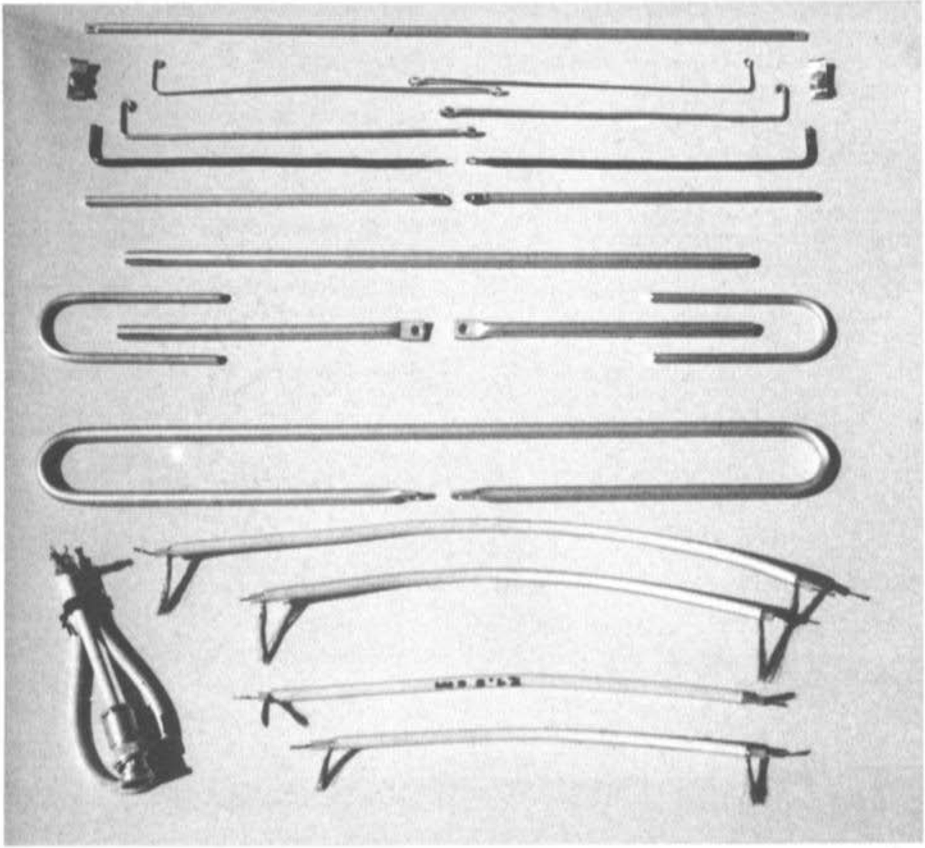
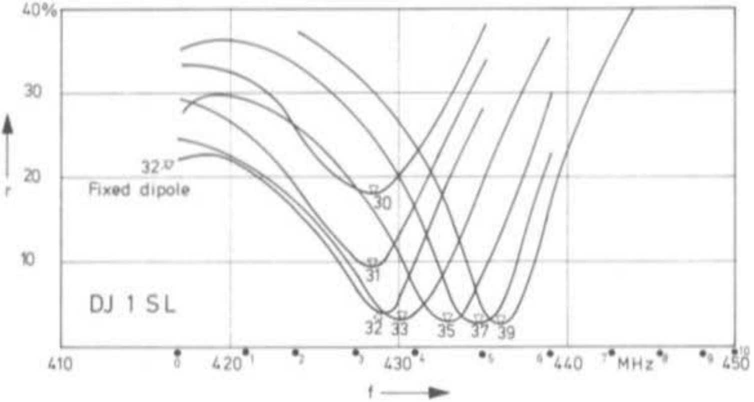


Fig. 5: Parts used during the matching experiments



λ/2 balun
24 cm long,
Z = 60 Ω,
ε_r = 2.3
Parameter:
Folded dipole
length in cm
Reference impedance
= 60 Ω
Points 0 - 10 =
11 Measuring
frequencies

Fig. 6: Reflection factor curve of a 9-element 70 cm antenna according to DL 6 WU

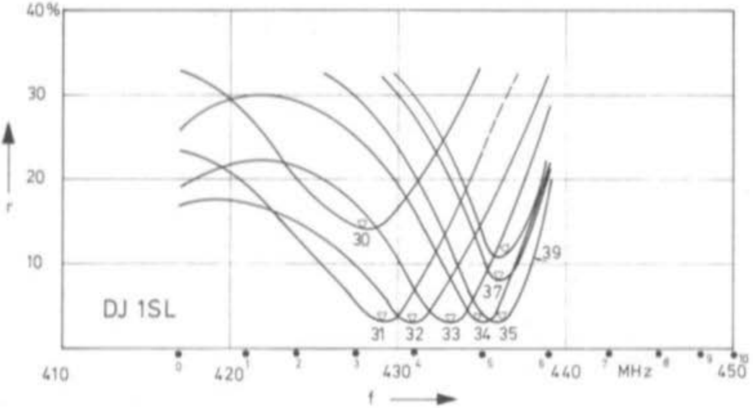


Fig. 7: The balun length was reduced to 21.5 cm with respect to the values given in Fig. 6

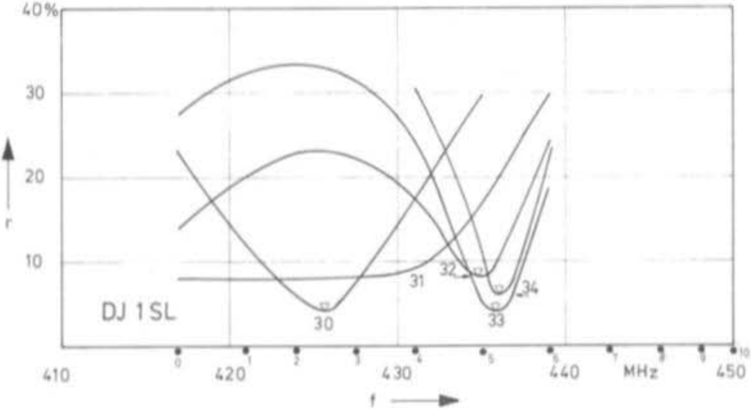


Fig. 8: These reflection factor curves are valid for a balun length of 19 cm

The balun transformers with the lengths b_1 to b_5 had to be soldered to the radiator and exchanged for each measuring series. The measuring bridge was connected only approximately 10 cm from the radiator in order to avoid any measuring errors due to additional standing waves. Since the reference resistor Z_0 could be exchanged, all measurements were carried out at an impedance of 50 and 60 Ω.

The radiator length was varied in steps of 1 cm during the following series of measurements. The reflection factor was then determined for both $Z_0 = 50\ \Omega$ and $60\ \Omega$ for each balun length and at 11 different frequencies. This led to approximately one thousand hand-written measuring values, which could be evaluated according to various criteria.

One error factor was represented by the diameter jump of the variable folded dipole. In order to determine the difference between this dipole and a fixed folded dipole constructed from one common diameter, a folded dipole was constructed with an external length of 32 cm, and also measured in the series.

MEASURED RESULTS

The evaluation of the measured results is best made in the form of diagrams which show the reflection factor as a function of frequency. These show the following parameters independent of another: Lengths of the balun transformer, and folded dipole, as well as the reference impedance Z_0.

Several diagrams that were used for determining the length of the radiator, and the associated balun transformer length are given in **Figures 6 to 8**.

The fundamental results of these experiments are:

1. A matching of the selected antenna to 60 Ω or 50 Ω coaxial cable is possible by selecting the correct combination of folded dipole and balun length.
2. The frequency of optimum matching can be varied approximately between 429 and 436 MHz by altering the dimensions of dipole and balun.
3. A shortening of the balun transformer length will increase the frequency of optimum matching (when keeping the length of the folded dipole constant).
4. A lengthening of the folded dipole will increase (!) the frequency of optimum matching (when keeping the balun transformer length constant).
5. A fixed folded dipole made from one piece of round material should be 5 mm shorter than the variable folded dipole in order to obtain the same characteristics.

CONSTRUCTION OF THE YAGI ANTENNA

In order to determine the final length of dipole and balun transformer, it was necessary to consider which frequency range was to be covered with which maximum reflection factor, by studying the measured reflection factor curves. In the case of the author, the whole of the 70 cm band should be covered, if possible, in order to carry out ATV-experiments and to operate via repeaters. This would mean that the SSB-band and the satellite communication band would be covered automatically.

The final selection was a dipole length of 34 cm, and a balun transformer length of 21.5 cm. (Ed.: When using the same cable as the author). The exact dimensions of the the folded dipole are given in **Figure 9**.

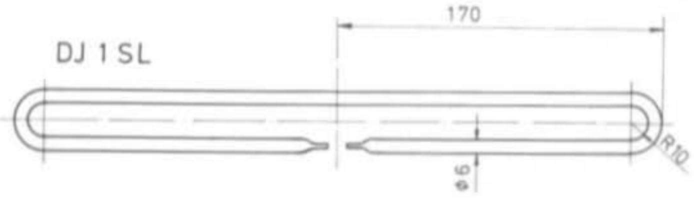


Fig. 9: The final folded dipole has an overall length of 698 mm

The frequency of optimum matching when using this arrangement is 435.5 MHz, where 10 % reflection factor can be measured between 433.5 and 438 MHz, and 20 % reflection factor between 431 and 439 MHz. This corresponds to a VSWR of 1.16 and 1.5 respectively.

The construction of the complete antenna with fixed folded dipole, and the selected balun transformer length provided the expected values of the reflection factor.

Up to this point, all measurements were made in only one polarization plane. However, all crossed parasitic elements were already mounted on the antenna, with a stagger of 25 mm behind the elements of the active antenna.

THE CROSSED YAGI ANTENNA

A large deviation of the reflection factor of the previously measured antenna plane was noticed after mounting the folded dipole and balun transformer of the second antenna plane.

After carrying out a series of experiments using different terminations of the non-connected antenna plane, detuning and dampening of the elements, it was found that the large deterioration of the reflection factor was due to an unwanted coupling between both planes in the area of the closely spaced folded dipoles. Strangely enough, only the rear folded dipole was interfered with, and not the dipole mounted in front.

The author's theory is that a close electrical coupling exists between the folded dipole and the first, closely spaced director, and this is very important for the operation of the directional antenna. The electromagnetic field in the immediate vicinity of the radiator shows a great deviation from the 90° polarization plane difference at greater distances from the antenna. This leads to a large coupling even to the oppositely polarized radiator that was mounted between the radiator and its first director. (Ed.: This has not been observed by DJ 0 BQ, however, his experiments were carried out on antennas having a greater spacing between folded dipole and first director).

The interference effects between the radiator and the first director of both planes were avoided by increasing the spacing between the folded dipoles to 100 mm. This was confirmed in measurements. Of course, it is also necessary to shift all parasitic elements by the same amount. The positions of the crossed elements are shown in Figure 1 as points on the boom.

A photograph of the completed 70 cm antennas in the overall antenna system for 2 m/70 cm is shown in **Figure 10**.

The 2 m antenna was also found to have the same interference effect in the vicinity of the radiator, encountered with the 70 cm antenna. The interference effect was caused by the rather large mast clamp, which was mounted at the centre of gravity between radiator and first director of the vertical elements. The two 2 m planes exhibited reflection factors of 14 % and 33 %, which corresponds to VSWR-values of 1.3 and 2.0 respectively.

FINAL CONSIDERATIONS

The determined, optimum dimensions of radiator and balun transformer are actually only valid for the 9-element antenna which means that it is necessary for them to be optimized experimentally when used in conjunction with other antennas. However, the experiments have shown in which way various measures have an effect, which means that this will reduce the extent of experiments in obtaining correct matching between cable and antenna that was experienced by the author.

The author does not have an exact explanation for the opposite effect of balun and dipole length on the frequency of optimum matching, however, it is assumed that there is a certain overall electrical length of balun transformer and folded dipole for a certain resonance frequency. The variation of the balun transformer length could then be assumed as being a shift of the cable feed point on the radiator, which makes it similar to a so-called T-match in the case of a straight dipole.

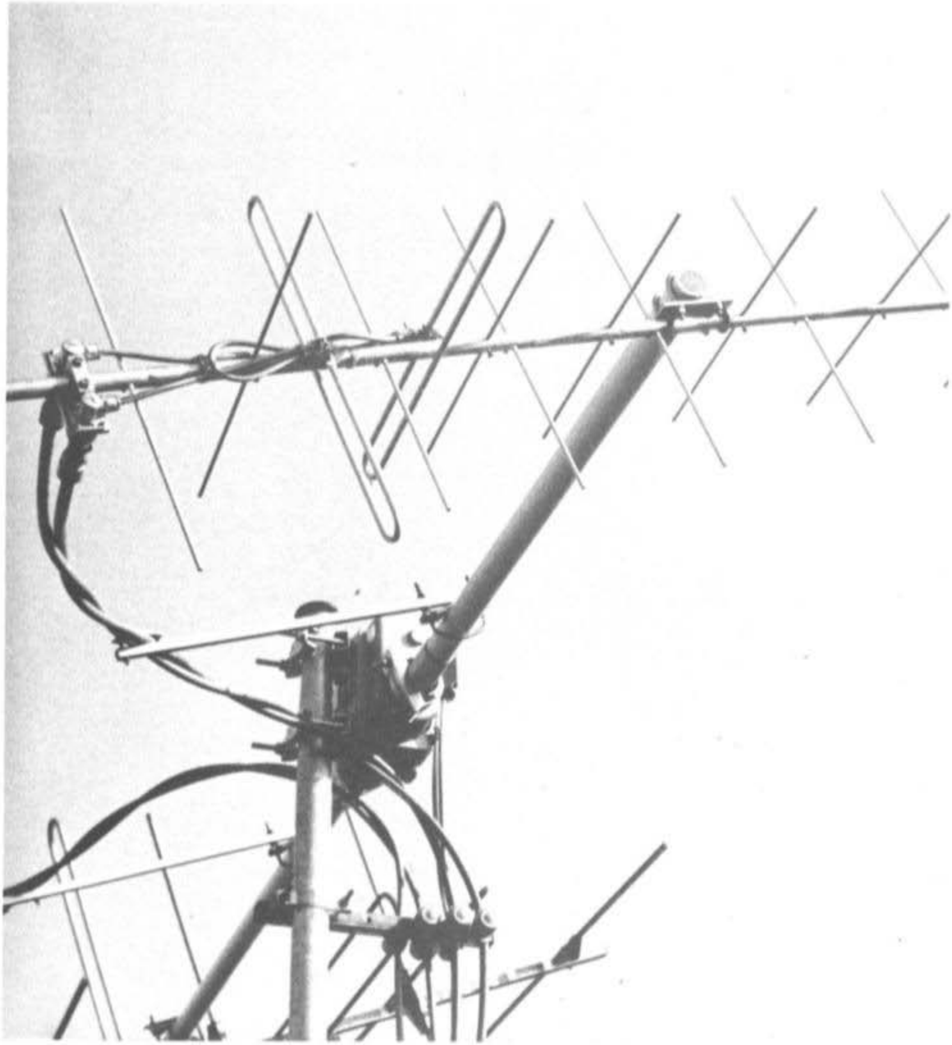


Fig. 10: Photograph of the completed crossed Yagi antenna mounted on a glassfibre tube

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An ATV-Transmitter for the 24 cm Band Constructed from Modules Described in VHF COMMUNICATIONS

by G. Sattler, DJ 4 LB

SUMMARY

The following information and measured values show that it is also advisable to construct an ATV-transmitter according to the intermediate frequency method even on the 24 cm band. When a single-conversion process is used that converts the standard video and sound intermediate frequency direct to the 24 cm band, this will mean that the 70 cm ATV-band is avoided, which means that it can be used for reception and duplex operation.

Figure 1 shows a block diagram of the video and sound processing at IF-level, and is identical to that described in (1) for a 70 cm transmitter.

The IF-signals of 38.9 MHz (video) and 33.4 MHz (sound) are converted to a frequency of 1252.5 MHz (video), and 1258.0 MHz (sound) with the aid of the local oscillator frequency of 1291.4 MHz. This is shown in the form of a block diagram in **Figure 2.** The output power level can be increased in a transistorized linear amplifier such as DC 0 DA 008/009 described in (2) or in DJ 4 LB 008 which will be described later.

Various modules can be used for generating the crystal-controlled local oscillator frequency of 1291.4 MHz: e.g. DF 8 QK 002 in (3). The module DF 8 QK 001, which was described in (4), is suitable for use as transmit mixer after carrying out the following modifications.

CIRCUIT DESCRIPTION

1. IF-MODULE

This is built up using the DJ 6 PI, and DJ 4 LB modules given in Figure 1. **Figure 3** shows an additional IF-output coupling stage which should be connected directly to the output of the residual sideband filter. This stage allows the 70 cm and 24 cm transmitter to be operated from the same IF-module, and saves switching the IF-voltage when operating on either the 70 or 24 cm band. The output of the additional IF-stage can remain disconnected. If the 70 cm mixer is not connected, it is necessary for the residual sideband filter to be terminated with approximately 60 Ω at this position.

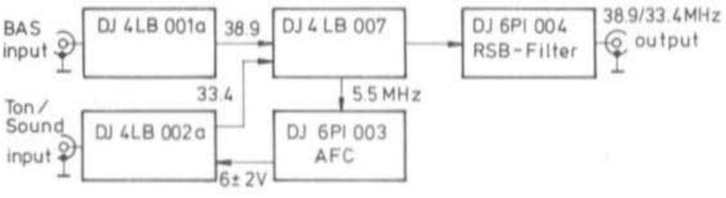

Fig. 1: Video and sound processing at IF-level, as was used in the DJ 4 LB 70 cm ATV-transmitter

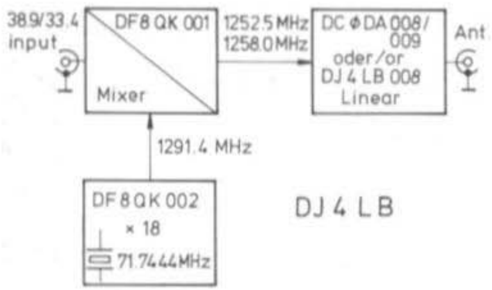

Fig. 2:
Modules and frequencies for converting the ATV-signal to the 24 cm band

2. LOCAL OSCILLATOR MODULE DF 8 QK 002

This module provides the eighteenth harmonic of the crystal frequency. This means that one will need a crystal whose frequency is 1291.4 MHz ÷ 18 = 71.74444 MHz. No further modifications are required to this module.

3. LINEAR CONVERTER DF 8 QK 001

3.1. IF-Input Circuit

The original version of this module was designed for SSB operation at 1296 MHz using an intermediate frequency of 28 MHz. **Figure 4** shows the circuit of the IF-input circuit of the mixer.

An IF-input circuit having a wider bandwidth is more suitable for ATV-operation. This should be designed for a mean intermediate frequency of approximately 36 MHz, as is shown in **Figure 5**. The following modifications should be made to the original version shown in Figure 4:

- Delete the parallel capacitance C 1 (22 pF trimmer), otherwise unwanted oscillation can occur in the video-frequency range !
- Wind inductance L 1' : 2 x 6 turns of 0.3 mm dia. enamelled copper wire on a coil former of 5 mm diameter, bifilar wound. Separate the windings and connect in

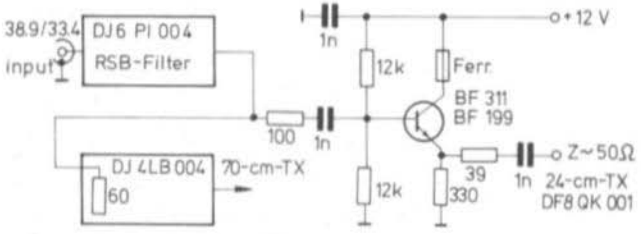

Fig. 3:
Both mixers can be connected simultaneously by using an additional buffer stage

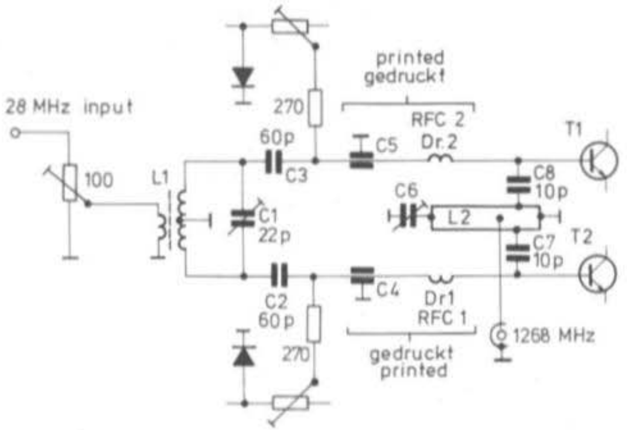

Fig. 4:
This original circuit of the mixer is not suitable for our application

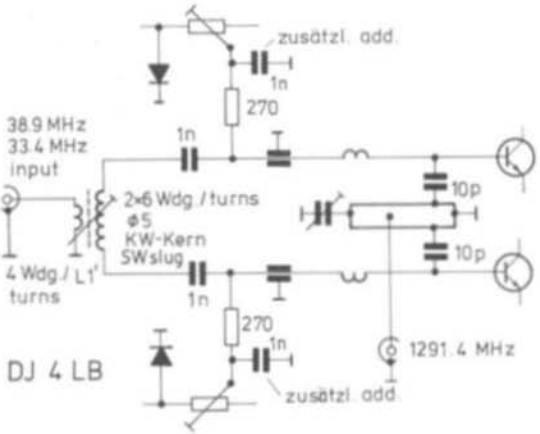

Fig. 5:
This is the modified mixer circuit for 24 cm ATV

series. Do not connect the resulting center tap to ground since the IF-circuit is balanced capacitively! Wind four coupling windings symmetrically to the center tap of the coil. Tune the IF-circuit using a HF-core to approx. 36 MHz.

- Replace the 60 pF capacitors C 2 and C 3 by 1 nF types. The DC-blocking instead of the capacitive divider ensures that the 270 Ω resistors dampen the whole IF resonant circuit.
- Add one 1 nF each from the cold end of the 270 Ω resistors to ground in order to achieve a defined dampening of the resonant circuit – independent of the adjustment of the potentiometer – and to isolate the IF-voltage from the diodes of the base-voltage divider.

3.2. Operating Point of the Transistors

Extensive experiments have shown the following:

- All transistors should be operated with stabilized collector DC-voltages. The resistors in the collector circuits are only provided to measure the collector currents without cutting the lines. They should have the lowest possible value.
- The active mixer will have its largest linear drive range with a collector DC-voltage between 8 and 9 V.
- The amplifier transistors T 3 and T 4 should be operated with a maximum collector DC-voltage of 8 V for thermal stability reasons.

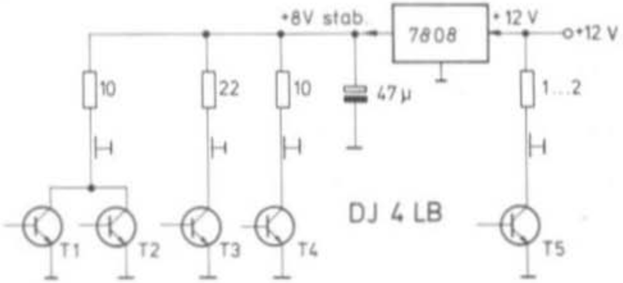

Fig. 6:
The new collector-voltage supply of module DF 8 QK 001

The circuit given in **Figure 6** shows how these demands can be satisfied using an integrated 8 V voltage stabilizer such as type 7808. It is also advisable to redesign all base voltage dividers to suit the stable 8 V supply.

Since the DC-gain of RF-transistors is not very high (e.g. $B \geqq 25$ in the case of the BFQ 34), the base voltage should be taken from a low-impedance source. **Figure 7** gives a suitable circuit which also includes a temperature compensation. The collector current of the BFQ 34 (T 5) should be adjusted to the most favorable value of approximately 150 mA.

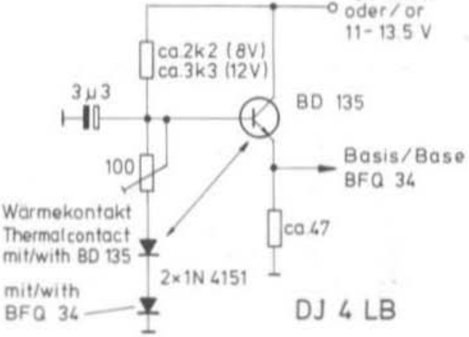

Fig. 7:
A low-impedance, base-voltage supply with temperature compensation

3.3. Measured Values

Complement:

T 1, T 2, T 3: BFR 34a
T 4: BFR 96
T 5: BFQ 34

Operating voltage: 12.0 V

IF-voltage (video + sound) at the IF-input connector: 50 mV RMS

Local oscillator power at the LO-input connector: approx. 3 mW

RF-output power for 1 dB compression: approx. 800 mW.

Overall bandwidth: Approx. 1 dB at $\Delta f = \pm 4$ MHz from the center frequency.

3.4. Spectrum Analysis

Figure 8 shows the most important components of the output frequency spectrum in a double-logarithmic display.

The sound carrier is a constant 11.5 dB down on the video carrier; according to the CCIR standard, values of 10 to 13 dB are permissible. At an output power of 0.8 W for the video carrier, the sound carrier is reduced by 1 dB, which is a sign of the commencing limiting of the sum signal of video and sound carrier. Roughly speaking, this point represents the upper limit of the drive during ATV-operation, since the synchronizing pulses of the video modulation will also be limited by approximately 1 dB at this output level.

The strongest intermodulation product during ATV-operation using a 5.5 MHz video/sound spacing is at a frequency of $f_{video} - 5.5$ MHz (curve 4). The amplitude of this line will increase considerably faster than the output power on increasing the drive level. Further, weaker intermodulation products can be seen at the frequencies $f_{video} \pm 11$ MHz (curves 5 and 6).

The image frequency of the video carrier is spaced 77.8 MHz higher than the required frequency, and is depressed by approximately 33 dB. If a linear amplifier having a similar construction to DC 0 DA 008/009, or DJ 4 LB 008 is connected after the mixer module, this will increase the image rejection per (single or parallel) stage by at least a further 8 dB.

The local oscillator frequency is only optimumly suppressed at the IF-level at which the transistor push-pull mixer is balanced with the aid of the base-bias voltage. This IF-level corresponds to an RF-output power of approx. 0.3 W in our example. The range of best balance and thus best rejection of the local oscillator frequency can be adjusted to any output power level by alignment.

A spectrum analysis such as given in Fig. 8 provides suitable criteria for calculating an output filter to provide further rejection of the spurious waves.

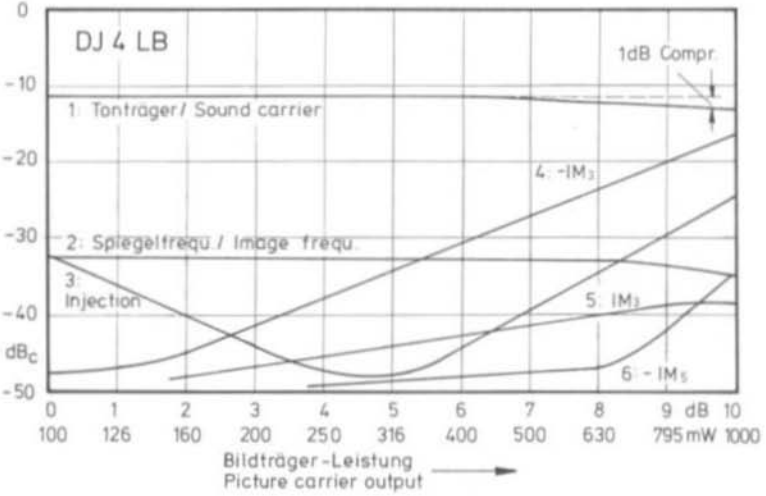

Fig. 8:
The most important finding on this diagram is that a transmit power increase of 3 dB will cause an increase of the strongest intermodulation product (curve 4) by approximately 10 dB !

1) Sound carrier = 1258.0 MHz
2) Image frequency = 1252.5 MHz + (2 x 38.9) MHz = 1330.3 MHz
3) LO = 1252.5 MHz + 38.9 MHz = 1291.4 MHz
4) $-\mathrm{IM}_3$ = 2 x 1252.5 MHz – 1258 MHz = 1247 MHz
5) IM_3 = 2 x 1258 MHz – 1252.5 MHz = 1263.5 MHz
6) $-\mathrm{IM}_5$ = 3 x 1252.5 MHz – 2 x 1258 MHz = 1241.5 MHz

4. TRANSISTORIZED LINEAR AMPLIFIERS

The following linear amplifiers are suitable for amplifying the output power level of an ATV-signal from module DF 8 QK 001. This can be seen by comparing the power levels at the 1 dB compression points (s. **Table 1**). Each of these single, or parallel stages has a power gain of approximately 7 dB at the 1 dB compression point. Since the power limit of an amplifier stage equipped with the BFQ 68 is only approximately 3.5 dB over that of the transmit converter (0.8 W to 1.7 W), a gain reserve of 3.5 dB is provided.

Modules	Output power for 1 dB compression
DF 8 QK 001 on its own	approx. 0.8 W
DF 8 QK 001 + amplifier with 1 x BFQ 34	approx. 1.2 W
DF 8 QK 001 + amplifier with 2 x BFQ 34 parallel	approx. 1.7 W
DF 8 QK 001 + amplifier with 1 x BFQ 68	approx. 1.7 W

Table 1

If the two modules are directly connected to another using a short coaxial cable, it is necessary for the IF-level to be reduced, in order to avoid overdriving the linear amplifier. This is made easily by adjusting the level controls provided for this in the IF-module DJ 6 PI 002 or DJ 4 LB 007.

On the other hand, it is possible to provide 3.5 dB attenuation between converter and linear amplifier in the above example. This could be in the form of a simple bandpass filter, or a longer coaxial cable (for example up to 5 m of RG-58/U), which may make it possible to mount the linear amplifier in the direct vicinity of the antenna.

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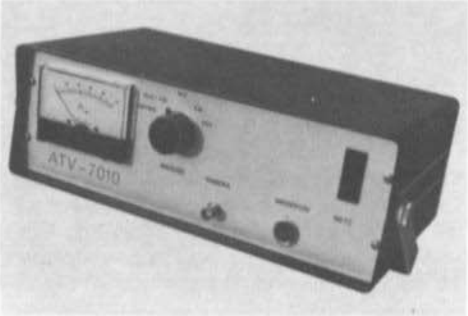

VHF communications

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A Digital Frequency Readout for Amateur Equipment with a 9 MHz IF

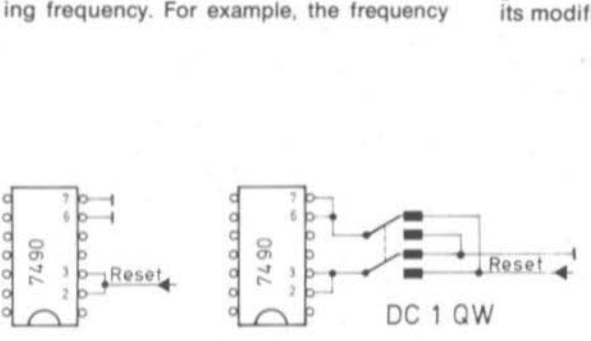
by G. Heeke, DC 1 QW

A conventional frequency counter cannot usually be used as a digital readout for amateur radio equipment, since a signal of constant amplitude at the actual operating frequency is neither available in the transmit nor in the receive modes. It is often only possible for the frequency of the local oscillator to be measured and indicated. A disadvantage of this is that the measured frequency will differ to the value of the intermediate frequency in the transmit and receive modes. This severely limits its usability.

The following article is to describe a modification to the circuit of certain frequency counters that allows the compensation of the intermediate frequency with the aid of a switch, and a few other components. The frequency readout will then show the transmit, or receive frequency directly.

This circuit can always be used when a transceiver is operating with a standard intermediate frequency of 9 MHz, and when the oscillator is operating below the working frequency. For example, the frequency counter will provide a readout of 144 MHz when a frequency of 135 MHz is measured. This modification can be carried out with all frequency counters that operate with decimal counters type 7490. The task is to set the counter state at the beginning of a counting period to 9 MHz instead of to 0. This means that the sum of IF and oscillator frequency will be indicated at the end of the counting period.

The circuit modification need only be carried out for one decimal point, this being 1 MHz. The four connections 2 and 3, as well as 6 and 7 of the integrated counter 7490 should be disconnected and exchanged as pairs. Each reset pulse will then lead to a counter state of 9. If a two-pole changeable switch is used, it is possible to change between normal operation, and IF-compensation, as required. Attention should be paid to keep the leads as short as possible, or to use a miniature relay. **Figure 1** shows the connections of the integrated counter 7490 in the original, and in its modified state.



Original

Modified version

Fig. 1: Digital Frequency readout for amateur radio equipment with 9 MHz IF

Coaxial SHF-Connectors Constructed from Bicycle Tire Valves

by E. Schäfer, DL 3 ER

Professional microwave coaxial connectors for screw fitting such as SMA plugs and sockets are not readily accessible to most radio amateurs. Either the prices are very high, or they are not available at all. However, such connectors are very necessary and can hardly be avoided. One may have obtained, for instance, a circulator inexpensively, or a professional waveguide/coaxial transition is to be integrated into a circuit.

Of course, one is usually able to improvise and find some way around the problem. For instance, the author has used an inexpensive, readily available component for many years: bicycle tire valves ! It is even possible to remove these from defective inner tubes including the threaded shaft of the valve, together with the nut and other pieces after preparing them mechanically.

Of course, it is favorable to possess or have access to a small lathe.

The author uses tire valve components in his 10 and 24 GHz modules as follows:

- As case for chokes in the Gunn oscillator and mixer modules, and for detector diode mounts
- For waveguide/coaxial transitions
- For cavity antenna exciters
- Suitable cables for use with such connectors are the PTFE-cables type RG-141/142 which are available as flexible and semi-rigid cables.

CONSTRUCTION

The mechanical construction of a transition from 50 Ω coaxial cable to waveguide WR 90, or R 100 (10 GHz band) will be shown as an example (**Figure 1**, upper left).

This can be realized very simply:

The outer body of the valve (part 1) is drilled out to a diameter of 5.5 mm and shortened to the given length. The hole in the waveguide has the diameter of the cable dielectric. Part 1 is held centrically to the hole in the waveguide and is soft-soldered into place. Any residual solder on the inside should be carefully removed.

The collar (part 2 for semi-rigid cable) is soldered to the cable (4), as shown in the diagram, after preparing the cable as shown. If flexible coaxial cable is used, a collar similar to part 2a should be used.

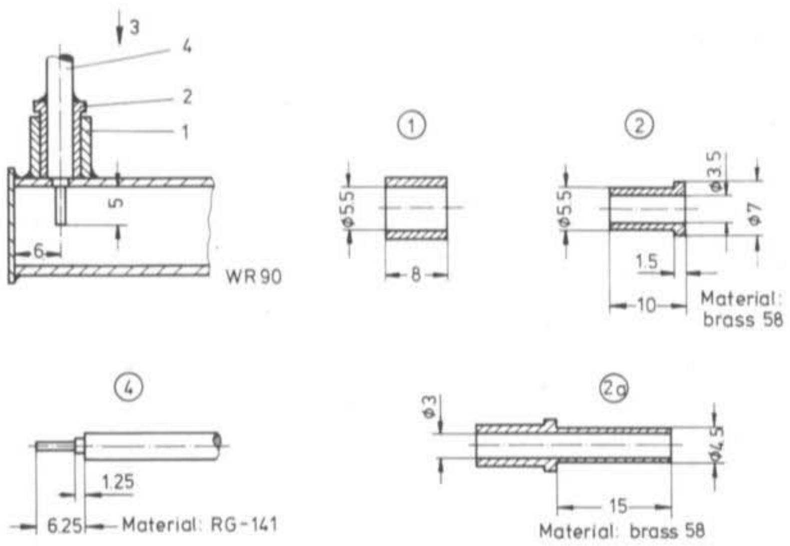


Fig. 1: SHF-connector constructed from bicycle tire valves

The sheathing of the cable is placed over the collar for approximately 5 mm and soft-soldered into place. For a better appearance, a piece of insulating tubing can be placed over the collar and cable for a length of approximately 30 to 50 mm.

If the given parts are to be used as diode holder (choke mount), the threading should be lathed down to 6 mm diameter for approximately 1.2 mm at the soldered end. It can then be placed into a suitable hole in the waveguide and soft-soldered into place.

A further example, which is not to be described in detail here, would be a cable connector between semi-rigid and flexible cable. It would then be possible, for instance, for a waveguide transition to be connected in a flexible manner with an antenna radiator.

EXPERIENCE

This form of connector does not, of course, represent a complete connector system (plug/coupling etc.). However, it can be used with advantage when the solid inner conductor of the cable is to be used directly to energize the waveguide.

However, the contact pressure must not be too great, otherwise it is possible that the soft-solder joint would be damaged. Of course, this could be avoided by hard (silver) soldering.

Matching measurements showed that VSWR-values of less than 1.1 were measured in a system comprising cavity antenna radiator for a X-band parabolic antenna, approximately 60 cm RG-141, one of the previously mentioned transitions, and a 3-screw tuner. Attenuation values were not measured; however, they are negligible according to the practical experience gained at X-band, and are mainly determined by the cable loss as given by the manufacturers.

A Settable 45 MHz Counter

by H. Eckhardt, DF 2 FQ

It is necessary in the case of a superhet receiver for the intermediate frequency to be added, or subtracted from the measured intermediate frequency, in order to indicate the receive frequency correctly. In addition to this, it is important to use a sufficiently fast counter so that it is possible to cover at least the shortwave range without using a prescaler. The following article is to describe a settable frequency counter that can be realized easily.

Specifications of the Counter:

Four-digit LED readout, last digit: 100 Hz
Frequency range: min. 35 MHz, typ. 45 MHz
Time base error: $\pm 5 \times 10^{-6}$
Measuring range: 5 measurements per sec.
Operating voltage: 9 to 15 V
Operating current, without readout: 30 mA

CIRCUIT

The operation of the counter can be seen in the circuit diagram given in **Figure 1**. The integrated circuit I 2 is a fourteen-stage binary counter with integrated oscillator. This generates the clock frequency. When using a crystal of 3.2768 MHz, a frequency of 200 Hz will be available at the output pin 3, which can be divided again by four in the subsequent divider 4017. The RC-combination at the reset input (MR) generates a clean output pulse.

The following IC 4017 (I 4) provides the control of the counter. This is especially simple since the output signals are already decoded with this circuit. The input signal divided by ten is available at the carry output (CO) with a ratio of one-to-one. This output is used for control of the counting gate and passes the signal via a level converter and inverter (T 2) to the reset input of I 1.

The TTL-circuit I 1 (7490) then divides the 100 ms by ten, and it is kept to zero for the same period. In this manner, it is possible to save an extra gate circuit. In addition to this, the use of a TTL-counter in the first stage considerably increases the measuring range, which more than compensates for the use of two level converters. A further advantage is also provided by the controlled, first counter: The ± 1 digital error in the last digit is reduced by 90 %, which means that the indication hardly flickers.

The chain of resettable decade counters 4029 is driven via a further level converter (T 1). These in turn pass on their output signal to the storage, decoder, and driver type 4511, to which the 7-segment readouts are connected.

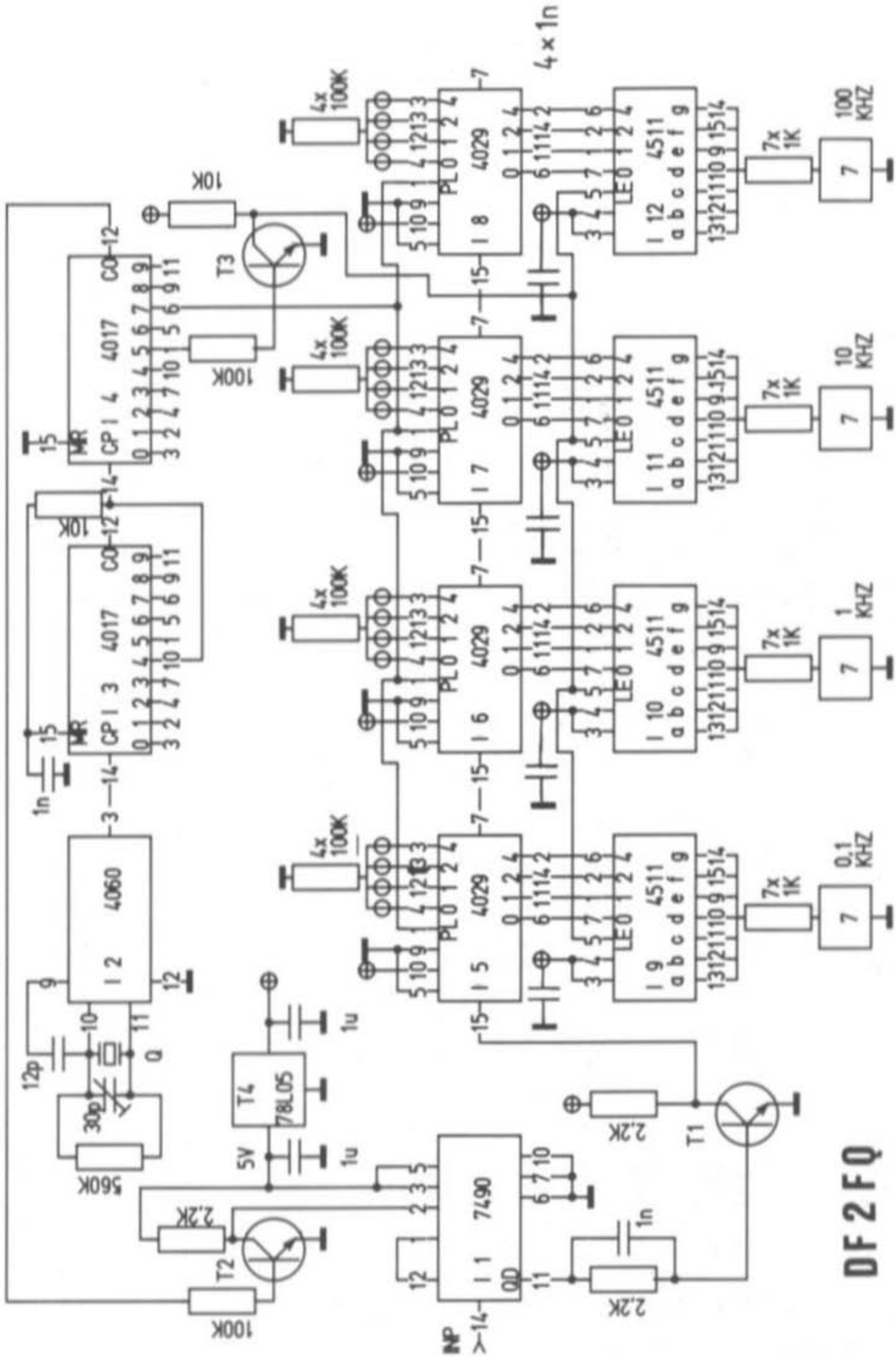


Fig. 1: A settable 45 MHz frequency counter with a resolution of 100 Hz

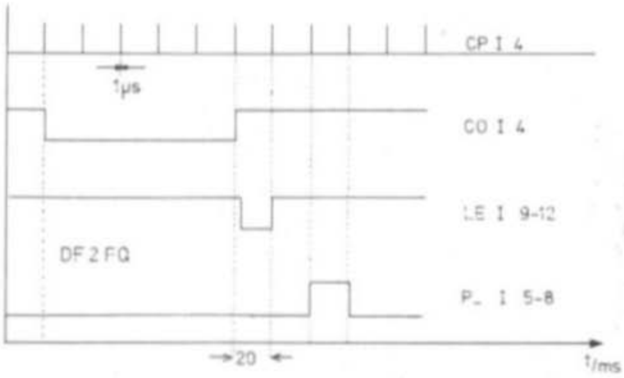


Fig. 2: Pulse diagram of the frequency counter shown in Fig. 1

After the end of the gate time, the storage transfer is made by a 20 ms pulse from output 5 of I 4 via inverter T 3 to the input latch enable (LE) of I 9 to I 12. The counted frequency will be indicated until the next storage transfer pulse appears. After a further 20 ms, the load pulse will appear at output 7 of I 4. This provides counters I 5 to I 8 (connection PL) with the information available at the present inputs. When no external connections are made, these inputs are connected via 100 kΩ to logic 0, which means that the counters are erased and are ready for the next counting phase. The time sequences are given in the time plan shown in **Figure 2**.

CONSTRUCTION AND ADJUSTMENT

The counter is accommodated on a 90 mm x 75 mm double-coated PC-board without through-contacts. **Figure 3** shows the component locations on this PC-board, which has been designated DF 2 FQ 001. No PC-board was designed for accommodating

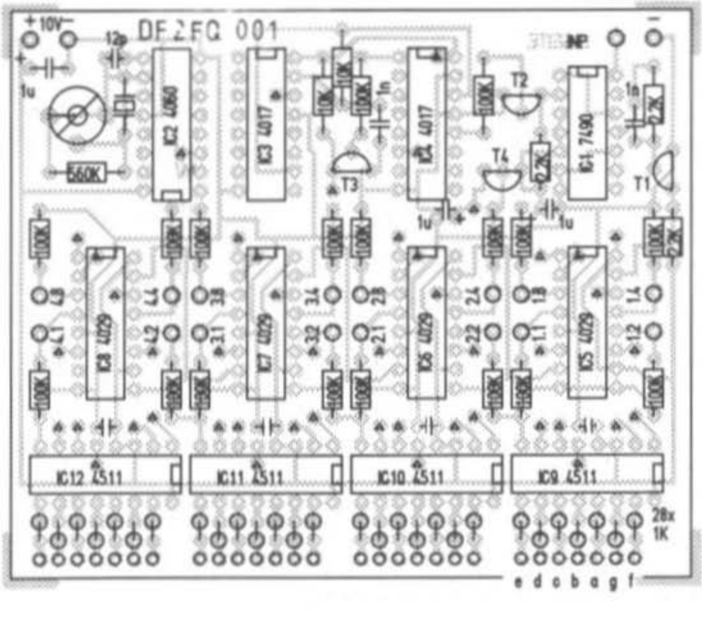


Fig. 3: Component locations on the double-coated PC-board for the frequency counter (without readouts). Dimensions: 90 mm x 75 mm

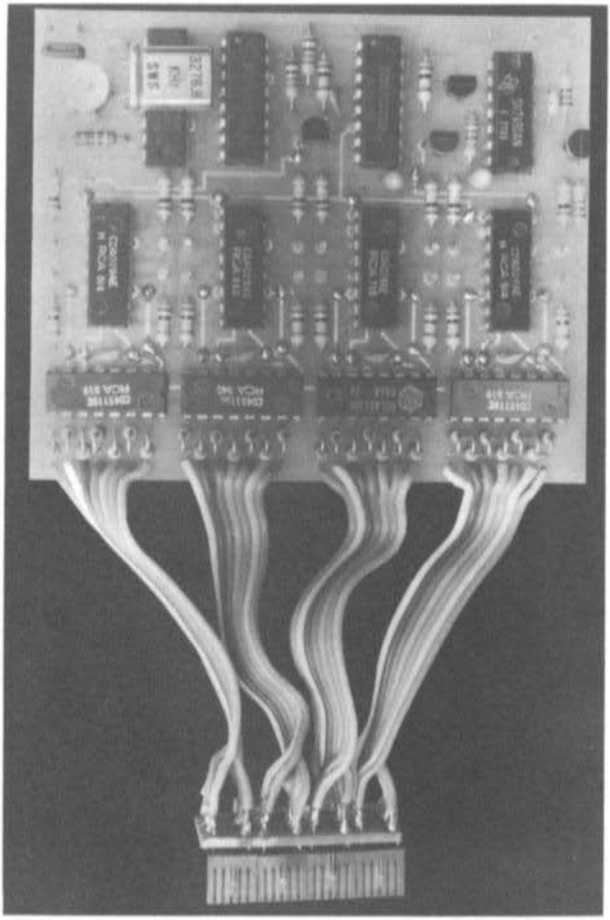


Fig. 4:
Photograph of the author's prototype with connected readouts

the 7-segment readout since it is more simple for them to be built up on a Vero-type board, which also means that one is not forced to use a certain type of indicator.

Since there is sufficient room on the board, construction should present no problems. This is commenced by making the through-contacts with the aid of small pieces of wire. These positions are marked with Δ at the corresponding positions in the component location plan. The through-contacts can be deleted if the components are soldered on both sides of the board.

After mounting all the components as shown in **Figure 4**, the PC-board should be checked for any excessive solder, short-circuits, and for correct position of the components, etc. After this, an operating voltage of 10 V can be connected, after which zeros should appear on the readout. The trimmer capacitor is now adjusted so that the readout coincides to a known frequency connected to the input. After this, the counter is ready for operation.

COMPONENTS

1 pc.	SN 7490 AN (TI)
2 pcs.	CD 4017 AE (RCA)
1 pc.	CD 4060 AE (RCA)
4 pcs.	CD 4029 AE (RCA)
4 pcs.	CD 4511 BE (RCA)
1 pc.	LM 78105 (National)
3 pcs.	BC 238 B or similar silicon PNP-AF transistor

4 pcs.	7-segment LED readouts, common cathode
1 pc.	Crystal 3.2768 MHz HC-25/U
1 pc.	12 pF ceramic cap., spac. 2.5 mm
2 pcs.	1 nF ceramic cap., spac. 2.5 mm
4 pcs.	10 nF ceramic cap., spac. 2.5 mm
1 pc.	0.1 µF ceramic cap., spac. 5 mm
2 pcs.	1 µF/16 V tantalum electrolytics, spacing 2.5 mm
1 pc.	5-30 pF plastic foil trimmer (red)
28 pcs.	1 kΩ carbon resistors, spac.10 mm
3 pcs.	2.2 kΩ carbon res., spac. 7.5 mm
2 pcs.	10 kΩ carbon res., spac. 10 mm
18 pcs.	100 kΩ carbon res., spac. 7.5 mm
1 pc.	560 kΩ carbon res., spac. 7.5 mm

OPERATIONAL TIPS

The frequency counter possesses a TTL-input, which means that a preamplifier will be required for normal operation. A number of suitable circuits have already been described (1), (2). For applications in the 2 m or 70 cm band, a prescaler will be required, and suitable modules were described in (3) and (4).

The maximum input frequency of the counter is determined by I 1 (7490). Although the various manufacturers of this integrated circuit only guarantee a maximum frequency of 35 MHz, the author has found that all prototype boards were able to operate correctly in excess of 45 MHz.

The highest value of the measured frequency indicated by this counter is the 100 kHz digit. For normal operation, e.g. as frequency readout in a shortwave transceiver, the MHz-readouts will be programmed and possibly switched with the aid of the band selection switch. If an intermediate frequency is to be added, all digits of this frequency that are to the right of the MHz-decimal point, are converted into a BCD-value and those preset inputs are connected to the operating voltage whose BCD-number is one. If a frequency is to be subtracted, one forms the 10000-complement of the four digits to the right of the MHz-decimal point, after which the previous procedure is carried out.

If one has calculated correctly, the frequency difference, or its 10000-complement will appear on the readout when no input signal is present. If no frequency is to be compensated, these connections remain unwired. The pins for programming are designated with 1.1, 1.2, 1.4, etc. in the component location plan. The first numeral indicates the decimal position, and the second the binary valency of the individual connections.

A few examples for programming:

1. Addition of 10.7 MHz

Since the highest indicated position amounts to 100 kHz, only the digit 7 is relevant: 7 ≙ 0111. This means that pins 4.1, 4.2, and 4.4 are connected to + U_{op}.

2. Subtraction of 455 kHz

All three positions are relevant, since they are within the readout range. For subtraction, it is necessary to form the 10 000-complement of 4550: 10000 – 4550 = 5450. 5450 ≙ 0101, 0100, 0101, 0000.
Pin 2.1, 2.4, 3.4, 4.1, and 4.4 must be connected to + U_{op}, and all other pins remain free.

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(1) H. Senking, DC 6 JA: Vorverstärker für Frequenzzähler von 0-80 MHz
cq-DL 2/1976, pages 46-47

(2) H. U. Schmidt, DJ 6 TA: High-Impedance Preamplifier for Frequency Counters from DC to 60 MHz
VHF COMMUNICATIONS 6, 3/1974, pages 177-182

(3) J. Grimm, DJ 6 PI: A 10:1 Prescaler and Preamplifier with an Upper Frequency Limit of 250 MHz for Use with Frequency Counters
VHF COMMUNICATIONS 5, 3/1973, pages 154-159

(4) J. Grimm, DJ 6 PI: A Sensitive 550 MHz 10:1 Prescaler and Preamplifier for Frequency Counters
VHF COMMUNICATIONS 6, 4/1976 pages 247-251

A System for Reception and Display of METEOSAT Images – Part 7

by R. Tellert, DC 3 NT

Part 6 of this series of articles completed the description of the electronic circuits of the FAX-machine. This article is to give details on the construction of the machine itself.

The FAX-machine was designed and constructed in such a manner to enable it to be constructed with the simplest means possible. Despite of this, a lathe is required for manufacturing some of the parts. Readers who would like to construct this FAX-machine should have at least a basic knowledge of such construction and metal work.

7.1. Concept Considerations

A facsimile image is transmitted in the same manner as a TV or SSTV image: line for line; it is only that the time relationships are different. In the case of mechanical scanning, the jump from the end of one line to the beginning of the next can be difficult to achieve. In the case of television images, approximately 20 % of the line duration is allowed for the fly-back of the electronic beam. In the case of facsimile technology, this fly-back sequence should amount to a maximum of 3 % of the line duration. It is, for instance, impossible to carry out such a scan using an X-Y recorder ! This means that some kind of »tricks« must be used so that the end of one line and the beginning of the next line are adjacent.

This can be solved in the most simple manner when the image is arranged in the form of a drum so that the commencement and the end of the line are adjacent on the circumference of the drum. In practice, a drum is used whose circumference determines the length of a line.

This is the best solution technically, but it does have several disadvantages:

- The format of the image is fixed by the length and circumference of the drum.
- The paper for the image must be firstly placed onto the drum and removed from it after recording the image; this means that it is not possible for a series of images to be recorded.
- It is difficult to determine the contents and drive level of the image being recorded due to the rotating drum.

Professional facsimile machines avoid these disadvantages by using several recording styli, or complete recording combs.

The disadvantages of such constructions are as follows:

- Very high demands on the coincidence and guides of the styli, as well as a complicated adjustment procedure.
- In the case of combs, it is necessary for the video signal to be intermediately stored.
- They are only suitable for reception.

This means that a drum-type of image recording is most suitable for construction with amateur means.

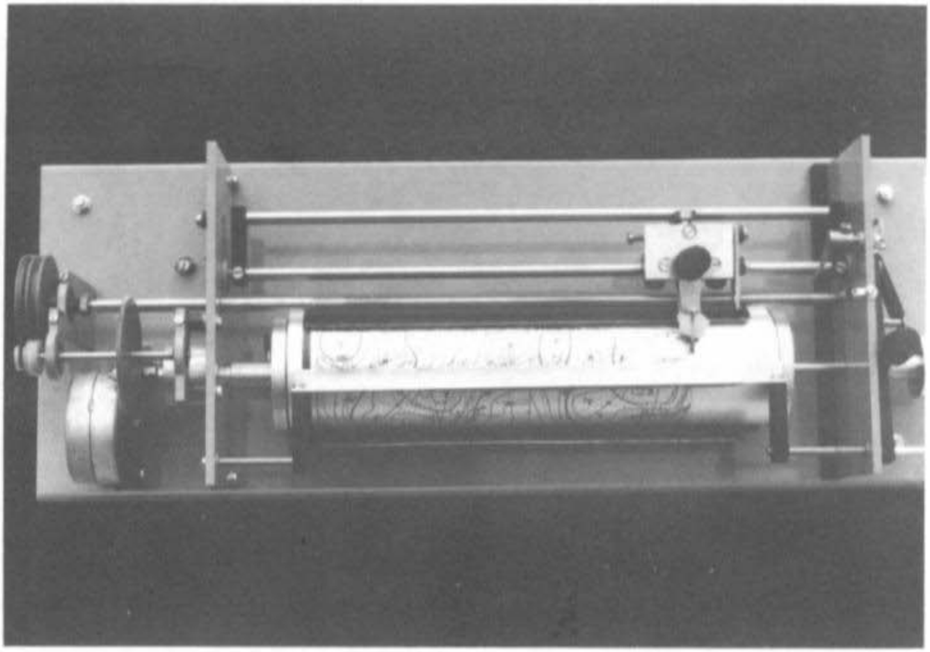


Fig. 62: A weather-map being recorded

7.1.1. Selection of the Format

A format of 160 mm x 208 mm was selected. Weather maps usually have a ratio of line length to height of 1 : 1.2. This means that the format will be most favorably used together with the synchronizing pulses. In addition, this makes it suitable to insert a DIN A 5 paper onto the drum in the transmit mode. Metalized paper is easily available in widths of 208 to 218 mm.

7.2. Construction of the FAX-machine

In order to give an impression of the facsimile machine, four photographs are now to be given that show the machine from above **(Fig. 62)**, from the drive side **(Fig.63)**, from the support bearing side **(Fig. 64)**, and finally with the drum removed **(Fig. 65)**. The last photograph given in Figure 65 shows the transmit probe (microscope and lamp), which is also the front page illustration of the constructional drawings.

The 20-page constructional drawings including list of parts were printed separately in larger scale (DIN A 4). These plans are available from the publishers or your national representatives for the equivalent of DM 8.00 (postage included). These can be ordered, if required, under the designation: »Constructional Drawings for the DC 3 NT FAX-Machine«. These constructional diagrams are required for carrying out construction in conjunction with this description.

The machine is mounted on a U-shaped base plate. This allows sufficient stability to be achieved together with low weight. Two side-pieces are mounted at right angles at each end of the drum. These are used for mounting the drum and stylus drive.

The drum is detachable, which simplifies winding on the metalized paper. For this reason, the support bearing side of the drum was made so that it could be shifted axially. When the drum is in place, it can be fixed with the aid of a knob. The drive side of the drum possesses a fixed bearing.

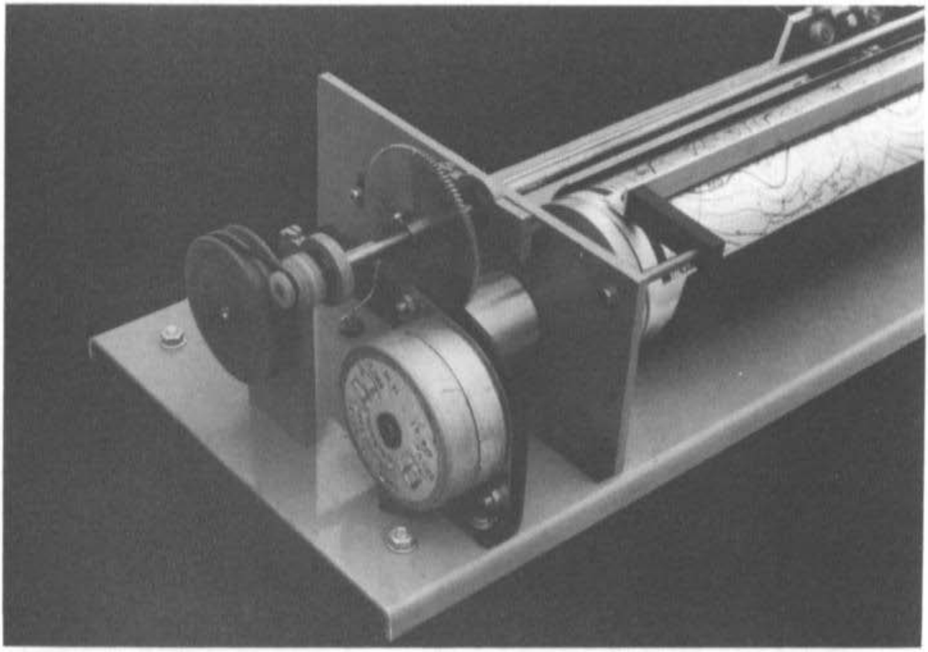


Fig. 63: The drive side of the DC 3 NT FAX-machine

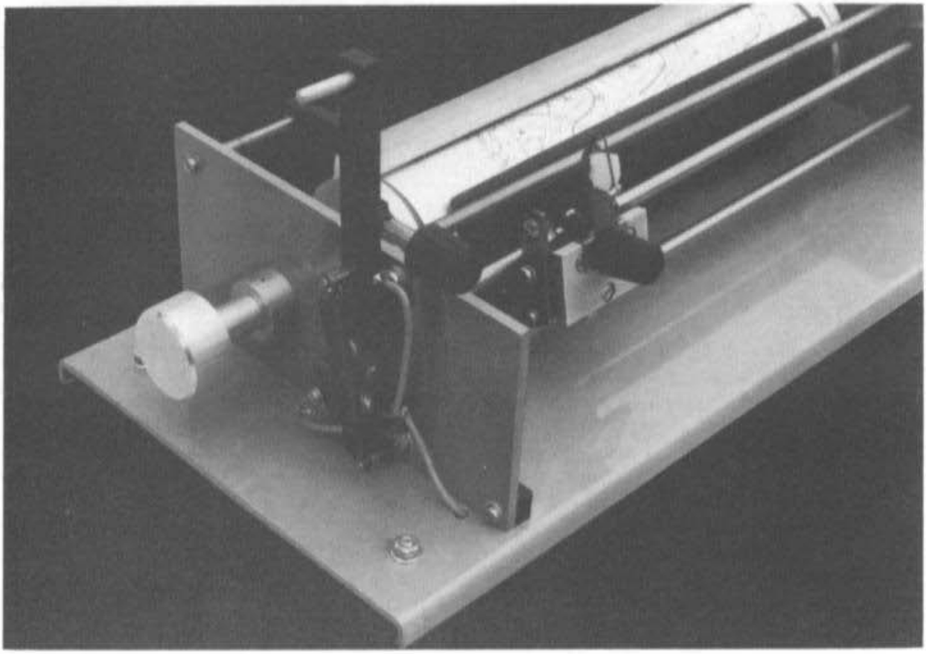


Fig. 64: The bearing side showing the folded-out stylus

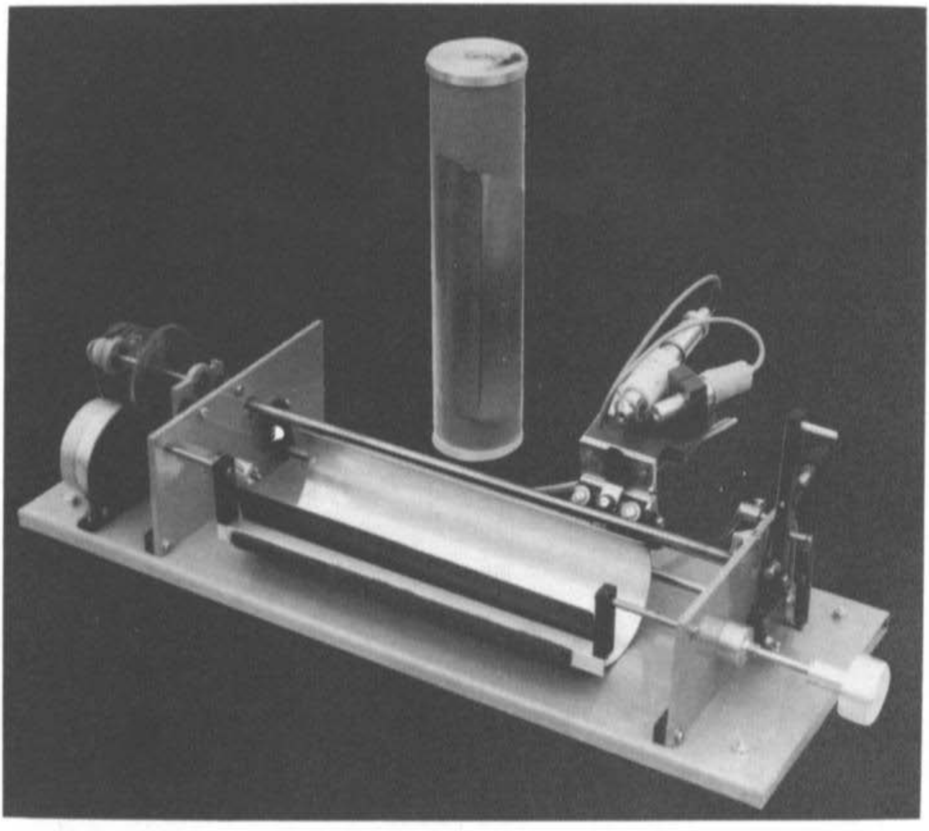


Fig. 65: The contact plates can be seen on the drum after it has been removed from the machine

The position of the drum is maintained axially and radially without play by using a locking spring. In order to facilitate removal of the drum, it is possible for the recording stylus to be folded out; at the same time, an »inforced stop« will be selected, which means that the motor of the machine will be switched off. When the stylus is folded out, the image can be easily removed, and the stylus replaced into the commencement position for the next image.

The stylus is supported with seven ball bearings and is free of play; it is necessary for it to be insulated from ground. The stylus current is passed via the guide shafts, which means that it is necessary for them to be also insulated !

The stop of the lifting lever is provided with an adjustment screw for the fine adjustment of the stylus. This ensures the most favorable distance between paper and stylus to be selected.

An important part of the facsimile machine is the forward feed of the stylus. Since the threaded bar is never quite straight, it was necessary for it to be supported in ball bearings on one side. It is depressed with a spring to the drive of the stylus. The play of the bearing is able to compensate for a slight bending of the threaded bar. When correctly adjusted, a constand forward drive of the stylus in conjunction with the threaded bar can be guaranteed. Inspite of these measures, attention should be paid that the threaded bar is as straight as possible.

The belt drive disk was mounted on the outside for two reasons:

1. In order to achieve the greatest possible distance between the supports: belt drive disk – stylus;
2. In order to allow the »index of cooperation« (line shift) to be changed easily.

The drive from the drum to stylus shaft is made with the aid of an intermediate shaft; this intermediate shaft carries out the following functions:

- A portion of the overall gearing;
- Direction reversal to ensure that the belt need not be crossed in the case of normal scanning;
- The gear wheel that is located at the top of the machine can be operated manually, which simplifies replacing the drum and bringing it into the start position.

7.2.1. Drive of the Machine

As was described in Part 4 of this series, a synchronous motor is used for driving the drum. Virtually any type with eight or twelve pairs of poles can be used that is approximately 3 W in size. However, this is somewhat limited, since only those constructions are suitable which use two windings and require a phase-shift capacitor when used on single-phase alternating currents. A capacitor of 68 nF to 0.1 µF at 220 V/50 Hz will indicate the correct type. When operating at lower voltages, it is, however, necessary to change the winding. These motors possess a permanent magnet rotor, and two windings in the form of simple cylinder, or disk windings. This means that the construction of the new windings is relatively simple.

The designation of the poles is somewhat complicated. The »8 or 12 poles« given in Part 4, should be designated as pairs of poles. When the same motor is used as step-motor, it would have 32 steps instead of 8 poles, or 40 steps instead of 10 poles. This is merely a problem of definition. However, how can we establish how many pairs of poles our motor has ? There are three possibilities for establishing this:

1. The speed at 50 or 60 Hz is known: A pair of poles would make one revolution per Hz/sec., e.g. 50 Hz x 60 s = 3000 rpm. A motor with 8 pairs of poles will rotate 1/8 times as fast, in other words 375 rpm; or a motor having 12 pairs of poles will rotate at 1/12 of 3000 which amounts to 250 rpm.
2. As step-motor: Number of steps per revolution: 4 = number of pole pairs (1 step ≙ 90° of a phase)
3. Counting the number of poles: They are usually punched out of the metal case. The number of slots therefore corresponds to the number of pole pairs.

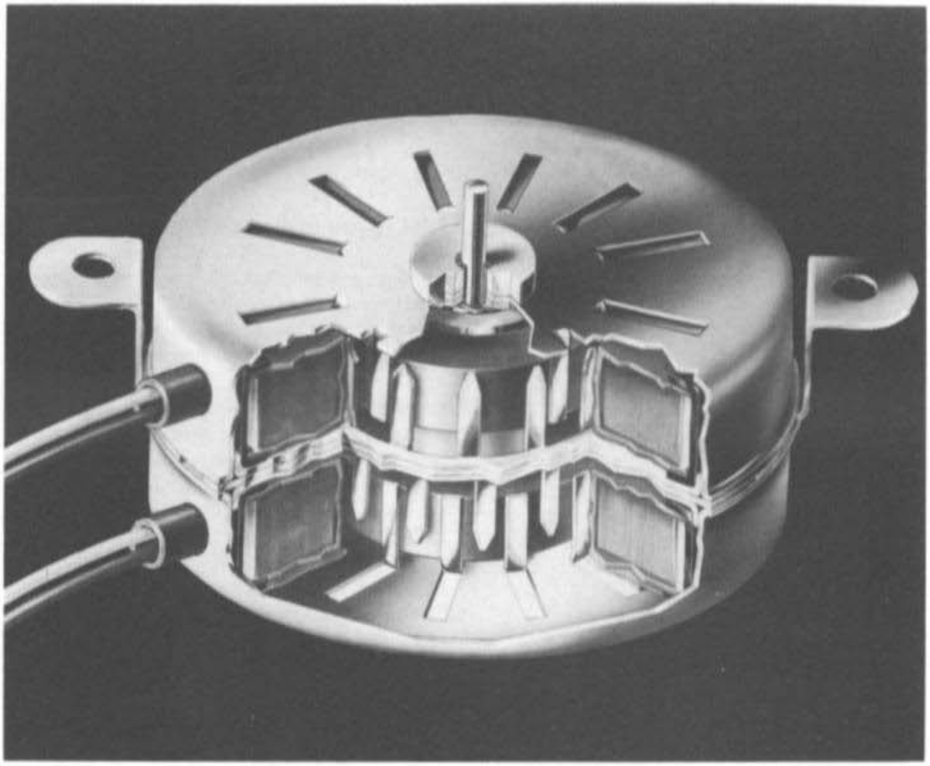


Fig. 66: Sectional drawing of a Philips synchronous motor

The number of pole pairs is important for the gearing between motor and drum. If a different type of motor is used than that recommended, the gearing should be made so that 24 pairs of poles result at the drum (i = 1 : 1).

A trapeze-poled motor should be selected for driving the machine, which provides a far smoother drive than motors having rectangular poles.

Further details regarding such motors are available in Philips data-books, that are readily available from the manufacturers. The photograph shown in **Figure 66** is taken from this book.

As was previously mentioned, it is necessary to rewind the motor for a different voltage. In the case of the prototype motor used (Philips type 9904 111 04131), this resulted in approximately 220 turns of 0.4 mm diameter enamelled copper wire per winding. Attention should be paid to the direction of rotation when connecting the motor: The shaft should rotate in a clockwise direction when looking towards the motor. If this is not the case, it is necessary for a winding to be reversed.

7.3. Further Special Parts

A number of styli (stylus, Part 43) should be available, since it is subject to wear. Of course, the whole stylus is not thrown away when worn, since it is only necessary to solder a new brush (pin) into place. It has been found that a Thungsten wire will possess the longest life. A defective filament of a car lamp (12 V/18-21 W) can be used for this. The part that is required is the unwound straight end of the filament. Since Thungsten wire cannot be soldered, it is necessary for a part of its holder to be cut off and this soldered to the stylus. In the case of circuit diagrams or weather maps (black on white), a wear of approximately 1 mm for 50 images is normal.

If, on the other hand, a wire from a wire brush is used, it is possible for this to be flatened using flat pliers after soldering into place. The flatter the stylus, the more grey tones can be made. However, too flat a stylus will be too weak and can bend or break easily. The most favorable stylus can be found experimentally.

The metalized paper used by the author is manufactured by Bosch, and is available in rolls.

The gears were obtained from a local hobby shop and are manufactured by WEBRA (order number 0/6 = 30 teeth, 0/9 = 60 teeth, 0/13 = 100 teeth).

The gear wheel with 30 teeth (order number 0/6) is fitted on the shaft of the motor. The original 3 mm hole in this gear wheel must therefore be drilled out to approximately 3.9 mm. The other two gear wheels (60 or 100 teeth) must be provided with a M 2 thread for accommodating a locking screw, which is only hinted at in the drawing.

7.4. Construction and Operation

Good mechanical practice should be observed during construction:

Exactly right-angled mounting of the side pieces and the motor drive; exactly align the bearings for the drum (if necessary, use small plate strips for correction); exactly align the guide shafts of the stylus to be parallel (otherwise there will be a spacing error between the stylus and drum between the commencement and end of the image); adjust the gearing play.

The drum should now be wound with metalized paper. This is done by folding out the depression bracket, uncoupling the drive on the drive side, folding out the stylus and screwing out the knob on the right-hand side. The drum can now be removed.

It is recommended to manufacture two reserve drums; one is provided with contact foil, and a simpler drum onto which the images to be transmitted can be mounted into place with adhesive tape.

The paper is wound onto the drum as follows:
The paper is cut at right angles and the commencement is folded at approximately 40 mm from the end so that it is metalized on both sides; this commencement is placed between the two foils of the drum and wound on. After the first winding, approximately 10 to 15 turns (images) should be wound thightly onto the drum. The drum is then replaced into the machine in the opposite order.

After the image is completed, the recording stylus is folded up, the commencement of the picture is pulled out and cut off using scissors. The recording head is then placed at the commencement, the paper end is pulled in again using the large gear wheel above the drum and rotated further until the commencement of the paper is opposite to the depressing bracket. This is the start position. The facsimile machine is ready for operation again after folding down the recording stylus.

An adjustment knob on the stylus lever is provided for exact adjustment of the stylus pressure.

7.5. Final Remarks

This is the author's first extensive description of a mechanical unit, and therefore requests that readers more knowledgeable in mechanical matters will excuse any wrong definitions. The author also hopes that the information given in this article is sufficient to construct and operate the machine. The mechanical construction has the great advantage that faults can be found by eye and good feeling – in contrast to some GHz-projects, that cannot be solved without expensive measuring equipment.

No doubt, it will be necessary to experiment for several days until the machine operates completely satisfactorily. However, the first image should be recorded immediately driven by the electronic circuits.

Of course, there must be a lot of improvements that can be made to the facsimile machine, and the author and editors would very much like to hear your comments. If these are advantageous, we will only be too pleased to publish them so that others can profit from these.

Part 8 of this series of articles will describe the operation of the TV-tube module.

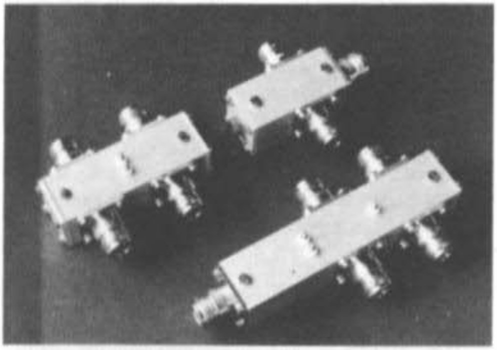


Fig. 1

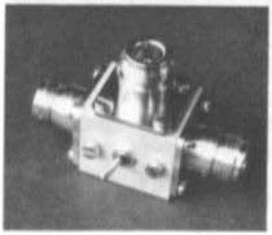


Fig. 2

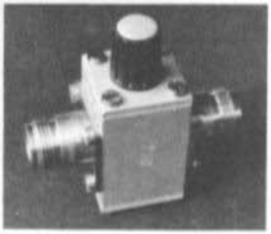


Fig. 3

A Microcomputer for Amateur Radio Applications

Part 5: The Clock Generator, Real-Time Clock, and Arithmetic-Processor

by W. Kurz, DK 2 RY

Parts 2, 3, and 4 described the CPU, memories, bus, and the input-output unit. This part is to describe module DK 2 RY 006 for the clock unit and the arithmetic-processor. Interested readers now have enough experience to decide whether it is worthwile constructing the microcomputer. The programs are to be given later.

5.1. The Clock Unit

The task of this circuit is to generate a clock time-base for real-time tasks (in our case the actual time). Fundamentally speaking, this could be done by the CPU, but this is not advisable since it is busy with other tasks, and would carry out the actual program more slowly due to this.

The counting tasks are therefore left to a special module, which informs the CPU of the end of a count with the aid of an interrupt request. This allows the calculation of the time to run in the »background« simultaneously with the main program. A suitable integrated circuit for such counting tasks is the Z 80-CTC used here.

5.1.1. Z 80-CTC

The Z 80-CTC is a programmable counter/clock module with four channels. **Figure 33** shows the connections of the Z 80-CTC (CTC = Counter Timer Circuit).

Connections 13 (IEI) and 11 (IEO) are the input and output respectively for the interrupt priority (1). Connections 18 (CSO) and 19 (CS 1) are used for selecting the channel.

The integrated circuit is reset via connection 17 (Reset), and it is selected via connection 16 (CE).

Each channel of the Z-80 CTC can be programmed separately. **Figure 34** shows the construction of the whole integrated circuit in the form of a block diagram. **Figure 35** shows one individual channel. Any required 8-Bit number can be loaded into the time-constant register, which is then counted down in the counter. As soon as a counter state of zero is reached, the CTC-channel will request an interrupt – if this has been programmed, and is permissible. The interrupt routine is then run – in our case the calculation of the time.

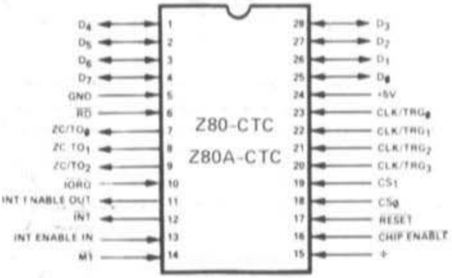


Fig. 33:
Connections of the counter Z 80-CTC

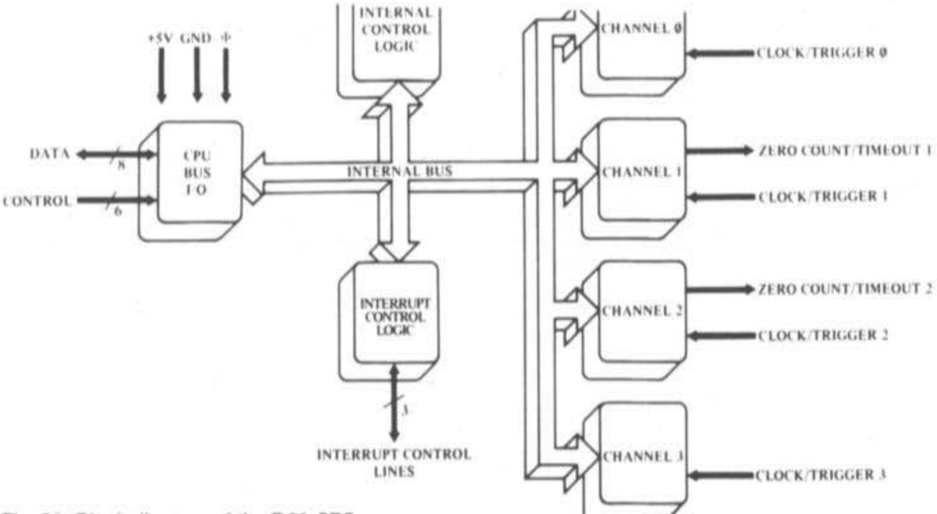


Fig. 34: Block diagram of the Z 80-CTC

The counter can count down in two ways: Either with the aid of an external clock connected via the trigger input CLK/$\overline{TRG}$, or with the aid of the system clock pulse $\bar{\phi}$, and the 8-Bit divider. In the last case, it is possible to divide the system clock pulse by 256 or by 16. The output ZC/TO (Zero Count / Time Out) will always assume H-state when the counter state is zero. This allows the division ratio to be programmed as any even multiple (1 – 256) of 16 or 256.

Those readers that require more details regarding the programming of the Z 80-CTC, will find more information in the 10-page data sheet given in (2).

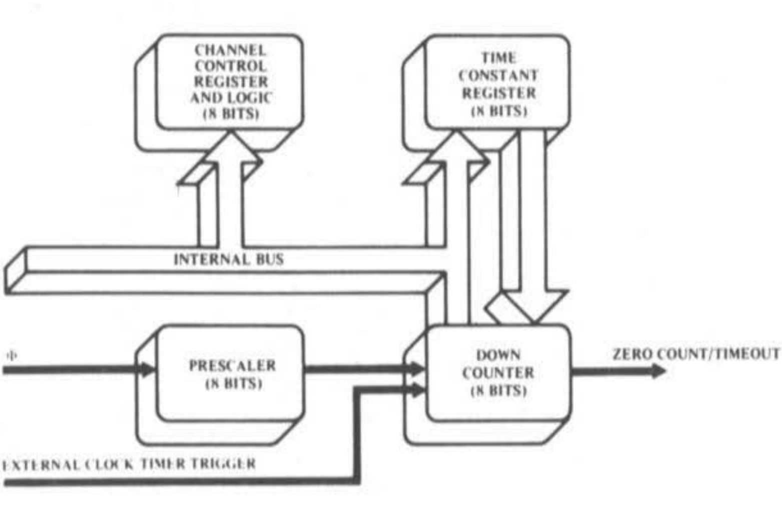


Fig. 35: Block diagram of an individual channel of the Z 80-CTC

5.2. The Arithmetic-Processor

The arithmetic-processor (often called »Number Cruncher« in American literature) is virtually the calculator of the CPU. This is a similar module in principle to that installed in pocket calculators. It is able to carry out mathematic calculations including such operations as angular functions, logarithms etc.

The National Semiconductors type MM 57109 has been selected for this task. It does not calculate very quickly, but is inexpensive. For instance, the AM 9511 manufactured by AMD counts approximately 100 times as fast, but costs ten times as much as the MM 57109. Since the price of the AM 9511 at present costs more than DM 700,—, the author found it to be uneconomical for radio amateurs, even though it was able to carry out a distance calculation from two QTH-locators in only 20 ms instead of approximately 2 s.

5.2.1. The MM 57109

Figure 36 shows the connections of the arithmetic-processor type MM 57109, and **Figure 37** shows its construction in the form of a block diagram.

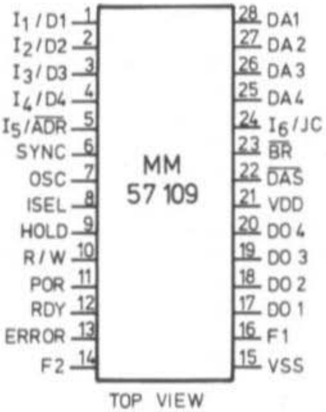


Fig. 36:
Connections of the arithmetic-processor MM 57109

Inputs I 1 to I 6 are used for entering the order code, or the data; the processor is set to a hold-state via connection 9 (HOLD). Connection 11 (POR) is used for resetting all memories and the counter of the processor on switching on, and it will report

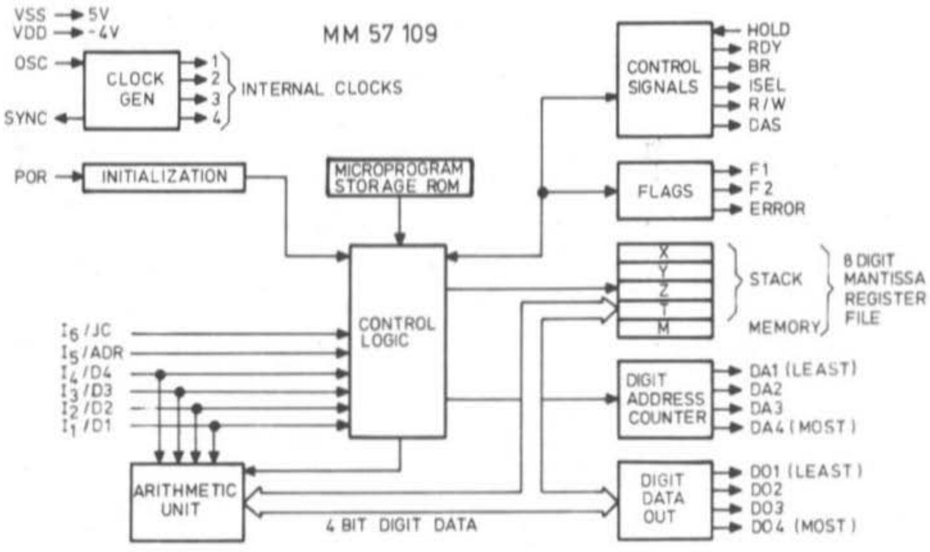


Fig. 37: Block diagram of the arithmetic-processor

via output 12 (READY) when it is ready to receive the next order. Outputs 22 (DATA ADDRESS STROBE) and 10 (READ/WRITE) offer information whether a digit is expected or is available at the data outputs D O 1 to D O 4 during an input/output process. The system clock is connected to input 7 (OSCILLATOR).

The arithmetic-processor MM 57109 can calculate with a maximum of eight positions, and can be programmed to operate with a floating decimal point or in scientific notation. In the latter case, two positions are provided in addition for the exponents in addition to the 8 digits.

The MM 57109 requires an operating voltage of 9 V. The inputs OSC, HOLD, and POR thus require a voltage deviation of 9 V, whereas the other inputs and outputs are compatible to TTL. This unit is programmed by the CPU, and operates as a so-called slave processor. The programming of the MM 57109 is not to be described here since it is very extensive. For those readers, that require more information, sufficiently detailed information is given in (3). For those that wish to make their own programs, the commencement addresses of the individual operating programs are to be given later. These can be requested then as CALL-orders.

5.3. Circuit Description of Module DK 2 RY 006

As was mentioned at the beginning of this article, this module consists of three different circuits: The clock generator, the counter/time generator, and the arithmetic-processor. **Figure 38** shows how these circuits are combined to form DK 2 RY 006.

5.3.1. The Clock Generator

The clock generator shown in the upper part of the circuit diagram, has the task of providing the clock pulse for the whole microcomputer system. The Colpitts oscillator equipped with transistor T 1, and a 5 MHz standard crystal can be aligned exactly to the nominal frequency with the aid of trimmer capacitor C 1. The time accuracy of the clock is directly dependent on the accuracy of the crystal frequency.

Transistor T 2 generates the required drive level for the 4-Bit binary counter I 1. The first divide-by-two circuit divides the crystal frequency down to 2.5 MHz at TTL-level. This is the clock pulse Φ of the system, which is fed to the bus (z 32).

Since the arithmetic-processor can only work with a maximum clock frequency of 400 kHz, the clock pulse of the system is divided by 8 in the subsequent three divide-by-two circuits. The resulting frequency of 312.5 kHz is brought to a suitable level for the arithmetic-processor in operational amplifier I 4, which is connected as comparator. Furthermore, the two double-decimal counters I 2 and I 3 divide the system frequency by 10 000 to 250 Hz. This is the reference frequency for the real-time clock.

5.3.2. The Real-Time Clock

The counter/time generator module Z 80-CTC (I 7) is provided with the reference frequency of 250 Hz at its input CLK/TRG$_0$ (23). Channel 0 represents the real-time clock. The time constant register is loaded with the binary equivalent of 250 (FAH). This means that an interrupt will be requested every second, which increases the time by 1.

The inputs of channels 1 (22) and 3 (20) are fed to connections Pt 1 and Pt 2 for further interrupt applications, such as for CW-decoding. Channel 2, on the other hand, generates the Baud-rates for series interfaces. Its output ZC/TO$_2$ (9) is connected with the bus.

Input IEI (pin 13) is provided with H-level via a resistor of 4.7 kΩ, which means that channel 0 has the highest priority.

5.3.3. Arithmetic-Processor

The required operating voltage for the arithmetic-processor of 9 V is derived from the operating voltages of other modules (+ 5 V and – 5 V) with the aid of diode D 1.

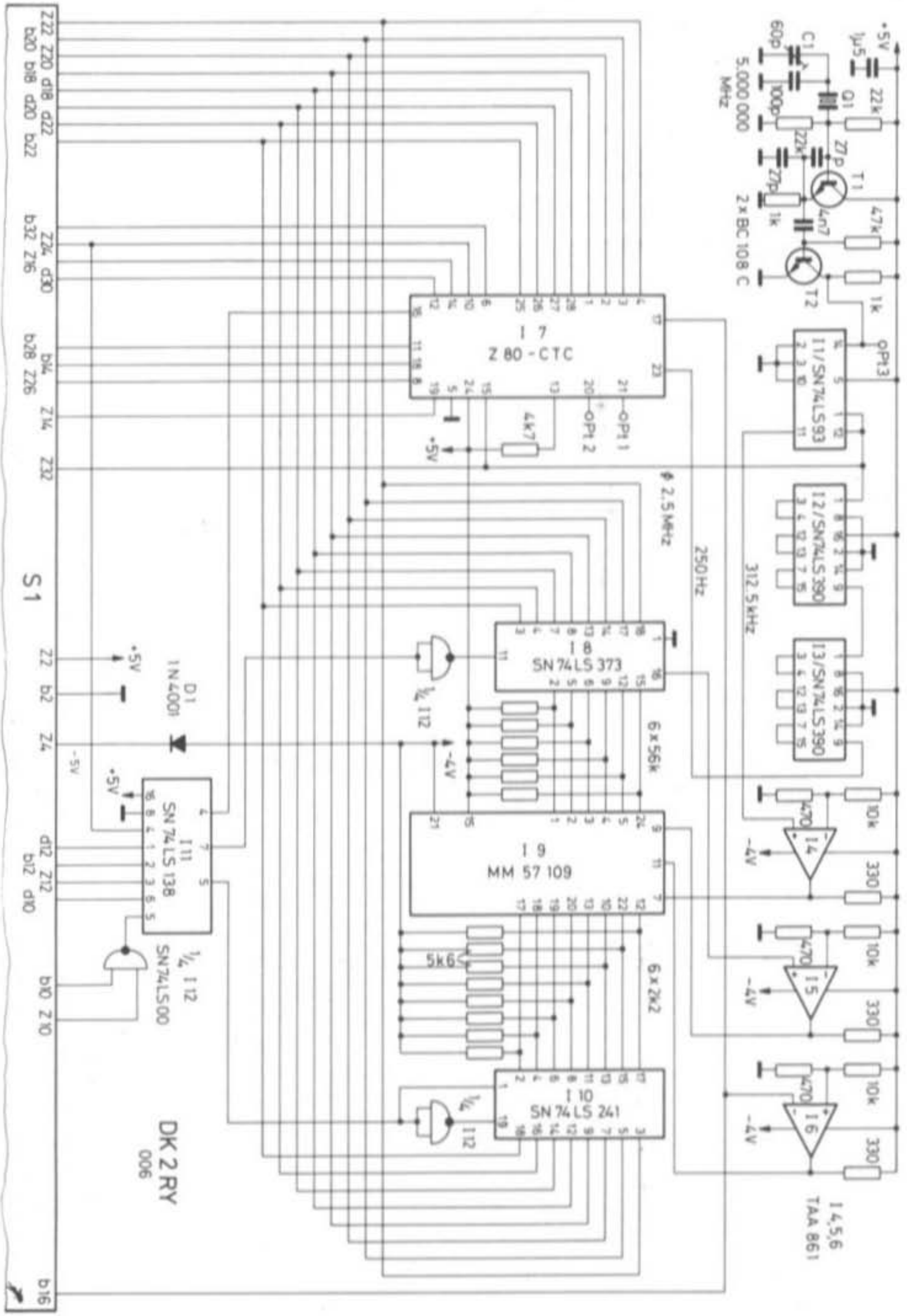


Fig. 38: Circuit diagram of module DK 2 RY 006

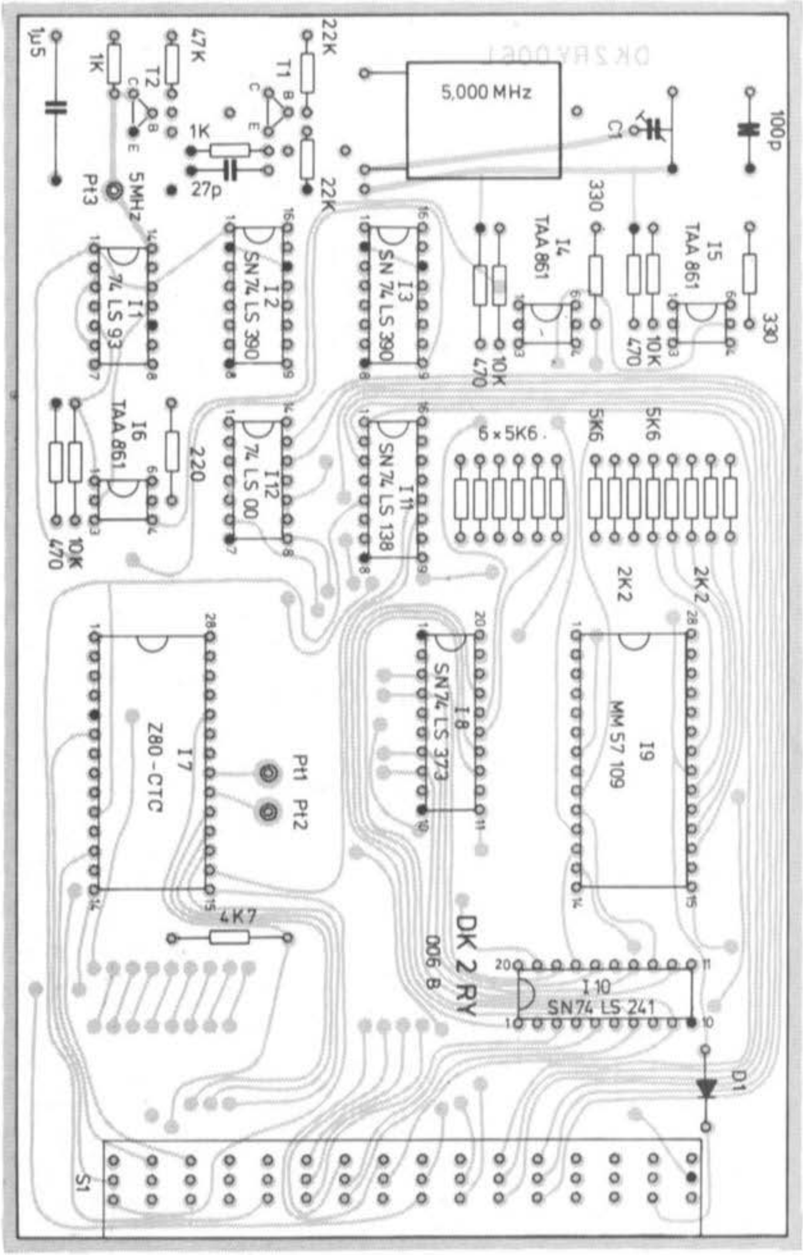


Fig. 39: PC-board for the clock-generator, real-time clock, and arithmetic-processor

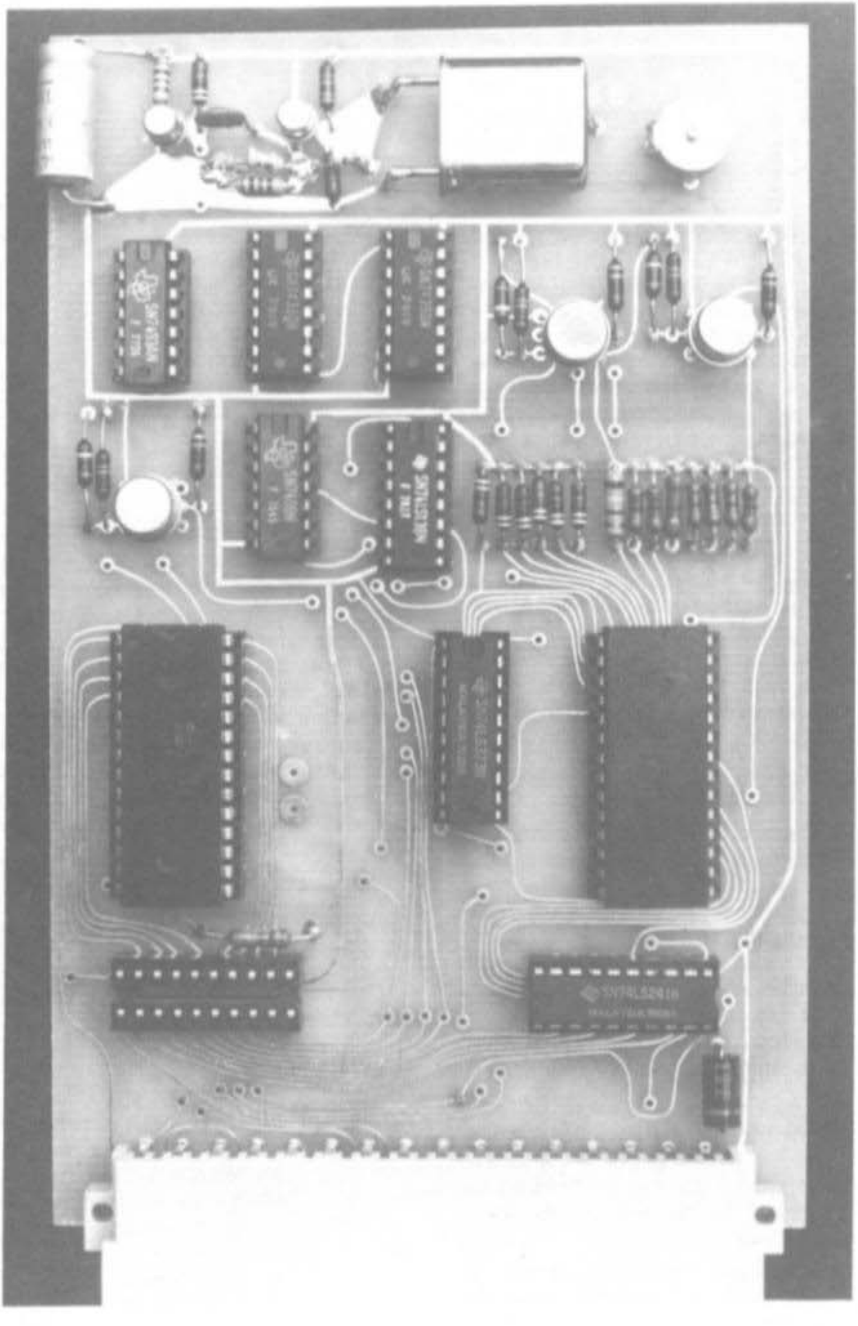


Fig. 40: Photograph of the author's prototype DK 2 RY 006
(this includes the connector for the bus driver which was deleted later)

Integrated circuit I 9 will thus receive 9.3 V. Its data inputs I 1 to I 6 (pin 1 to 5, and 24) are connected to + 5 V via pull-up resistors, and its data outputs D 0 1 to D 0 4 (pin 17 - 20), as well as outputs RDY (12), DAS (22), R/W (10), and ERROR (13), on the other hand, are connected via pull-down resistors to – 4.3 V.

The given outputs are connected via the bus driver I 10 (74 LS 241) to the bus, and can be read out by the CPU. The data inputs are also connected to the bus via I 8 (74 LS 373). Since the HOLD-input requires a voltage deviation of 9 V, as has been previously mentioned, an operational amplifier (I 5) has been provided. Its non-inverting input is connected via I 8 to the data input/output D 6 (b 20) of the bus. This allows the CPU to place the arithmetic-processor into the HOLD-condition.

In order to reset the arithmetic-processor on switching on the unit, the reset-output of the bus is connected to input POR (pin 11) via operational amplifier I 6 that is used for level matching. Finally, let us mention I 12, which is a 3-Bit demultiplexer type 74 LS 138 (see Part 3): it is used for selecting the modules.

The function of the arithmetic-processor operates in the following manner:

The CPU tests the RDY-bit of the arithmetic-processor via the bus. If this is »L«, the order code will be entered into the intermediate memory I 8. The CPU then waits until the RDY-bit »H« followed by »L« is received, before further activities take place. If RDY is »H«, the arithmetic-processor will read out the order code from the intermediate memory, and will set RDY to »L«. The order is carried out after this.

The data input is also carried out via the intermediate memory I 8, after receiving the »IN«-order. The data address strobe is set to »L« after each digit, in order to signal to the CPU that a further digit is expected (multi-digit input).

The output is made in the same manner via data outputs D 0 1 to D 0 4 after receiving an »OUT«-order. In this case, the R/W-bit is set to »L« after each digit. This allows an exactly defined operation of the arithmetic-processor.

The addresses of the individual units are now to be given for those users that wish to develop their own, additional programs.

Address	Unit
ECH	CTC Channel 0
EDH	CTC Channel 1
EEH	CTC Channel 3
EFH	CTC Channel 4
F3H	MM 57109 Output
FBH	MM 57109 Input

5.4. Construction

Module DK 2 RY 006 including the clock generator, real-time clock, and arithmetic-processor is also accommodated on a PC-board whose dimensions are 163 mm x 102 mm. Through-contacts should be provided (see **Figure 39**). This board is also provided with the 48-pin connector strip for interconnection to the bus board. The module will be immediately ready for operation after providing the components on the side of the board designated with »B« (see **Figure 40**). It is only necessary for the crystal frequency to be aligned exactly to 5 MHz. It can be made with the aid of a precision frequency counter. This is followed by inserting the module into one of the connectors on the bus board.

5.4.1. Components

I 1:	SN 74 LS 93 (TI)
I 2, I 3:	SN 74 LS 390 (TI)
I 4 - I 6:	TAA 761 or TAA 861 (Siemens)
I 7:	Z 80-CTC (Zilog)
I 8:	SN 74 LS 373 (TI)
I 9:	MM 57109 (National Semiconductors Corp.)
I 10:	SN 74 LS 241 (TI)
I 11:	SN 74 LS 138 (TI)
I 12:	SN 74 LS 00 (TI)
S 1:	C 74334-A 40-A 60 (Siemens)
T 1, T 2:	BC 108 C or BC 413 B/C or similar

C 1:	Plastic foil trimmer 60 pF
Q 1:	Crystal 5.000 000 MHz HC-6/U, 30 pF
D 1:	1 N 4001 or similar silicon diode

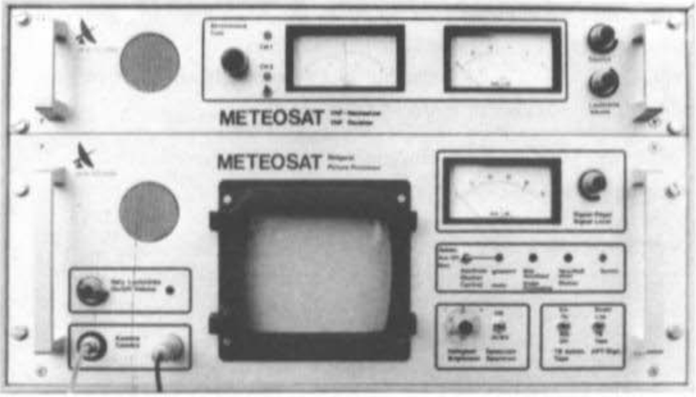
The next part of this article will describe the power supply of the microcomputer, and the interface-board for the digital rotator control as described by DK 1 OF. In contrast to previous plans, the author has decided to develop a TV-interface instead of a 16-segment readout. This will be published later.

REFERENCES to Part 5:

(1) W. Kurz, DK 2 RY: A Microcomputer for Amateur Radio Applications
Part 4: The Input-Output Unit
VHF COMMUNICATIONS 12, Edition 4/1979, pages 246 - 255

(2) Product Specification Z 80-CTC / Z 80 A-CTC.
Zilog Inc., Cupertino, Ca., USA, April 1978

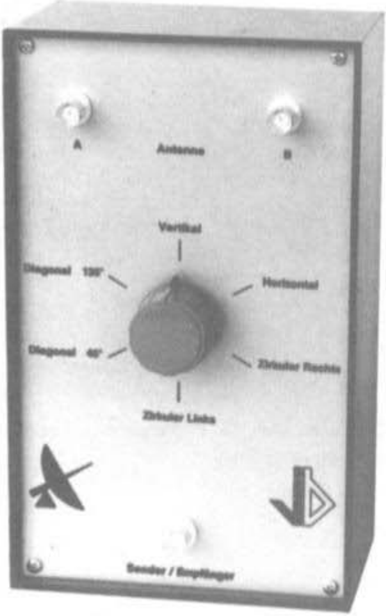
(3) P. Nelson:
The Number Crunching Processor
BYTE, August 1978, pages 64-74



MATERIAL PRICE LIST OF EQUIPMENT
described in Edition 1/1981 of VHF COMMUNICATIONS

DF 2 FQ 001	**45 MHz Frequency Counter**		**Ed. 1/1981**
PC-board	DF 2 FQ 001	Double-coated, drilled, but without thru-contacts	DM 19.—
Semiconductors	DF 2 FQ 001	1 TTL, 11 C-MOS ICs, 1 voltage stabilizer, 3 transistors	DM 62.50
Minikit	DF 2 FQ 001	8 ceramic caps., 2 tantalum electrolytics, 1 plastic-foil trimmer, 52 resistors	DM 18.50
Readout Set	DF 2 FQ 001	4 pcs. red 7-segment readouts, 8 mm high digits, common cathode	DM 23.50
Crystal	3.2768 MHz	HC-25/U	DM 16.—
Kit	**DF 2 FQ 001**	**complete with above parts**	**DM 134.—**
DF 8 QK 001/ATV	**Linear ATV Transverter for 1252.5 MHz**		**Ed. 1/1981**
PC-board	DF 8 QK 001	Double-coated with printed plan	DM 18.—
Semiconductors	DF 8 QK 001	5 transistors, 5 diodes	DM 83.50
Minikit	DF 8 QK 001	14 plastic-foil trimmers, 2 chip, 8 disc, 6 feedthru caps., 1 coil-former, 1 ferrite bead, 4 trimmer potentiometers	DM 34.—
Kit	**DF 8 QK 001 / ATV with above parts**		**DM 134.—**
DF 8 QK 002/ATV	**1291.4 MHz Local Oscillator**		**Ed. 1/1981**
PC-board	DF 8 QK 002	Double-coated, with plan	DM 18.—
Semiconductors	DF 8 QK 002	6 transistors, 1 diode	DM 18.—
Minikit 1	DF 8 QK 002	11 trimmers, 1 feedthru, 9 ceramic, 1 tantalum caps., 1 coilformer with core, 1 choke, 4 ferrite beads, 1 potentiometer	DM 28.—
Minikit 2	DF 8 QK 002	9 ceramic caps., 13 resistors	DM 7.—
Crystal	71.4444 MHz	HC-25/U	DM 26.—
Kit	**DF 8 QK 002 / ATV complete with above parts**		**DM 95.—**
Kits	**DF 8 QK 001/002 ATV**		**DM 220.—**
DC 3 NT	**FAX-Machine**		**Ed. 1/1981**
Complete set of drawings			**DM 8.—**
Components			
P 8002	Latest type of the wellknown low-noise FET for large-signal applications		DM 9.80

UKWberichte Terry Bittan · Jahnstr.14 · Postfach 80 · D-8523 Baiersdorf
Tel. 09133/855



NEW! NEW!
Polarisations Switching Unit for 2 m Crossed Yagis

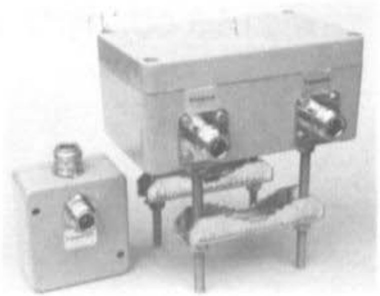
Ready-to-operate as described in VHF COMMUNICATIONS. Complete in cabinet with three BNC connectors. Especially designed for use with crossed yagis mounted as an »X«, and fed with equal-length feeders. Following six polarisations can be selected: Vertical, horizontal, clockwise circular, anticlockwise circular, slant 45° and slant 135°.

VSWR:	max. 1.2
Power:	100 W carrier
Insertion loss:	0.1 to 0.3 dB
Phase error:	approx. 1°
Dimensions:	216 x 132 x 80 mm

Low-Noise Masthead Amplifiers for 144 MHz and 432 MHz SMV 144 and SMV 432

Selective High-Power Masthead Amplifiers in Waterproof cast-aluminium case with mast brackets. Built-in relay for transmit-receive switching. PTT via coaxial cable using supplied RF/DC-splitter.

- Noise figures: SVM 144 0.9 dB, typ.
  SVM 432 1.9 dB, typ.
- Overall gain: SMV 144 15/20 dB, switchable
  SVM 432 15 dB
- Insertion loss, transmit: typ. 0.3 dB
- Maximum transmit power:
  SVM 144: 800 W SSB, 400 CW/FM
  SVM 432: 500 W SSB, 250 CW/FM
- Operating voltage: 12 V via coaxial cable



- Connections:
  N-Connectors
- Dimensions:
  125 x 80 x 28 mm
  (without brackets)

Further details on request.

UKWtechnik Terry Bittan · Jahnstr.14 · Postfach 80 · D-8523 Baiersdorf
Tel. 09133/855

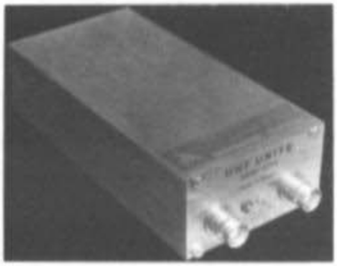
A New Generation of Transverters for 1296 MHz

We would like to introduce our second generation of 23 cm transverters for operation in conjunction with either 10 m or 2 m transceivers.

- Double-conversion both on transmit and receive with the 10 m version to obtain the extremely high image and spurious rejection and clean spectrum.
- Overall noise figure of the receive converter typically 3.9 dB
- Transverters are available in the following versions:

ST 1296/144 A:	2 m IF, output 1 W	**DM 620.—**
ST 1296/144 B:	2 m IF, output 3 W	**DM 786.—**

NEW 23 cm CONVERTER SC 1296/144



Noise figure:	typ. 3.9 dB
Gain:	typ. 22 dB
Operating voltage:	12 V =

Contained in aluminium case
with BNC-connectors.

Price:	**DM 225.—**

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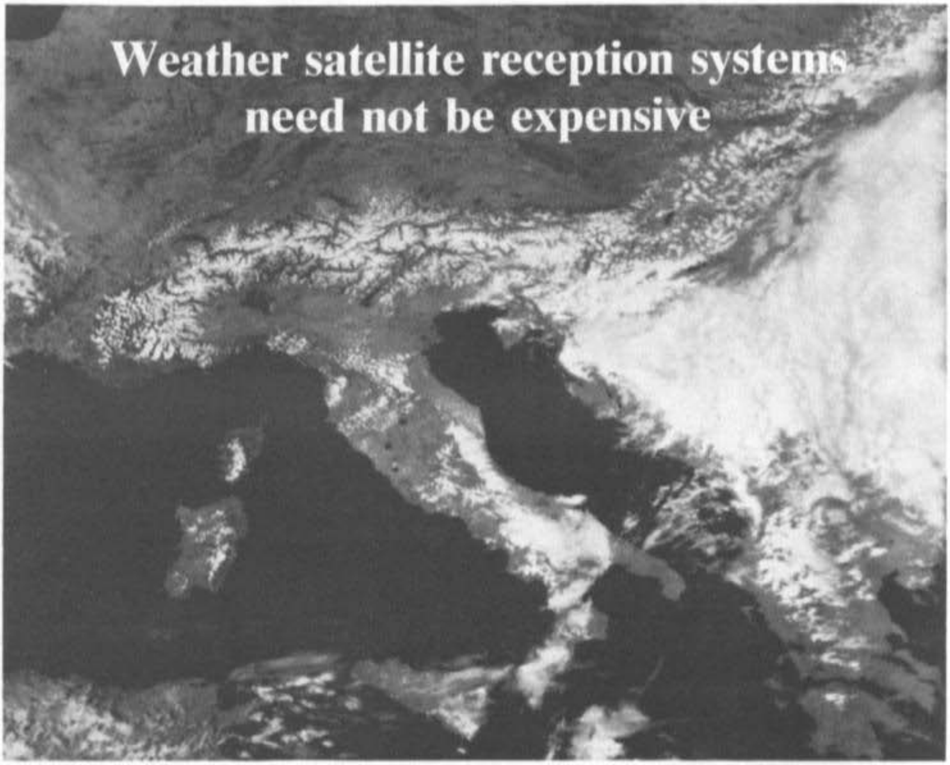
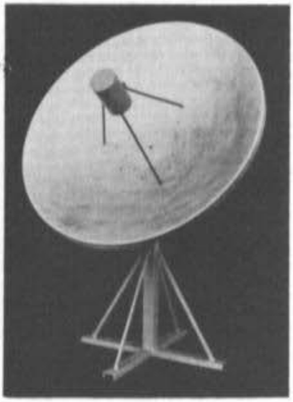
Tel. 09133/855



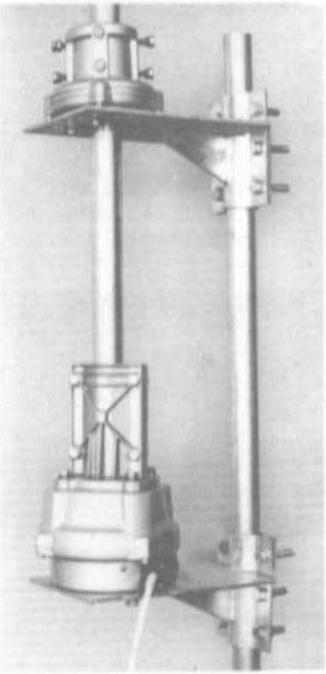

METEOSAT
METEOSAT



Getting ready for OSCAR 9 ?
Then you need the Vertical Rotor KR 500

Especially designed for vertical tilting of antennas for EME, OSCAR etc.

Type	**KR 500**
Load	ca. 250 kg
Brake torque	197 Nm *)
Rotation torque	40 Nm *)
Horiz. tube diam.	32 - 43 mm
Mast diameter	38 - 63 mm
Speed (1 rev.)	74 s
Rotation angle	180° (+ 5°)
Control cable	6 wires
Line voltage	220 V/50 Hz 30 VA
Weight	4.5 kg



Antenna rotating system as described in 1/1977 of VHF COMMUNICATIONS

We have designed an antenna rotating system for higher wind loads. This system is especially suitable when it is not possible to install a lattice mast. The larger the spacing between the rotator platforms, the lower will be the bending moment on the rotator. This means that the maximum windload of the antenna is no longer limited by the rotator, but only by the strength of the mast itself and on its mounting. Please request the prices either from your National representative, or direct from the publishers.

This system comprises:
Two rotator platforms
One trust bearing
One KR 400 rotator, or other rotator.

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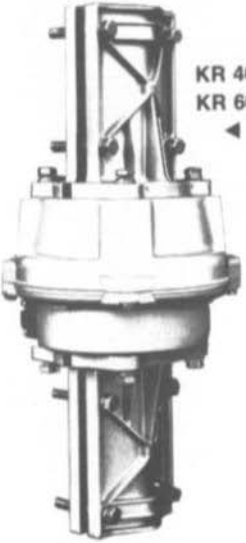
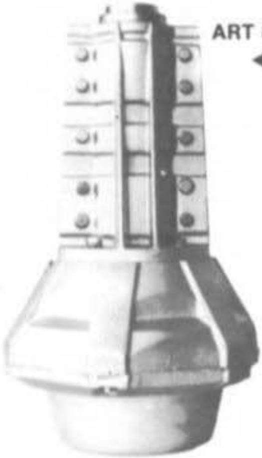
ANTENNA ROTATING SYSTEMS



KR 400
KR 600
◄

KR 2000
◄



ART 8000
◄

SPECIFICATIONS

Type of Rotator	KR 400	KR 600	KR 2000	ART 8000	
Load	250	400	800	2500	kg
Pending torque	800	1000	1600	2450	Nm *)
Brake torque	200	400	1000	1400	Nm *)
Rotation torque	40	60	150	250	Nm *)
Mast diameter	38 - 63	38 - 63	43 - 63	48 - 78	mm
Speed (1 rev.)	60	60	80	60	s
Rotation angle	370°	370°	370°	370°	
Control cable	6	6	8	8	wires
Dimensions	270 x 180 ∅	270 x 180 ∅	345 x 225 ∅	460 x 300 ∅	mm
Weight	4.5	4.6	9.0	26.0	kg
Motor voltage	24	24	24	42	V
Line voltage	220 V / 50 Hz	220 V / 50 Hz	220 V / 50 Hz	220 V / 50 Hz	
	50	55	100	200	VA

*) 1 kpm ≙ 9.81 Nm

Controllers for above rotators

Our well-known rotators KR 400, KR 600 and KR 2000 are now available with large 360° compass indicators of 105 mm diameter. These models are designated by the suffix »RC«.

KR 400, KR 600, KR 2000

KR 400 RC, KR 600 RC, KR 2000 RC

ART 8000

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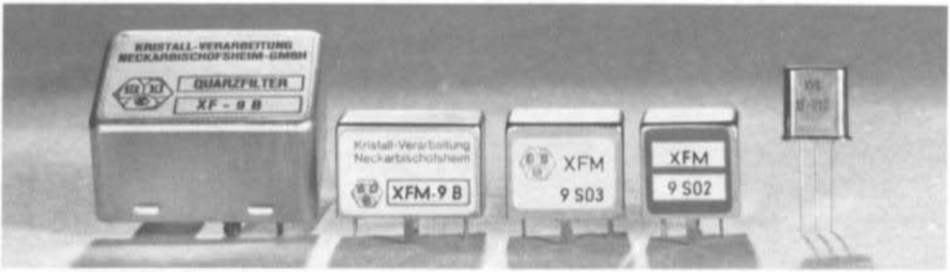
OUR GREATEST now with reduced dimensions !



Case: 1 15 14 13 17

DISCRETE CRYSTAL FILTER	Application	MONOLITHIC EQUIVALENT					
		with impedance transformation			without impedance transformation		
		Type	Termination	Case	Type	Termination	Case
XF-9A	SSB	XFM-9A	500 Ω ‖ 30 pF	15	XFM-9S02	1.8 kΩ ‖ 3 pF	13
XF-9B	SSB	XFM-9B	500 Ω ‖ 30 pF	15	XFM-9S03	1.8 kΩ ‖ 3 pF	14
XF-9C	AM	XFM-9C	500 Ω ‖ 30 pF	15	XFM-9S04	2.7 kΩ ‖ 2 pF	14
XF-9D	AM	XFM-9D	500 Ω ‖ 30 pF	15	XFM-9S01	3.3 kΩ ‖ 2 pF	14
XF-9E	FM	XFM-9E	1.2 kΩ ‖ 30 pF	15	XFM-9S05	8.2 kΩ ‖ 0 pF	14
XF-9B01	LSB	XFM-9B01	500 Ω ‖ 30 pF	15	XFM-9S06	1.8 kΩ ‖ 3 pF	14
XF-9B02	USB	XFM-9B02	500 Ω ‖ 30 pF	15	XFM-9S07	1.8 kΩ ‖ 3 pF	14
XF-9B10*	SSB	—	—	–	XFM-9S08	1.8 kΩ ‖ 3 pF	15

*** New: 10-Pole SSB-filter, shape factor 60 dB : 6 dB 1.5**

Dual (monolithic twopole)	**XF-910;** Bandwidth 15 kHz, R_T = 6 kΩ, Case 17
Matched dual pair (four pole)	**XF-920;** Bandwidth 15 kHz, R_T = 6 kΩ, Case 2 x 17

DISCRIMINATOR DUALS (see VHF COMMUNICATIONS 1/1979, page 45)

for NBFM	**XF-909**	Peak separation 28 kHz
for FSK/RTTY	**XF-919**	Peak separation 2 kHz

CW-Filters – still in discrete technology:

Type	6 dB Bandwidth	Crystals	Shape-Factor	Termination	Case
XF-9M	500 Hz	4	60 dB : 6 dB 4.4	500 Ω ‖ 30 pF	2
XF-9NB	500 Hz	8	60 dB : 6 dB 2.2	500 Ω ‖ 30 pF	1
XF-9P*	250 Hz	8	60 dB : 6 dB 2.2	500 Ω ‖ 30 pF	1

*** New !**

KRISTALLVERARBEITUNG NECKARBISCHOFSHEIM GMBH

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