Jochen Jirmann, DB 1 NV

A Stable Crystal-Controlled-Source for 10,37 GHz

Two families of equipment have evolved for the 3 cm band, the simple, unstabilised Gunn or FET oscillators for portable, wide-band, FM equipment and complex quartz-stabilised systems for fixed-station SSB. Unfortunately many people have considerable anxieties about varactor multipliers which tends to explain the dearth of usable construction articles about them (such as the X9 multiplier by DK2VF/DJ1CR).

This article describes a simple-to-construct oscillator chain which delivers more than 10 mW at 10,37 GHz without using complex milled and rotary parts.

1. THE CONCEPTION

The author has constructed two well-known modules, the 1152 MHz multiplier (DCØDA) (1) and the X9 multiplier DK2VF/DJ1CR (2) and with some important improvements has developed a simple and reliable concept. The block-diagram is shown in **fig. 1** which represents the two units together.

2. THE 1152 MHz GENERATION

The 1152 MHz multiplier chain is almost exactly identical with that of the DCØDA 005 module, except the following modifications were carried out: –

- an FM modulator was included as an integral part of the crystal oscillator,
- the discretly-built voltage regulator was replaced by a 78LØ8,
- instead of the simple λ/2 circuit at the module's output, a three stage, micro-strip filter has been included which ensures a 50 dB suppression of spurs and harmonics,

DB 1NV

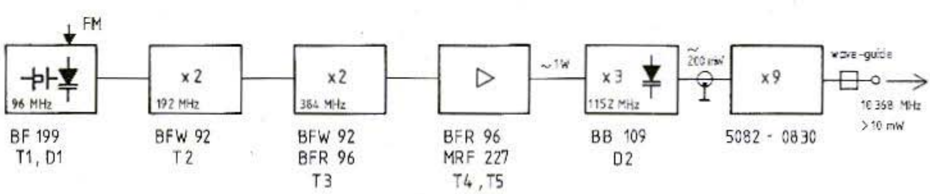


Fig. 1: Block diagram of complete multiplier chain

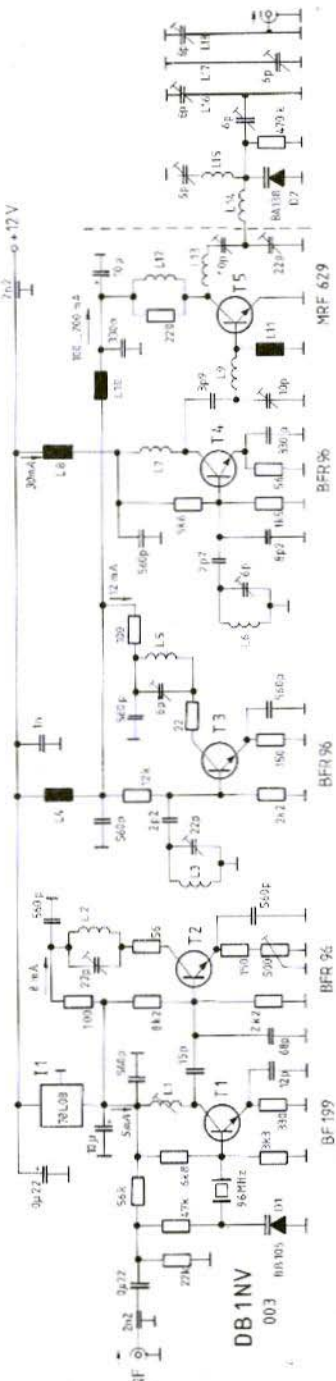


Fig. 2: Circuit schematic of the 1152 MHz generator

- easily obtainable, Valvo foil-trimmers were used exclusively throughout,
- all stages are built according to the recommendations of DJ1ZB and are sure-fire and easy to tune,
- the output power can be adjusted by one trimmer
- the PCB could be reduced to 70 mm x 145 mm thereby fitting into a standard tin-plate container.

Figures 2 and 3 show the circuit diagram , the PCB layout, and the component placement of the PCB DB1NV 003.

2.1. Components for the PCB DB1NV 003

Semi-conductors

T1 :	BF 199, BF 224 or equiv. BEC series
T2, T3:	BFW 92, BFR 96 (T-plastic case)
T4:	BFR 96, BFT 12 (T-plastic case)
T5:	MRF 227, MRF 629 (T039 with **emitter** to case)
D1:	BB 105, BB 505
D2:	BB 109, BA 138 or if need be, BB 105 or BB 505
IC1:	78L08 voltage regulator

All trimmer-caps: Valvo foil 7,5 dia
All capacitors: ceramic 5 mm lead spacing
All electrolytics: Tantalum
Resistors: 0207 construction

Winding details

L1:	5,5 turns, 0,3 CuL on 4 mm form with UHF core
L2, L3:	1,5 turns, internal dia 7,5 mm
L4:	1 µH choke
L5, L6:	wire loop 6 mm internal dia, 12 mm hole spacing
L7:	10 turns, 0,5 mm CuL, internal dia, 3 mm

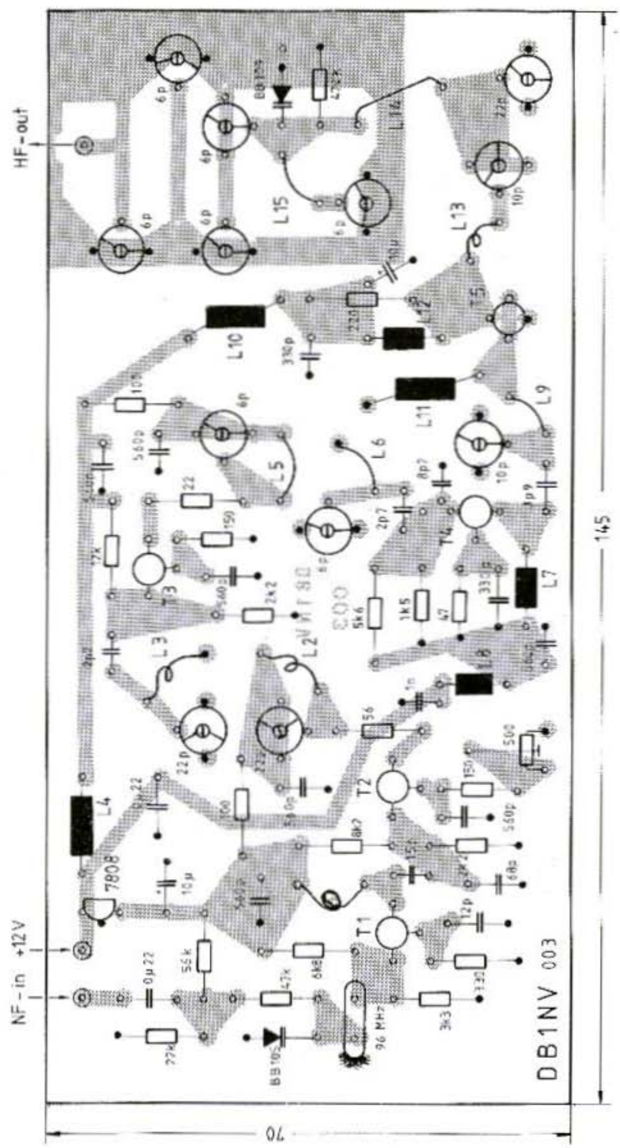


Fig. 3:
Component layout of 1152 MHz generator (• soldered to ground on upper-side of PCB)

L8:	1 μH choke
L9:	wire loop 6 mm internal dia, 9 mm high
L10, L11:	Broadband choke VK 200
L12:	10 turns 0,5 mm CuL, internal die 3 mm
L13:	1,5 turns, internal dia, 6 mm
L14:	1,25 turns, internal dia, 6 mm
L15:	2 turns, internal dia, 2,5 mm
L16 - L18:	Microstrip-lines
wire:	1 mm dia silvered

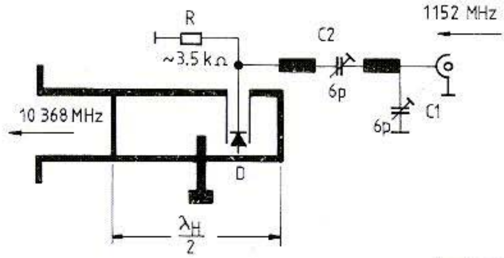
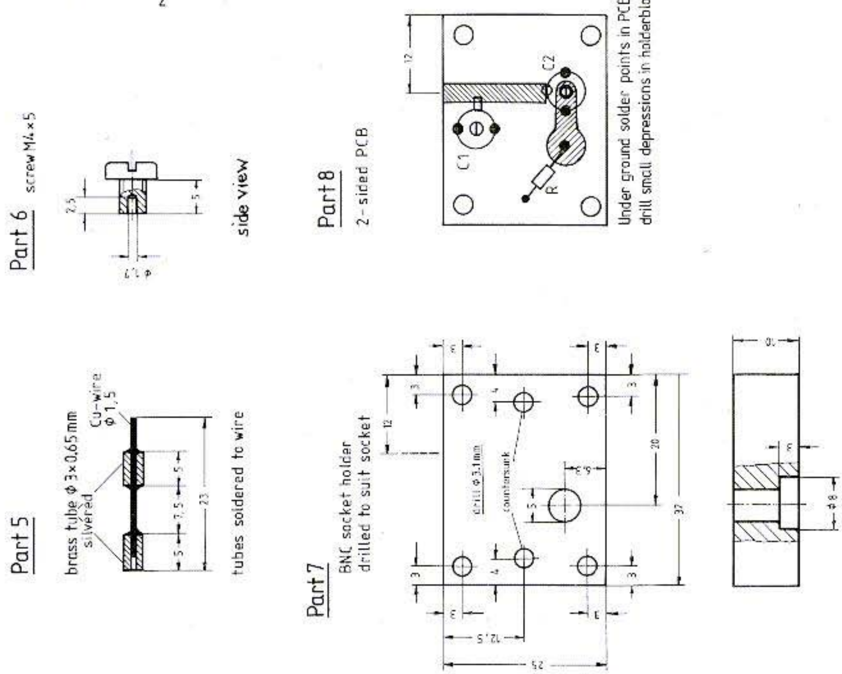


Fig. 4:
Electrical representation of the X9 multiplier



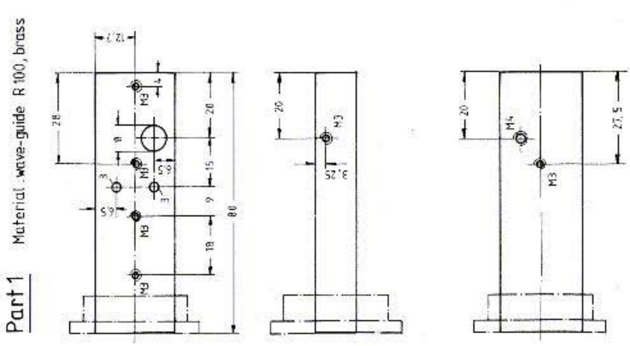


Fig. 5:
Component parts of the SRD multiplier 1152/10368 MHz
Part 2: wave-guide flange R 100
Part 3: short-circuit slider brass 22,7 x 10 x 10 mm to fit in W/G
Part 4: λ/2 line, Brass tube, 5 dia x 0,5, 18,5 mm long
Part 9: brass posts 12,7 mm x 3 mm dia

As can be seen, the circuit exhibits no particular features, only the selection of the varactor represents a little trial and error. The author found that the BA 138 (no longer manufactured) and the BB 109 proved successful. Even some 1N4148 diodes could be used, following adjustment of the working point by a suitable parallel resistor.

2.2. Construction Notes

Those, who are not afraid of a little metal-work can construct the output filter from lines and trimmers supported above the PCB plane, thereby obtaining somewhat more output power. The correct tune-up procedure for a multiplier has been dealt with so often that it will not be repeated here in detail. A diode probe with an indicator will be useful to adjust each stage, in turn, for maximum output when coupled to its tuned circuit. The output should be a little over 200 mW for the microstrip version and 300 to 400 mW for the air-dielectric version.

3. THE X9 MULTIPLIER

An SRD (step recovery diode) HP 5082-0830 is employed in order to multiply the frequency from 1152 MHz to the final frequency of 10368 MHz. This diode is considerably cheaper than the earlier type recommended by DJ1CR but has a somewhat lower efficiency. Whereas DJ1CR obtained efficiencies in the order of 10 to 15 %, the circuit recommended here works with only 5 to 10 % according to the diode selection. Diodes possessing a higher breakdown voltage tend to deliver more power.

As **fig. 4** shows, the multiplier comprises a matching circuit for 1152 MHz, the diode itself, as well as a half-wave, short-circuited line associated with the diode. The half-wave section oscillates at a greatly reduced attenuation at the final frequency in accordance whith the current impulses through the diode. The required final frequency is then selected by a post-coupled wave-guide resonator.

More information about SRD multipliers can be found in the Hewlett-Packard Application Notes 918 and 920. **Fig. 5** shows the component parts of the multiplier. The following materials are required: R 100 wave-guide, brass-plate 25 mm x 10 mm and 3 mm dia. external, 1,7 mm dia. internal, as well as 5 mm external, 4 mm internal, diameter brass tubing. The brass tubing may be obtained from model hobby shops.

3.1. Construction

First of all, the wave-guide section, part 1 in **fig. 5** (preferably made of copper owing to its high heat conductivity), is suitably drilled to receive the diode holder. The holding block 7 is also drilled and prepared for the matching circuit. After a test assembly according to **fig. 6** the drilling for the diode-holder is checked to see that it is in alignment with the W/G hole. The brass M 3 holding screws for the diode-block are filed down flush with the inner surface of the wave-guide. The two 3 mm dia. posts (part 9) of the filter are placed in the wave-guide, the wave-guide flange (2) is placed over the end and the whole assembly soldered together. The $\lambda/2$ line (part 4) is soldered into the brass block. The choke (part 5) is constructed as shown in **fig. 5** by slipping the two 5 mm long, 3 mm dia. tubes over a 23 mm length of silvered 1,5 mm dia. wire. The tubes are placed in position and soldered, the whole choke assembly insulated with teflon tape. The sliding short-circuit (part 3) is provided with 0,1 mm copper foil surfaces to slide on, thus making a better binding contact with the inner wave-guide surfaces without a precision mating being necessary.

The tuning-screw on the side wave-guide wall, forms a capacitance for the $\lambda/2$ section and is tuned for best results – it is sometimes not necessary.

Before mounting the matching components on the PCB, the brass block (7) must be suitably drilled to provide sufficient clearance for the solder points on the underside of the PCB. The PCB must lie on the brass block according to the component layout.

After the assembly has been completed, the diode is inserted by ensuring that the heat-sink

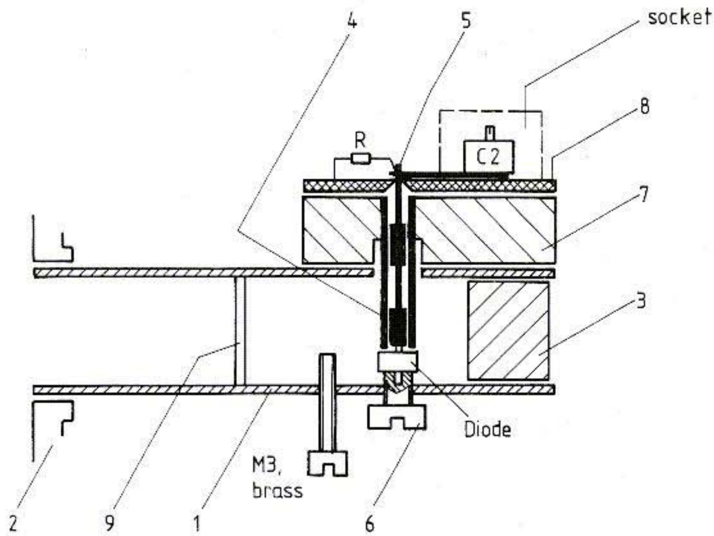


Fig. 6: cross section of X9 multiplier

end (without ring) is placed in the screw-cap (part 6) thus using the greater mass of the wave-guide to dissipate the heat. Use also a little heat contact paste for this purpose. **Fig. 7** shows the completed multiplier.

3.2. Tuning

The tuning of an SRD multiplier is not exactly easy but the diodes are so robust that they cannot be damaged during tuning. A good indication of the correct tune point is, that when the tuning elements are turned, the power varies smoothly and without sudden jumps. A signal-generator adjusted to 1152 MHz and 200 to 300 mW output power is applied to the BNC input socket. This bias potentiometer is set to 3 or 4 kΩ and the input trimmer adjusted for maximum voltage across the diode. The output circuit is then adjusted for maximum output power. The short-circuit slider is about 5 to 7 mm behind the diode. **All** elements are then tuned in order to maximise the output power by a **process of iteration**, as the position of some controls may be mutually dependent. The input power from the generator is then increased to 600 mW when the output power should saturate at 30 to 40 mW.

The preset potentiometer may be replaced by a fixed resistor if desired. This turned out to be 3,5 kΩ on the prototype and a standard 3,3 kΩ resistor was used to fix the diode working point. This, however, is temperature dependent and it may have to be determined again later. Suitable circuits for this may be found in HP application notes 918 and 920.

4. TESTING

The complete multiplier chain was fed into a cavity mixer which had an IF amplifier DB1NV 001 (3) connected to its output port. The assembly formed a simple FM receiver. The output power was adjusted for maximum receiver sensitivity which occured at 10 mW, the noise figure being 9 dB. Test contacts with DG2ND confirmed the usability of the system.

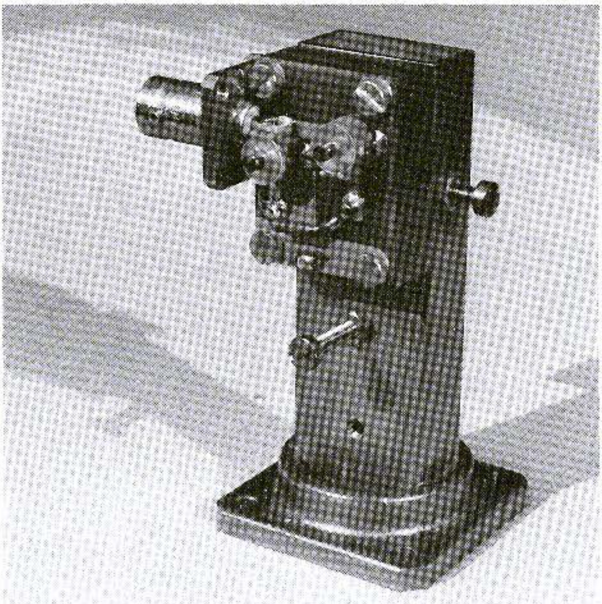


Fig. 7:
X9 multiplier prototype

5. REFINEMENT POSSIBILITIES

For stationary use, the simple crystal oscillator can be replaced with a low-noise FET in a temperature-controlled oven. For portable use, an oscillator, able to be pulled to allow a swing in output frequency of 3 MHz, may be useful. For this purpose, a 96 MHz crystal, in an external circuit, may be excited at its basic frequency (for greatest frequency pull) and then multiplied by 5 and fed into the existing crystal oscillator stage which then works as a buffer. The 96 MHz signal from the X5 multiplier must be inspected, however, for spectral purity.

The 1152 MHz generator can, of course, be used as a low-power transmitter for the 23 cm band but the author has not conducted any experiments with this possibility.

6. REFERENCES

(1) Dahms, J.:
A local Oscillator Module for 200 mW at 1152 MHz
VHF COMMUNICATIONS Vol. 10, Ed. 1/78
P. 18 - 22

(2) Griek, R. and Münich, M.:
A Frequency Multiplier for Narrow Band, 3 cm Band Communications.
VHF COMMUNICATIONS Vol. 11, Ed. 2/79
P. 66 - 73

(3) Jirmann, J.:
A FM Transceiver for 10 GHz with dielectrically-stabilized Oscillator
VHF COMMUNICATIONS Vol. 16, Ed. 1/84
P. 2 - 12