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A Spectrum Generator for the 24 GHz Band

A signal generator is also required for test and calibration applications even on the 10 GHz and 24 GHz bands. In this frequency range, professional measuring equipment is usually either completely inaccessible, or so large and heavy that it is impossible to lend them out over the weekend. Luckily, very many checks can be made with relatively simple signal sources and these can be simply constructed at home.

A very useful calibration spectrum generator for the 10 GHz band was described in (1). A similar unit has been used bythe author for four years now, and the obtainable output power could be increased considerably by use of a fast, storage varactor. When driven with a crystal-controlled signal at 100 MHz and provided with a subsequent 3-stage waveguide, the output frequency is sufficiently pure and provides sufficient power in order to synchronize a power-Gunn oscillator in the frequency range between 10.0 and 10.5 GHz.

This article is to describe such a module for the 24 GHz band, whose output power is sufficiently great that it is possible to cover a range of more than 500 m when using antenna gains in the order of 30 to 40 dB and in conjunction with conventional receive systems used for amateur communications. When used in conjunction with a home-made waveguide attenuator, it is possible for relative measurements of the sensitivity of receivers to be made.

1. THE CIRCUIT

As can be seen in the simplified block diagram given in **Figure 1**, the calibration spectrum generator comprises three modules that are driven from a DC-voltage of 12 V. The circuit is accommodated in a TEKO-box type 2B.

The first module is a 50 MHz crystal-controlled oscillator, which is followed by a 50 MHz amplifier that increases the output power to 1 W. This signal drives a storage varactor D which works into a λ/2 resonator.

The resonator is the third module and consists of a piece of waveguide type WR-42 (R 220). The resonator is completely coupled to the main waveguide (possibly complete with antenna) and is strongly dampened. For this reason, it is not necessary to provide a tuning screw or a plunger.

The author used a storage varactor type BXY 18 AB (Siemens), and was able to obtain an output power of 1.2 mW in the 24 GHz range. Unfortunately, no equipment was available to measure the spectral power distribution; however, it can be estimated to be as follows assuming a bandwidth of approx. 2 GHz:

$$P_s \approx \frac{P_{out}}{B/f}$$

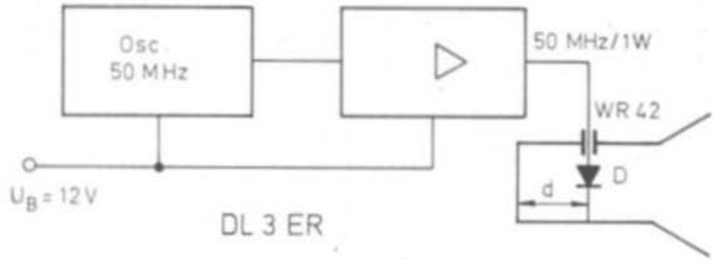


Fig. 1: Calibration spectrum generator for the 24 GHz band

where

P_s = Power of **one** spectral line
P_{out} = Measured total output power
B = Bandwidth in which lines appear
f = Spacing between spectral lines (here: 50 MHz)

$$P_s \approx \frac{1.2\ \text{mW}}{40} \approx 30\ \mu\text{W}$$

2. CONSTRUCTION OF THE DRIVE CIRCUIT

In the auhtor's prototype, an available crystal oscillator manufactured by the US-company »Monitor« was used. This oscillator operates from 5 V DC-voltage and provides an output frequency of 50 MHz at two antiphase TTL-outputs. It is immaterial which output is used.

Virtually any circuit can be used to replace this oscillator, and examples are given in (2). Attention should only be paid that the subsequent amplifier is able to provide at least 0.5 W for the storage varactor.

The most interesting part of the circuit is given in **Figure 2**. Due to the high heat-loading of the transistor 2N 3866, it is very important to provide a heat sink. The output power and thus the operating point of the storage varactor D can be adjusted with the aid of the emitter resistor R 1.

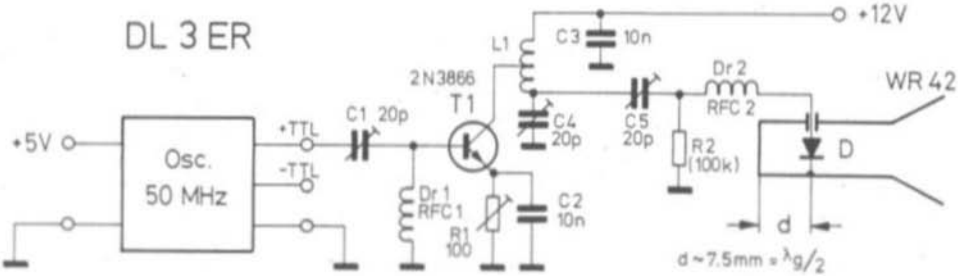


Fig. 2: 50 MHz amplifier with coupling to the varactor

Matching is made using the trimmer capacitor C 5 and inductance RFC 2, whose spacing between turns should be determined experimentally.

The given values for C 5, RFC 2, and R 2 have been found to be favorable in the author's prototype. According to the characteristics of the diode, some changes may be required, at least to RFC 2 and R 2. The most favorable adjustment is best made experimentally, by monitoring the output power with the aid of a power meter or measuring detector.

2.1. COMPONENTS

Oscillator:	TTL clock, 50 MHz (Monitor, type 801280)
T 1:	2N 3866, 2N 4427 or similar with cooling fins
D:	BXY 18 AB (Siemens) or similar storage varactor
C 1, C 4, C 5:	Plastic foil trimmer 20 pF (Philips, green)
C 2, C 3:	10 nF ceramic bypass capacitor
R 1:	100 Ω trimmer potentiometer
R 2:	100 kΩ carbon resistor, optimize the value experimentally !
L 1:	7 turns of 0.8 mm dia. silver-plated copper wire wound on a 6 mm former, self-supporting, approx. 15 mm in length, coil tap at the center
RFC 1:	7 turns of enamelled copper wire, 0.3 mm dia. wound on a 3.5 mm former, self-supporting
RFC 2:	12 turns wire and former as for RFC 1; optimize turn spacing experimentally !

Since the oscillator module will usually be home-made in most cases, the author does not consider it necessary to provide a PC-board for the 50 MHz amplifier, since the construction is not critical. The only important point is that a defined ground connection exists between the oscillator and amplifier, and to the waveguide module.

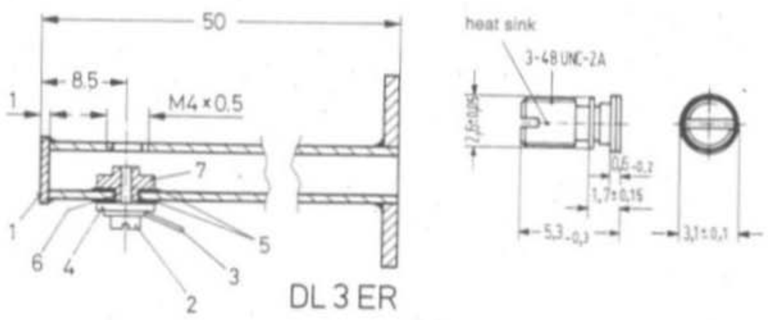
3. CONSTRUCTION OF THE WAVEGUIDE MODULE

Figure 3 shows the overall construction of the waveguide module complete with soldered flange, and a small lathed piece; the shape and dimensions match the previously mentioned diode. Since this type of diode possesses a flat surface, a matching piece (part 7) is required that must be installed in an insulated manner. The drive power can then be fed via the solder tag. The center frequency of the dampened resonator is dependent on dimension »d«, which is 8.5 mm in our case. The heat sink of the diode has a USA-thread, which can be fitted through an M 4 fine thread with the aid of the adapter (part 8).

If one is not able to cut this thread, this can be made as follows:

Solder a M 5 nut to the waveguide. The thread adapter (part 8) is provided with a M 5-thread on the outside, and a flat surface with the outer diameter of the 3-48UNC-thread on the inside. A small disk is now made from approx. 0.2 mm thick spring bronze, which is pushed through the hole of the threaded adapter. The disk is provided with a centrical hole through which the diode thread can be screwed. This disk fixes the diode in the adapter hole and is used as stop.

The centrical hole should be made on a lathe, however, it is possible for it to be made with the aid of a drill. It is not neceassry for it to fit exactly to part 7, which means that a slight excentricity is not important.



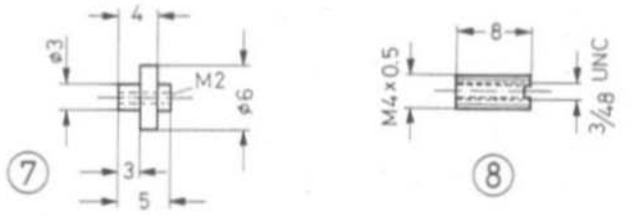


Fig. 3:
Waveguide module, part 7, and diode BXY 18 AB

If necessary, the author is willing to make such adapters in exchange for the actual costs involved.

3.1. COMPONENTS

1 Terminating panel, brass 1 mm thick
2 M 2 screw, 5 mm long
3 Solder tag
4 6 mm dia. disk, 1 mm thick, brass, centrical hole of 3 mm dia.
5 2pieces, PTFE disk, 7 mm dia., 0.1 mm thick, centre hole of 3 mm dia.
6 Insulating bushing for the screw, PTFE, or Sellotape
7 Lathed piece according to detailed drawing, material: brass
8 Adapter 3/48 UNC to M 4 x 0.5 for BXY 18 AB. Material: Brass

4. REFERENCES

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(2) B. Neubig, DK 1 AG:
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