Wideband centimetre range detector

A Zikiy^{1,*}, P Zlaman¹, and K Rumyantsev¹

¹Southern Federal University, Taganrog, Rostov Region, Russia

Abstract. An experimental study of the diode detector of the centimeter wavelength range has been carried out. A brief description of the circuit and design is given. The experiment was carried out on an installation containing a standard signal generator, a digital oscilloscope, a power supply, and a offset panel. The results of the experiment are the amplitude and amplitude-frequency characteristics of the detector. The following parameters have been shown to be achieved: operating frequency range of at least 8-18 GHz, voltage sensitivity of at least 100 $\mu\text{V} / \mu\text{W}$, dynamic range of input signals at least 35 dB, voltage sensitivity unevenness of no more than 1.6 dB.

1 Introduction

Microwave detectors are widely used in transmitting, receiving and measuring equipment. There are numerous publications on microwave detectors, including monographs [1,2], tutorials [3], articles [4-6], patents [7], advertisements [8], however, the increased requirements for microwave detectors stimulates further research. The purpose of this work is an experimental study of a wideband centimeter range detector. The object of research is a microstrip detector with a frequency overlap of more than an octave and a complex matching circuit at the input. Previously, a similar detector was investigated in [2, 6], but in them the upper cutoff frequency does not exceed 10 GHz.

The following requirements are imposed on the detector:

- operating frequency range from 8 to 18 GHz;
- voltage sensitivity with a load resistance of 15 k Ω and an input power of 0.1-2 mW should be at least 100 $\mu\text{V} / \mu\text{W}$;
- the dynamic range of input signals is not less than 35 dB;
- the polarity of the output signal is negative;
- input resistance 50 Ohm;
- load resistance 2 kOhm.

2 Diagram and design

The scheme of the investigated detector is shown in figure 1 [1, 2, 9, 10]. Resistors R1-R3, inductive elements L1, L2 ensure the matching of the diode with the microstrip line. Capacitor C1 and resistor R4 are elements of the low-pass filter [9, 10]. Structurally, the detector is a rectangular cup-type body made of brass. On one end of the body there is a

* Corresponding author: zikiy50@mail.ru

connector X1 of type IX according to GOST13317, on the other end there is a glass isolator through which the output signal is output. A photo of the detector is shown in figure 2. A polycor board with sprayed and soldered elements L1, L2, R1-R4, VD1 is installed inside the case. The body is closed from above with a sealed cover.

Fig. 1. Detector schematic diagram.

Fig. 2. Detector photo.

3 Experiment

The experiment was carried out on an installation, the block diagram of which is shown in figure 3. The offset panel is used to set a fixed load value.

Fig. 3. Detector photo.

In the first experiment, the amplitude-frequency response of the detector was measured at an input signal power of minus 10 dBm. The generator was tuned in the frequency range from 8 to 18 GHz with a step of 0.2 GHz. The results of measuring the output voltage (peak-to-peak) were recorded in table 1. According to table 1, a diagram is built in figure 4. It can be seen that the unevenness of the voltage sensitivity is 1.6 dB. In the second experiment, the amplitude characteristics of the detector were measured at two frequencies, namely 8 GHz and 18 GHz. The measurement results were recorded in table 2. According to table 2, the diagram are plotted in figure 5. These diagrams show that there is no explicitly quadratic detection area.

Table 1. Amplitude-frequency characteristic. ($i_{of}=50\text{ }\mu\text{A}$; $P_{in}=-10\text{ dBm}$; $\tau_i=100\text{ }\mu\text{s}$; $T_i=1\text{ ms}$; $R_i=2\text{ k}\Omega$).

Frequency (GHz)	Amplitude (mV)		Frequency (GHz)	Amplitude (mV)
8.0	17		13.2	16
8.2	17		13.4	16
8.4	17		13.6	16.5
8.6	16.5-17		13.8	16
8.8	16.5		14.0	16
9.0	16.5		14.2	16
9.2	16.5		14.4	16
9.4	16.5		14.6	15
9.6	16.5		14.8	15
9.8	16.5		15.0	16
10.0	16.5		15.2	16.5
10.2	16.5		15.4	17
10.4	16.5		15.6	17
10.6	16.5		15.8	17.5
10.8	16.5		16.0	18
11.0	16.5		16.2	18
11.2	16.5		16.4	18
11.4	16.5		16.6	18
11.6	16.5		16.8	18
11.8	16.5		17.0	18
12.0	16.5		17.2	18
12.2	16.5		17.4	18
12.4	16.5		17.6	18
12.6	16.5		17.8	18
12.8	16.5		18.0	18
13.0	16			

Table 2. Detector amplitude characteristic. ($i_{of}=50\text{ }\mu\text{A}$; $P_{in}=-10\text{ dBm}$; $\tau_i=100\text{ }\mu\text{s}$; $T_i=1\text{ ms}$; $R_i=2\text{ k}\Omega$).

P _{in} . dBm	f=8.0 GHz. R _i =2 kΩ		f=18.0 . R _i =2 κΩ	
	U _{out} . mV	U _{out} . dBmV	U _{out} . mV	U _{out} . dBmV
-20	5	14.0	4.48	13.0
-18	6	15.6	5.44	14.7
-16	7	16.9	7.52	17.5
-14	8	18.0	8.2	18.3
-12	11.6	21.3	11.4	21.1
-10	16.0	24	16.0	24.1
-8	22	26.8	21.2	26.5
-6	32	30.1	30.4	29.6
-4	44	32.8	42.4	32.5
-2	60	35.6	58.4	35.3
0	82	38.3	80	38.0
2	110	40.8	107.2	40.6
4	144	43.1	144	43.1
6	192	45.7	192	45.6
8	248	47.9	248	47.9
10	320	50.1	336	50.5
12	408	52.2	416	52.4
14	516	54.2	528	54.4
16	640	56.1	656	56.3
18	808	58.1	800	58.0
20	968	59.7	960	59.6
-20	6.56	16.3	7.2	17.1
-18	7.68	17.7	8.0	18.0
-16	10.24	20.2	10.48	20.4
-14	13.6	22.6	13.36	22.5
-12	16.24	24.2	18.0	25.8
-10	21.8	26.7	25.0	27.9
-8	31.6	30.0	36.0	31.1
-6	45.2	33.5	50.4	34.0
-4	62.0	35.8	72.0	37.1
-2	84.8	38.5	98.0	39.8
0	115.0	41.2	132.0	42.4
2	160.0	44.0	176.0	44.9
4	208.0	46.3	234.0	47.3
6	276.0	48.8	306.0	49.7
8	356.0	51.0	408.0	52.2
10	456.0	53.2	520.0	54.3
12	576.0	55.2	648.0	56.2
14	760.0	56.0	808.0	57.1
16	940.0	57.6	981.0	58.1
18	1140.0	61.1	1200.0	61.6
20	1320.0	62.4	1426.0	63.0

Fig. 4. Output voltage vs frequency.

Fig. 5. Detector amplitude characteristics.

In the third experiment, the oscillograms were photographed at the detector output. In this case, the following signal parameters were set on the generator of standard signals: for figure 6, the carrier frequency is 8.0 GHz, the power $P_{in} = -10 \text{ dBm}$, the duration is 100 μs , and the repetition period is 1 ms. For figure 7, the signal parameters are set: carrier frequency 18.0 GHz, power $P_{in} = 0 \text{ dBm}$, duration 100 μs , repetition period 1 ms, $R_l = 100 \text{ k}\Omega$.

Fig. 6. Mixture of signal and noise at the detector output at $i_{of}=0$; $P_{in}= -10$ dBm; $\tau_i=100\ \mu s$; $R_i=100\ k\Omega$.

Fig. 7. Mixture of signal and noise at the detector output at $i_{of}=0$; $P_{in}= 0$ dBm; $\tau_i=100\ \mu s$; $R_i=100\ k\Omega$.

4 Conclusions

Table 3 below shows a comparison of the given and achieved parameters of the detector.

Table 3. Detector amplitude characteristic.

Parameter name, dimension	Given	Measured
Operating frequency range, GHz	8-18	8-18
Voltage sensitivity with a load resistance of 2 kOhm and input powers of 0.1-2 mW, not less, $\mu V / \mu W$	100	150 with $P_{in}=0.1$ mW
Dynamic range of input signals, not less, dB	35	40

Output signal polarity	negative	negative
Input impedance, Ohm	50	50
Load resistance, kOhm	2	2; 10; 100
Voltage sensitivity unevenness, dB	-	1,6

Table 3 shows that all the requirements for the detector are met.

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