Measuring Detector for Microwave Signals

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Abstract – **In this paper, the possibility is considered for constructing a measuring detector for microwave signals, with an extended input signal range and a linear detecting response.**

Keywords – **Microwave detector, rectifying characteristic, error of quadratics, dynamic range.**

I. INTRODUCTION

Experimental measuring of S-parameters of SHF devices is usually performed by measuring voltage ratio indicated by quadratic microwave detectors [1]. Quadratic semiconductor detectors have an operating range of input signal level of about 35 dB. Such a range is insufficient for solving some measuring problems. In order to extend the range of input signal level, a new measuring detector for microwave signals (MDMS) is suggested.

II. OPERATING PRINCIPLE OF MDMS

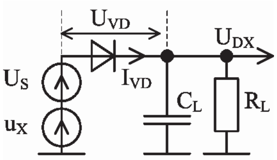

Fig 1. Equivalent MD Wiring Diagram

A semiconductor microwave detector (MD) is one of the basic units of MDMS. An equivalent wiring diagram for MD is shown in Fig. 1.

MD receives input signal $u_X = U_X \sin \omega t$ and DC shifting voltage U_S. If VAC of the diode [2] is $I_{VD} = I_S[\exp(\alpha U_{VD}) - 1]$, then the MD output voltage $U_{DX} = RI_S\left[e^{\alpha(U_S - U_{D0})} - 1\right] + U_{DDX}$. Where $U_{D0} = U_{DX}$ if $U_X = 0$; I_S, α is the diode parameters. The U_{DDX} component is determined by the following equation:

$$U_{DDX} = (RI_S + U_{D0})\left(I_0(\alpha U_X)e^{-\alpha U_{DDX}} - 1\right), \qquad (1)$$

where $I_0(\alpha U_X)$ is modified Bessel function of zero order.

Relative U_{DDX} deviation from the quadratic principle is characterized by the following value:

$$\delta_q = 10\lg\left(4\frac{I_0(\alpha U_X)e^{-\alpha U_{DDX}} - 1}{\alpha^2 U_X^2 [1 + \alpha(RI_S + U_{D0})]^{-1}}\right). \qquad (2)$$

MDMS operating principle is minimizing the module of the difference between the results of consequent u_X signal detecting and shifting $u_C = U_C \sin \omega_{\tilde{N}} t$ voltage detecting. This minimizing is effected by altering $u_C = U_C \sin \omega_{\tilde{N}} t$.

MDMS output voltage is determined by following formula $U_{OUT} = k_1 U_X (1 + \delta_X)$. Where k_1 is MDMS conversion factor. Ratio error of conversion is calculated by the following approximation:

$$\delta_X = \frac{\Delta_X}{U_X} = -\left(k_E \frac{\alpha(RI_S + U_{D0})I_1(\alpha U_X)}{e^{\alpha U_{DDX}} + \alpha(RI_S + U_{D0})I_0(\alpha U_X)} + 1\right)^{-1},$$

where $I_1(\alpha U_X)$ is modified Bessel function of first order, k_E is MDMS loop transfer ratio.

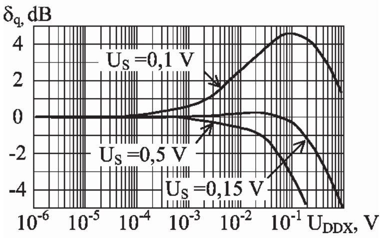

Fig. 2 Correspondence between δ_L and U_{DDX}.

Fig. 2 and Fig. 3 show the correspondence betwen δ_q and $\delta_L = 20\lg(1+\delta_X)$ on one hand, and U_{DDX} on the other hand. MDMS non-linearity is characterized by δ_L.

The values of δ_q and δ_L are calculated at R=3 kΩ for a silicon Shottky diode [2]; the diode parameters are: $I_S = 10^{-8}$ A, $\alpha = 39\ V^{-1}$.

It is known that the upper limit of quadratic section of the detecting response is U_{DDX}=(4…10) mV; the lower limit is U_{DDX}=(1..4) µV. Inside this section δ_q can reach the level of several decibel (Fig. 2).

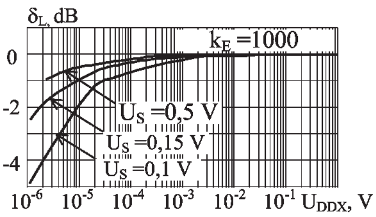

Fig. 3 Correspondence between d_L and U_{DDX}

If it is assumed that $\delta_{max} = \delta_q = \delta_L = 2$ dB, then, according to the shown correspondence, the lower operating voltages of MD and MDMS are not essentially different. δ_L value is monotonically decreasing; this decrease corresponds to the increase of U_{DDX}. Therefore, the theoretic range of MDMS input signal level is limited by the diode breakdown voltage.

III. CONCLUSION

Therefore, by the use of the substitution method, the suggested device allows to extend the range of the measured signals by approximately (10…20) dB.

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