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Analysis and Calculation of Current-Flow Amplitude Spectrum of a Microwave Mixer Diode at Poly-Harmonic Excitation

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Abstract—A new approximating function in the form of a fifth-order polynomial is obtained for the current-voltage characteristic of a mixer diode with Schottky barrier and with compensation of potential barrier of *p*-*n*-junction. Mathematical expressions are set up and relative levels calculated for the amplitude spectrum of harmonic and combinative components of the current in a mixer diode excited by four independent signals with different frequencies. The conditions for minimum of the combinative components are formulated for a wide dynamic range of input signals.

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Frequency converters (spectrum carriers) using mixer diodes have found wide application in various microwave systems of communication and radiolocation. The operation principle of microwave frequency converter, with a mixer diode (diodes) as its main part, is well elaborated and known [1–4].

Here we deal with the nonlinear process of mixing several signals having different frequencies and, as a result, with formation, in the mixer diode (diodes) current spectrum, of combinative and harmonic components of the type

$$i(K\omega_1 \pm L\omega_2 \pm M\omega_3 \pm N\omega_4) = i_{\sum} \text{ of the diode,} \quad (1)$$

where ω_1 is the heterodyne signal frequency, ω_2–ω_4 are frequencies of the signals falling in the band of the input filter of the frequency converter; ω_2 is the legitimate signal frequency, ω_2 and ω_4 are interference (noise) frequencies; K, L, M, and N are coefficients comprising the series of integers 0, 1, 2, 3, … .

In practice we deal with single-diode, balance-type, double-balance, ring-type, and full-wave bridge converters of frequency for suppression of the even components in current-flow spectrum of the mixer diode and for raising the saturation current. As a result, the dynamic range of input signals widens considerably.

In designing the microwave receivers operating in a wide frequency spectrum of input signals in the presence of interference, one of the most important requirements is minimum level of combinative components in the working band of the intermediate frequency signal.

In literature we can find nomograms [2, 5] used for determination of such heterodyne signal frequency which permits to eliminate the combinative and harmonic components in the working band of the signal of intermediate frequency. These nomograms are convenient in the case of a narrow frequency range of input signals, at free choice of the intermediate frequency.

Below is considered the case of a broad frequency range of input signals at a prescribed intermediate frequency value—i.e., with a minimum of freedom in choice of the heterodyne signal frequency. Then the main method, permitting to minimize the levels of combinative and harmonic components in the working band of the intermediate frequency signal and to broaden the dynamic range of the frequency converter, is division of the frequency range of received signals into bands with the coefficient of overlapping in frequency not exceeding 1.5–1.8. The off-band signals are suppressed by the input filter. Also, we can use special adaptive devices able to reduce the receiver sensitivity under interference conditions.

Formulation of unambiguous requirements to parameters of the filtering, decoupling and noise-stable devices can be simplified if we know the calculated values of components of the amplitude spectrum of the microwave mixer diode as a function of input signals' and heterodyne signal's levels.