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# Analysis on diode electrical circuits

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**ABSTRACT**: **The article deals with the approximation of the current-voltage characteristics of the diode and provides a solution to the differential equation of state of the circuit by a numerical method**. Currently, there are many analytical, graphical and numerical methods for calculating linear and nonlinear circuits, which are based on solving equations of value, derived from the laws of electrical engineering. In many cases, the variables and coefficients are expressed in nominal units. We have proposed a method for obtaining algebraic and differential equations of chains in relative units, which allow reducing the number of coefficients and reducing equations to a standard mathematical form.In addition, it is possible to analyze the modes in nonlinear circuits without determining the numerical values, the coefficients of approximation of the characteristics of nonlinear elements.

**KEYWORDS**: diode, nonlinear resistive chains, resistance, volt-ampere characteristic, inductance, transition processes of chains.

## I. INTRODUCTION

Under nonlinear electrical circuits is commonly understood as electrical circuits containing nonlinear elements. Nonlinear elements are divided into resistive, inductive and capacitive. Unlike linear resistors, nonlinear resistors have nonlinear current-voltage characteristics. Nonlinear resistors are divided into two large groups: managed and unmanaged. In controlled nonlinear resistors in contrast to unmanaged, in addition to the main circuit, as a rule, there is at least one more, auxiliary or control circuit, controlling the current or voltage of which you can deform the voltage-current characteristic of the main circuit. The group of controlled nonlinear resistors includes transistors, thyristors, thermistors and other elements. The group of uncontrolled nonlinear resistors includes incandescent lamps, electric arc, baretter, zener diode, semiconductor diodes and the like.

## II. SIGNIFICANCEOFTHESYSTEM

Nonlinear resistive elements are also classified according to the degree of influence of the heating temperature on the shape of the current-voltage characteristic. Since thermal processes are inertial processes, such non-linear resistors are usually called inertial processes. In turn, the resistors, the nonlinearity of the current-voltage characteristic of which is not due to thermal processes, are called non-inertial.

## III. LITERATURESURVEY

In the period of widespread development of electronic equipment in various fields of automation, electronics, computing and power supply, nonlinear resistive circuits are widely used. Uncontrolled semiconductor diode, as an element of an electrical circuit, is a nonlinear asymmetric resistance, its value depends on the polarity and the value of the potential applied to it.

Quite often, when considering the operation of rectifier circuits, in which diodes are usually used, the term "ideal diode" is used. This concept implies a certain asymmetrical resistance, the value of which is equal to zero in the positive direction of the current and infinite in the opposite direction.

The current-voltage characteristic of the diode can be obtained experimentally or from reference data for this semiconductor element. In the analytical study of circuits with valves, an important issue is the choice of the

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approximating function of a nonlinear element. Volt-ampere characteristic of direct current semiconductor diode can be described by a function of the form:

$$i = au_d^2 \quad (1)$$

Here, $a$ - is the coefficient of the approximating function, which is determined by the method of selected points.

## IV. METHODOLOGY

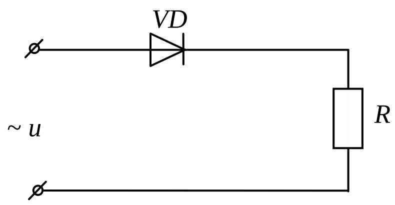


**FIG.1. Scheme of the diode connected in series with a resistance.**

We will assume that the diode with $R$ resistance connected in series (fig.1.) is connected to a network with voltage:

$$u = U_m \sin \omega t \,. \quad (2)$$

According to the second law of Kirchhoff:

$$u = u_d + ri \,. \quad (3)$$

Considering the approximating function, we can write:

$$u = \sqrt{\frac{i}{a}} + ri \,. \quad (4)$$

After some transformations we obtain the following equation:

$$r^2 i^2 - i \cdot \left(2ru + \frac{I}{a}\right) + u^2 = 0, \quad (5)$$

from where,

$$i = \frac{(2rau + 1) - \sqrt{4rau + 1}}{2r^2 a} \,. \quad (6)$$

Here the minus sign before the radical considers that at voltage $u=0$, the current will also be equal to zero.

## V. EXPERIMENTAL RESULTS

In the method of the chosen points, considering the volt-ampere characteristic of the D226 diode, we have $a$=0,41.

On the basis of equation (6) with use of the computer, it is possible to calculate and build the graph of change of the current in time. Fig.2. shows these dependences at various values of resistance $R$ for input voltage $u = 100 \sin \omega t$ .

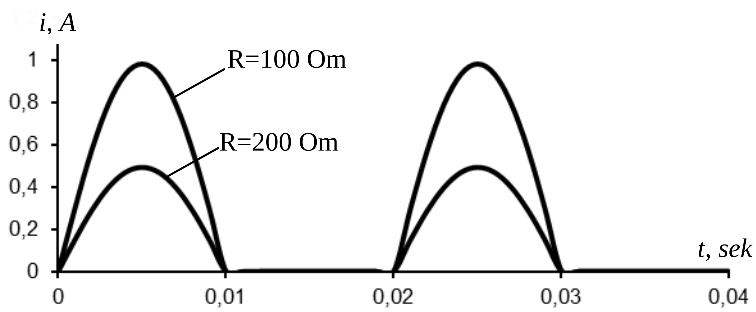


**FIG.2. Characteristic of dependence of *i*=*f* (*t*).**

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We will carry out the theoretical analysis of the scheme provided on Fig.3. where the diode, inductive and active resistance are connected in series. For the analysis of this chain we offer to use the numerical solution of the equation of a chain condition.

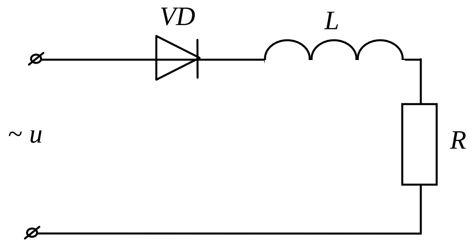


**FIG.3. Scheme of the diode connected in series with inductive and active resistance**

The equations of this chain are as follows:

$$u = u_d + L\frac{di}{dt} + ir \qquad (7)$$

Using more exact approximating function $i = au_d^2$, we will get:

$$u = \sqrt[4]{\frac{i}{a}} + L\frac{di}{dt} + ir \qquad (8)$$

At $u = U_m \sin\omega t$ we have:

$$\frac{di}{dt} = \frac{I}{L}\cdot\left[U_m \sin\omega t - \sqrt[4]{\frac{i}{a}} - ir\right] \qquad (9)$$

Apply numerical Euler's method to solve equation (9):

$$i_n = i_{n-1} + \frac{I}{L}\cdot\left(U_m \sin\omega t_{n-1} - \sqrt[4]{\frac{i}{a}} - i_{n-1}\cdot r\right)\cdot h \qquad (10)$$

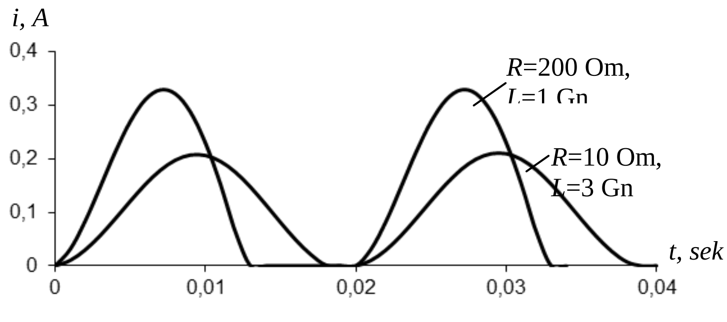


**FIG.4. Characteristic of dependence of *i*=*f* (*t*).**

Fig.4. shows the current curves built after solving equation (9) with a numerical method using the computer. Apparently from this dependence, a relative smoothing of the current curve follows. The shape of the current curve depends on a ratio of parameters of a chain *L* and *R*.

## VI. CONCLUSION AND FUTURE WORK

In conclusion, it should be noted that the diode resistive nonlinear chain consisting of the diode, the active resistance and the inductance can be analyzed by solving the equations of a chain condition by a numerical Euler's method. The offered method allows to analyze the set modes and transition processes of chains at various parameters.The passport data on the permissible current and voltage loads of a diode usually refer to a single half-period rectification circuit containing a diode VD and a load resistance R (fig.3).

For diodes as basic values are as follows:
- rated operating current (average value);
- rated reverse voltage (amplitude value);
- direct fall on the valve at rated current (average value).

Suppose the circuit is turned on by an AC sinusoidal voltage. In ideal diode operation, when the reverse current and the internal voltage drop across the diode are not taken into account, during the positive half-cycle of the alternating voltage, the current in the circuit is limited by the load resistance R. The voltage uR on the load resistance is equal to the applied voltage. In the nonconducting period of the diode, the voltage across the load is zero.

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