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NEW TECHNOLOGIES FOR VOLTAGE REGULATION IN RURAL ELECTRICAL NETWORKS

Abstract: Moreover, the initial phase of the excited oscillations has a section where the initial phase of the current in the unbranched section changes inversely with the magnitude of the applied voltage. The width and slope of this section can be adjusted by changing the parameters of the circuit in question. The features of the oscillating circuit are investigated in order to determine the possibility of their application for controlling thrusters when building new, simple and reliable circuits for regulating booster voltage stabilizers from the value of the supply voltage. In Ferro resonant circuits connected to a voltage source with low internal resistance, with a certain combination of parameters, oscillations are excited at the fundamental frequency, the initial phase of which has a shift relative to the initial phase of the applied voltage.

Keywords: circuit, voltage source, Ferro resonant, booster transformer.

Devices that could compensate for voltage dips in the supply network must meet the following requirements: greater sensitivity to changes in the voltage value at the input of this device and the speed of regulation of the voltage value of the power source.

Electricity, as a special type of product, has certain characteristics that make it possible to judge its suitability in various production processes.

The set of characteristics under which power receivers are able to perform their functions are united by the general concept of power quality. The quality of electricity is assessed by the damage caused to the national economy.

The quality of electricity, along with reliability and safety, is one of the mandatory requirements for power supply systems. The quality of electricity is characterized by a set of properties and indicators of energy quality.

One of the reasons for the deterioration in the quality of electricity is the so-called "dips" of voltage that are observed during the switching of powerful steel-smelting electric furnaces, semiconductor converters, etc. Voltage dips can be both short-term and long-term, one-time and reusable per shift in enterprises with a continuous nature of production. Voltage dips lead not only to a deterioration in the operation of electrical receivers in these enterprises, but also to a complete stop of the entire technological process. For example, in the spinning shops of textile mills, when the spinning machine is stopped, it takes up to three hours to fully restore their work, which leads to great economic damage.

Ensuring the required quality of electrical energy is a problem that is present at all stages of the existence of electrical energy, including generation, transmission, distribution and consumption. The main parameter and indicator of the quality of electrical energy is considered to be voltage and its quality.

Each specific power receiver is affected by power quality indicators in different ways. But in general, for all electrical receivers, the following can be distinguished:

- an increase in voltage leads to heating of the conductive parts of household appliances and industrial installations, and sometimes to the failure of the electrical receiver;
- low voltage, in turn, makes it impossible to use household appliances (the luminous flux of lighting lamps decreases, the performance of electric motors decreases), leads to lengthening of technological processes and to defects in manufactured products;
- changing the frequency leads to a change in the rotational speed of asynchronous motors;
- non-sinusoidal voltage affects the operation of electronic equipment (TVs, computers, radios), and also leads to heating of capacitor units;

- voltage fluctuations reduce the service life of electrical receivers, cause fluctuations in the luminous flux of lighting lamps (flicker), affecting people's health.

There are a large number of works devoted to voltage regulation using a booster transformer (VDT), the control system of which is based on semiconductor elements.

It should be noted that these systems have a relatively complex semiconductor circuit base, and also in regions where the average ambient temperature in summer can reach 500C and above, small-sized semiconductor devices begin to work with a large error or completely fail.

Despite the recent rapid growth of semiconductor technology, the variety of physical properties and numerous possibilities of electro ferromagnetic circuits still attract the attention of researchers to them.

This article discusses the issue of creating simple and reliable control systems for VDTs based on a parallel oscillatory circuit connected in series with a linear inductance.

To conduct a theoretical analysis, we will take the following assumptions:

1.

nly the fundamental harmonic of the harmonically changing magnitude of the magnetic flux is taken into account.

In addition, we neglect the losses in the core of the linear choke, in view of their smallness.

The study is carried out by the method of slowly changing amplitudes. The circuit under study is described by the following differential equation:

$$u = w\frac{d\phi}{dt} + L_0\frac{di}{dt} \qquad (1)$$

where

$$i = i_C + i_g + i_{ФЭ} \qquad (2)$$

here

$$i_C = wC\frac{d^2\phi}{dt^2} \qquad (3)$$

$$i_g = wg\frac{d\phi}{dt}; \qquad (4)$$

$$i_{ФЭ} = \frac{K}{w}\phi^7 \qquad (5)$$

Taking into account expressions (3-5), we rewrite the equation (1)

$$u = w\frac{d\phi}{dt} + wCL_0\frac{d^2\phi}{dt^2} + wgL_0\frac{d^2\phi}{dt} + \frac{KL_0}{w}\frac{d\phi^7}{dt} \qquad (6)$$

$$y = \frac{u}{U_б}; \quad x = \frac{\phi}{\Phi_б}; \quad \Phi_б = \sqrt[6]{\frac{64\omega^2 w^2 C}{35K}}; \quad U_б = \omega w \Phi_б; \quad \tau = \omega t. \qquad (7)$$

Here, the amplitude value of the first harmonic of the magnetic flux, determined from the condition of equality of the amplitude values of the currents in the winding of the PV and capacitor C, connected in parallel, is taken as the basic value of the magnetic flux, which corresponds to the point of intersection of the VAC of the PV and capacitor C.

Therefore, it is determined from the equality condition

$$\frac{35K}{64w}\Phi_m^7 Sin(\tau + \psi) = \omega^2 wC\Phi_m Sin(\tau + \psi)$$

taking into account expressions (7), after simple transformations, equation (6) will have the following form:

$$y = \frac{dx}{d\tau} + \omega^2 CL_0\frac{d^3x}{d\tau^3} + \omega gL_0\frac{d^2x}{d\tau^2} + \omega^2 CL_0\frac{64}{35}\frac{dx^7}{d\tau} \qquad (8)$$

assuming dimensionless coefficients:

$$\beta = \omega^2 C L_0; \quad \gamma = \omega L_0 g \tag{9}$$

we have

$$y = \frac{dx}{d\tau} + \beta \frac{d^3x}{d\tau^3} + \gamma \frac{d^2x}{d\tau^2} + \beta \frac{64}{35} \frac{d\phi^7}{d\tau} \tag{10}$$

We integrate this equation

$$\int y dx + c = x + \beta \frac{d^2x}{d\tau^2} + \gamma \frac{dx}{d\tau} + \frac{64}{35} \frac{d\phi^7}{d\tau} \beta x^7 \tag{11}$$

where c is the integration constant.

Solution (11) will be sought in the form

$$x = X_m Sin(\tau + \psi) \text{ at } y = Y_m Sin\tau . \tag{12}$$

Derived from x; looks like:

$$\frac{dx}{d\tau} = \frac{dX_m}{d\tau} Sin(\tau + \psi) + X_m Cos(\tau + \psi) + \frac{d\psi}{d\tau} X_m Cos(\tau + \psi)$$

Taking into account the fact that $X_m >> \frac{dX_m}{d\tau}$ и $X_m >> \frac{d\psi}{d\tau} X_m$ can be taken as a first approximation

$$\frac{dx}{d\tau} = X_m Cos(\tau + \psi) \tag{13}$$

$$\begin{aligned} \frac{d^2x}{d\tau^2} = {} & \frac{d^2X_m}{d\tau^2} Sin(\tau+\psi) + \frac{dX_m}{d\tau} Cos(\tau+\psi) + \frac{dX_m}{d\tau}\frac{d\psi}{d\tau} X_m Cos(\tau+\psi) + \\ & + \frac{dX_m}{d\tau} Cos(\tau+\psi) - X_m Sin(\tau+\psi) - X_m \frac{d\psi}{d\tau} Sin(\tau+\psi) + \\ & + \frac{dX_m}{d\tau}\frac{d\psi}{d\tau} Cos(\tau+\psi) + X_m \frac{d^2\psi}{d\tau^2} Cos(\tau+\psi) - X_m \frac{d\psi}{d\tau} Sin(\tau+\psi) \\ & X_m \left(\frac{d\psi}{d\tau}\right)^2 Sin(\tau+\psi) \end{aligned} \tag{14}$$

From (14), neglecting the terms of the second order and taking into account the first harmonic of the magnetic flux, we have:

$$\frac{d^2x}{d\tau^2} = 2\frac{dX_m}{d\tau} Cos(\tau+\psi) - 2X_m \frac{d\psi}{d\tau} Sin(\tau+\psi) - X_m Sin(\tau+\psi) \tag{15}$$

Substituting (14) and (4) into equation (11) we get

$$Y_m Cos\psi = \gamma X_m \tag{16}$$

The joint solution of equations (18), (19) gives the amplitude value of the input voltage, in relative units, and the phase angle between the power supply voltage and the PV magnetic flux.

$$Y_m = \sqrt{\left[\beta(1 - X_m^6\right]^2 - \gamma^2} \tag{17}$$

$$\mathrm{tg}\,\psi = -\frac{\beta(1 - \mathrm{X}_\mathrm{m}^6) - 1}{\gamma} \tag{18}$$

The results obtained by formula (29) have both positive and negative values:

- the negative value of the angle φ corresponds to the phase advance of the load current, from the mains voltage;

- the positive value of the angle φ corresponds to the lag of the phase of the load current from the voltage of the power source.

The dependences φ=f(Um) and Um = f(Zm), respectively, of the characteristic of the circuit under consideration, constructed using equations 20, 21, 28 and 29.

The dependence f=(Zm) has a falling section-drain (ab) where the current value changes inversely with the applied voltage, the width and slope of which can be changed by changing the circuit parameters. On the dependence curve φ=f(Уm), there is also a falling section (cd) here, the initial phase of the phase shift of the voltage and current in the unbranched section of the circuit under consideration varies inversely with the magnitude of the applied voltage [1-3].

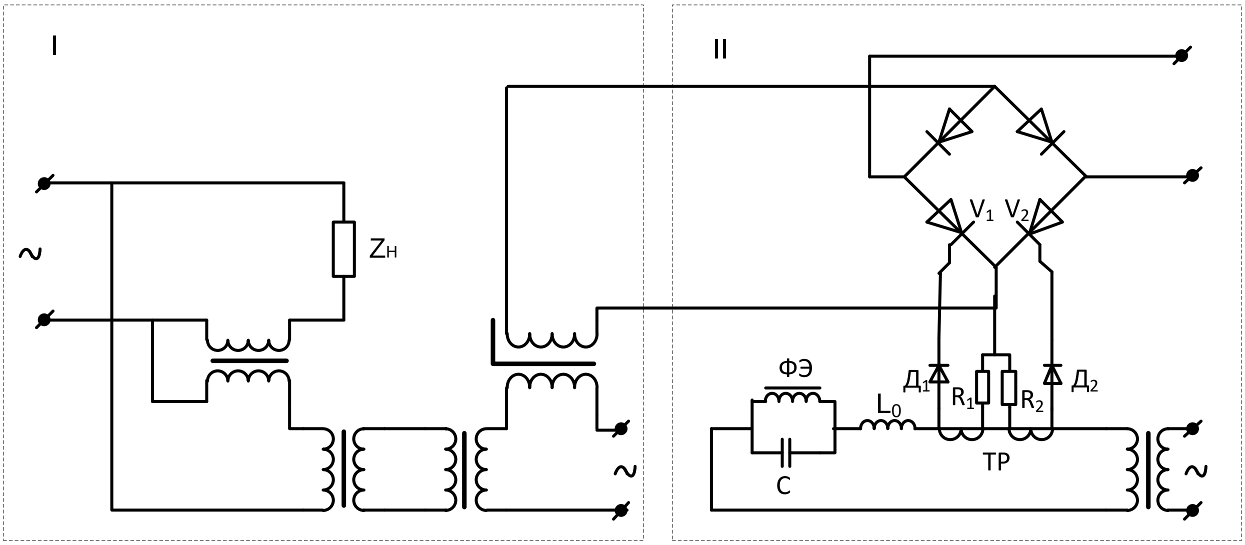

Figure 1. Diagram of a VDT with a smooth control system as a function of voltage

So, based on the above, this circuit can be used in the VDT control system for smooth voltage regulation at the load as a function of the power supply voltage.

This device consists of two parts: I - power part i.e. booster transformer and II - VDT control system, which consists of a step-down transformer, a parallel oscillatory circuit connected in series with a linear inductance, a transactor with two secondary windings included in an unbranched section of a parallel oscillatory circuit. The secondary windings of the transreactor are connected through diodes and resistances to the control electrodes of the thyristors located in the arms of the bridge circuit.

Conclusions.

1. The possibilities of obtaining amplitude-phase relationships of a given type when using a circuit for smooth control of the thyristor states as a function of the mains voltage and creating a continuously adjustable booster transformer based on them are established.

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