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Regulation system by voltage booster transformer

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Abstract. In this article, the features of the oscillatory 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.

1 Introduction

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 [1-5, 8, 10].

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 combination of properties and indicators of energy quality.

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.

2 The current state of the investigated problem

One of the reasons for the deterioration of the quality of electricity is the so-called "dips" of voltage, which 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 power 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 stops, it takes up to three hours to fully restore their work, which leads to great economic damage [6-12, 14, 15].

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 [13, 14, 20-26].

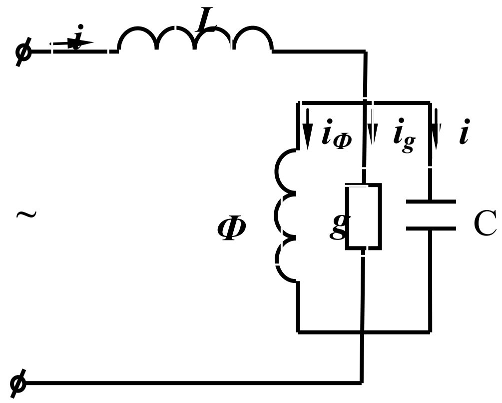

Fig. 1. Parallel oscillating contour

There are a large number of works devoted to voltage regulation using a booster transformer (VDT), the control system of which is made on the basis of semiconductor elements [8, 15, 17-19, 27-30].

It should be noted that these systems have a relatively complex semiconductor circuit base, and in regions where the average ambient temperature in summer can reach 50^0 C 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 electroferromagnetic 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 (Fig. 1) [28, 9, 15].

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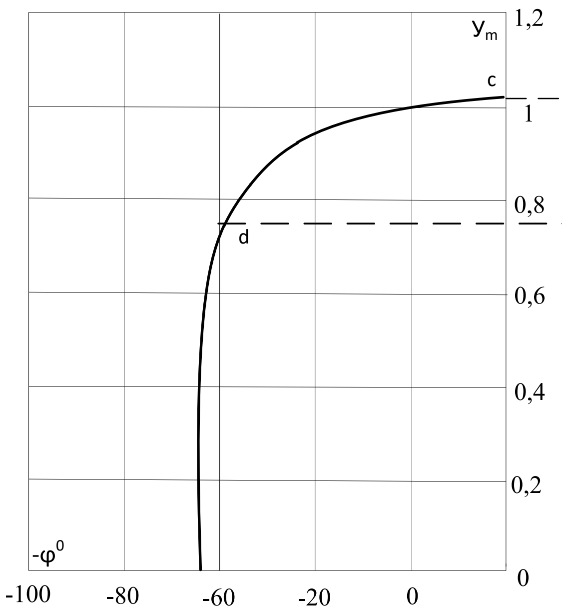

Fig. 2. Dependence φ=f(Um)

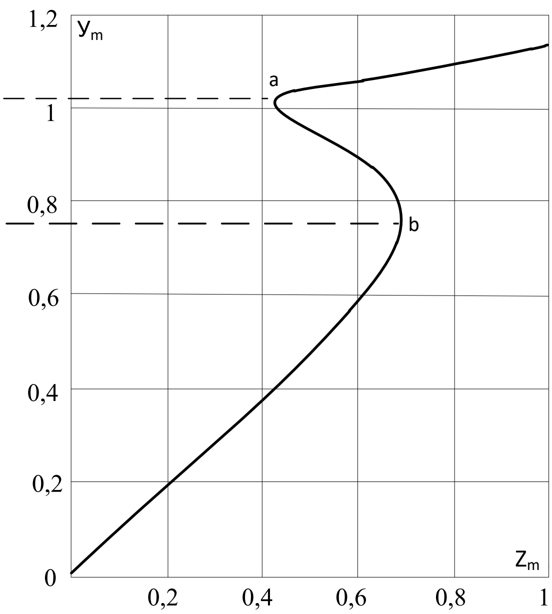

Fig. 3. Dependence $Y_m=f(Z_m)$

To conduct a theoretical analysis, we will take the following assumptions [1, 2, 16]:

1. Hysteresis losses, eddy currents and active resistance of the winding of a non-linear PV are considered constant and are taken into account by the conductivity g connected in parallel to the PV.
2. We neglect losses in capacitance C and leakage inductance of PV windings.
3. Only the fundamental harmonic of the harmonically changing magnitude of the magnetic flux is taken into account.
4. PV magnetic flux curve belongs to the category of symmetrical characteristics, so it must be approximated by a power function of an odd degree.

In addition, we neglect the losses in the core of the linear inductor, 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:

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

Where

$$i = i_C + i_g + i_{\Phi Э} \quad (2)$$

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 the capacitor, is taken as the basic value of the magnetic flux C connected in parallel, which corresponds to the point of intersection PV and capacitor C.

$$Y_m = \sqrt{\left[\beta(1 - X_m^6\right]^2 - \gamma^2} \quad (3)$$

$$\mathrm{tg}\psi = -\frac{\beta(1 - X_m^6) - 1}{\gamma} \quad (4)$$

To build the CVC of the circuit and determine its amplitude-phase characteristics, it is necessary to determine the dependencies I=f(Φ) and ϕ=f(U)

$$Z_m = X_m\sqrt{(1 - X_m^6)^2 - \left(\frac{\gamma}{\beta}\right)^2} \quad (5)$$

$$\mathrm{tg}\varphi = -\frac{(X_m^6 - 1)tg\psi - \frac{\gamma}{\beta}}{(X_m^6 - 1) - \frac{\gamma}{\beta}tg\psi} \quad (6)$$

The results obtained by formula (6) 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.

Fig. 2 and Fig. 3 show the dependences φ=f(Ym) and Ym= f(Zm) characteristics of the circuit under consideration, constructed using equations 1, 2, 3 and 4.

As can be seen from these Fig. 3, the dependence $Y_m = f(Z_m)$ has a falling section (ab) where the magnitude of the current varies inversely with the magnitude of the applied voltage, the width and slope of which can be changed by changing the circuit parameters. On the dependence curve *φ=(Ym)* (Fig. 2), there is also a falling section (cd) here the initial phase of the voltage and

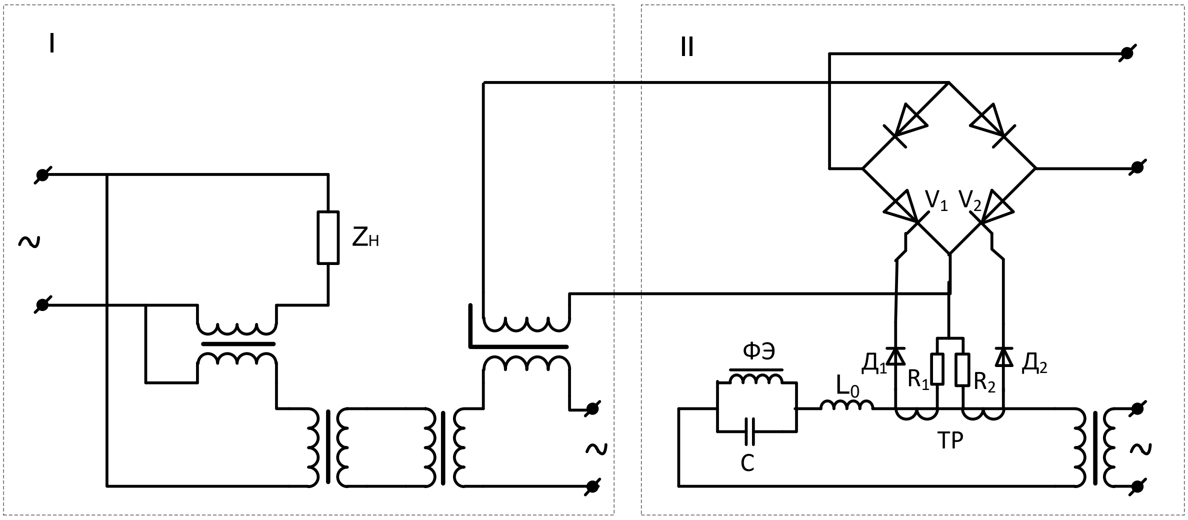

Fig.4. VDT circuit with a smooth control system as a function of voltage

current phase shift in the unbranched section of the circuit under consideration varies inversely with the magnitude of the applied 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 [3, 18, 23, 25, 27] (see Fig. 4).

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 trans reactor with two secondary windings included in an unbranched section of a parallel oscillatory circuit.

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3 Conclusion

1. The amplitude value of the load current in relative units and the phase angle between the load current and the mains voltage are revealed.
2. The analysis of the phase relations of the resonant circuit, connected in series with the inductance, showed that the initial phase of the current on the unbranched part of the circuit changes inversely with the applied voltage and has a wide range of dependence on the change in the input voltage.
3. Possibilities are established for 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.

References

1. Bessonov L.A. Nonlinear electrical circuits. - M.: Higher School, 1997, p.343.
2. Novikov SS Methods of operational planning and control of power consumption of large-capacity electric steel-smelting furnaces when operating on the wholesale electricity market: Avtorefer. dis. Cand. those. sciences. - M., 2008.- 18 p.
3. Rasulov A.N., R in zinazars M.R. Methodology for calculating electroferromagnetic circuits. Scientific journals: "GLOBUS". (42-48bet) St. Petersburg-2016.
4. Kadyrov T.M., Alimov Kh.A., Usmanov E.G. Analysis of the regimes of electroferromagnetic circuits by reducing the equations of state to relative units. Uzbek Journal of Problems of Informatics and Energy, No. 6, 2000, pp. 48 -51.
5. Usmanov E.G. RSES 2020. E3S Web of Conferences **216.** 01160. (2020). DOI: 10.1051/e3sconf/202021601160
6. Usmonov E.G. AIP Conference Proceedings 2552. 050020. (2023). https://doi.org/10.1063/5.0111537
7. Erejepov, M., Novikov, A.N., Khusanov, B.M., Seytmuratov, B., Sayimbetov, Z. E3S Web of Conferences. **289.** (2021). 07018. https://doi.org/10.1051/e3sconf/202128907018
8. Rakhmonov I.U., Najimova A.M., and Reymov K.M. AIP Conference Proceedings **2647.** 030010. (2022). https://doi.org/10.1063/5.0104788
9. Rakhmonov I.U., Najimova A.M. AIP Conference Proceedings **2647.** 030011. (2022). https://doi.org/10.1063/5.0104791
10. Rakhmonov I.U., Najimova, A.M., Esemuratova Sh.M., Koptileuov T.T. AIP Conference Proceedings **2647.** 070024. (2022). https://doi.org/10.1063/5.0104793
11. Hoshimov F.A., Rakhmonov I.U., Niyozov N.N., Omonov F.B. AIP Conference Proceedings **2647.** 030025. (2023). https://doi.org/10.1063/5.0112388

12. Rakhmonov I.U., Hoshimov F.A., Kurbonov N.N., Jalilova D.A. AIP Conference Proceedings **2647.** 050022. (2023). https://doi.org/10.1063/5.0112391
13. Rakhmonov I.U., Ushakov V.Ya., Niyozov N.N., Kurbonov N.N., Mamutov M. E3S Web of Conferences **289.** 07014. (2021). https://doi.org/10.1051/e3sconf/202128907014
14. Rakhmonov I.U., Ushakov V.Ya., Najimova A.M., Jalilova D.A., Omonov F.B. E3S Web of Conferences **289.** 07013. (2021). https://doi.org/10.1051/e3sconf/202128907013
15. Khakimov, HT, Shayumova, ZM, Kurbanbaeva, ZK, Khusanov, BM Development of optimal modes and mathematical models of energy performance of electric steelmaking production//E3S Web of Conferences, 2019, 139, 01076.
16. Rakhmonov,I., Berdishev,A., Khusanov, B.M, Khaliknazarov, U., Utegenov, U. IOP Conference Series: Materials Science and Engineering **883(1)**. 012104. (2020). DOI 10.1088/1757-899X/883/1/012104
17. I.U. Rakhmonov, T.H. Khakimov, I.I. Bakhadirov, B.M. Khusanov. International Journal of Advanced Science and Technology **Vol. 29**. (2020). pp. 1525-1533.
18. IU Rakhmonov, TH Khakimov, II Bakhadirov, BM Khusanov. Differentiated block method of analysis and forecasting indicators of power consumption of the industrial complex // International Journal of Advanced Science and Technology Vol. 29, no. 11s, (2020), pp. 1525-1533.
19. Rakhmonov, I.U., Kurbonov, N.N. E3S Web of Conferences **216**. 01178. (2020). DOI: 10.1051/e3sconf/202021601178
20. Hoshimov, F.A., Rakhmonov, I.U., Niyozov, N.N. E3S Web of Conferences **209**. 07017. (2020). DOI: 10.1051/e3sconf/202020907017
21. Rakhmonov, I.U., Reymov, K.M. E3S Web of Conferences **216**. 01167. (2020). DOI: 10.1051/e3sconf/202021601167
22. Rakhmonov, I.U., Hoshimov, F. E3S Web of Conferences **209**. 07018. (2020). DOI: 10.1051/e3sconf/202020907018
23. Usmanov EG, Khusanov BM Phase relations in resonant circuits with a wide falling section on the amplitude characteristic // RSES 2020. E3S Web of Conferences. 216 (2020) 01161. https://doi.org/10.1051/e3sconf/202021601161
24. Taslimov A.D. AIP Conference Proceedings **2552.** (2023). 050023. https://doi.org/10.1063/5.0112398
25. Melikuziev M.V., Nematov L.A., Novikov A.N., Baymuratov K.K. E3S Web of Conferences **289.** 07016 (2021). https://doi.org/10.1051/e3sconf/202128907016
26. A.D.Taslimov, A.S.Berdishev, F.M.Rakhimov, Melikuziev M.V. E3S Web Conf. **Vol. 139**. 2019. https://doi.org/10.1051/e3sconf/201913901081.
27. A.D.Taslimov, A.S.Berdishev, F.M.Rakhimov, Melikuziev M.V. E3S Web Conf. **Vol.139**. 2019. https://doi.org/10.1051/e3sconf/201913901082
28. Taslimov A.D., Melikuziev M.V., Najimova A.M., Alimov A.A. E3S Web of Conferences **216**. 01159 (2020). https://doi.org/10.1051/e3sconf/202021601159
29. Saidkhodjaev A.G., Nuriddinova Kh.R. AIP Conference Proceedings **2552.** 050037. (2023). https://doi.org/10.1063/5.0133486
30. Saidkhodjaev A.G. AIP Conference Proceedings **2552**. 050026. (2023). https://doi.org/10.1063/5.0111540