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DETERMINATION OF THE RIPPLE FACTOR OF THE VOLTAGE OF SINGLE-PHASE THREE SIDED RECTIFIER

Monophase thyristor rectifiers are used for the supply of windings of excitation and windings of armature of DC motor by power to 5 kVt in the machineries of serve of metal-working machine-tools. The coefficient of pulsations of voltage is one of basic operating descriptions of thyristor rectifier. Difficult character of dependence control angle by thyristor, electromagnetic permanent time of circle of armature and loading on the billow of engine eliminate possibility of its receipt in an analytical kind. Dependence of coefficient of pulsations of voltage on the indicated factors is definite with the use of computer model, as windings of excitation and windings of armature of engines of direct current behave to the class of the determined systems. Researches of dependence of coefficient of pulsations of voltage were conducted as follows. For three values of power DC motor dependences of coefficients of pulsations of voltage separately from each of influences were determined: control angle by thyristor, the electromagnetic became to time of circle of armature and loading on the billow of DC motor, during stabilization the two other. The control angle by thyristor was set by the delay of impulses of control on a model, electromagnetic permanent to time was set by the change of inductance of circle of armature, the current of loading was set by the change of size by electric motive force of armature. By the method of complete factor experiment analytical dependences of coefficient of pulsations of voltage, which, are definite, in obedience to a method, are goal functions. The method of determination of coefficient of pulsations of voltage of monophase thyristor rectifiers, which consists in the following, is offered as a result: 1) nominal passport data of engine are set: voltage, current, moment and speed; 2) on computation middle regulation speed are determined relative and absolute value of permanent constituent of the straightened tension; 3) on the relative value of permanent constituent of the straightened tension the middle control angle by thyristor in radianah is determined; 4) on the computation middle moment of loading the relative value of permanent constituent of current is determined; 5) the number value of coefficient of pulsations of voltage and virtual value of variable component tension are determined.

Keywords: *three sided rectifier, voltage ripple, computer model*

Introduction

Single-phase thyristor rectifiers are used to supply excitation windings and windings of the armature of DC motors up to 5 kW in the feeder machine tools (e.g. reversing thyristor rectifier series EPU-2-2). Voltage ripple factor is one of the main operational characteristics of thyristor rectifier, so determining its size is an urgent task.

Literature review

In [1-3] ripple voltage ratio is defined as the ratio of the current value of the variable component of the rectified voltage $\sqrt{\sum U_k^2}$ to the average value (DC component) of rectified voltage U_d, that is $K_U = \sqrt{\sum U_k^2} / U_d = \sqrt{U_{d-дюче}^2 - U_d^2} / U_d$, where $U_{d-діюче}$- current index of the voltage rectified. In the studied sources, for example in [2], given the graphic-analytical method for determining the voltage ripple factor for DC motors only in the case of work with nominal load and nominal speed. But this method, on the one hand, it is inconvenient and cumbersome, and the other - creates significant error in calculations because usually DC motors operate with load and speed lower than nominal, so you need to develop more convenient and more accurate method of determining ripple voltage coefficient of average values for the load and speed, if in the process of operation the latter change in a certain range.

The purpose of the article

Determine the dependence of the ripple voltage single phase thyristor rectifier control according to the angle of thyristors electromagnetic time constant circle of anchor and load current.

The main material

The complex nature ripple voltage dependence of the angle control of the thyristors, electromagnetic time constant circle of anchor and load on the motor shaft exclude the possibility of getting in an analytical way. Therefore this relationship is necessary to determine experimentally with further analytical approximation polynomial. Experiments can be performed on a laboratory bench - or a full-scale experiment on a mathematical model - a computer experiment. Since DC motors belong to a class of deterministic systems, the computer efficiently carry out the experiment. Computer model of single-phase thyristor rectifier with DC motors in the software package Simulink [4] presented in Figure 1.

The model engine represented electromotive force (EMF) anchors, active resistance and inductance range of anchor considering smoothing reactor. Angle control thyristor units is set by Pulse Generator. Constant component rectified voltage is defined by block Magnitude signal, and the current value of the rectified voltage is set by the block signal rms. The resistance and winding inductance range of anchors set in blocks $R_я$ and $L_я$. The value of EMF anchor is given by block $E_я$ with the sign "minus" because the scheme is not enabled models opposite voltage rectifier that caused units feature included in the software package Simulink. As a model of the DC motor can also be used with the engine model library Simulink. The results showed identity oscillograms of voltage and current anchor of the engine model from the library of Simulink and the model of the engine by the replacement scheme.

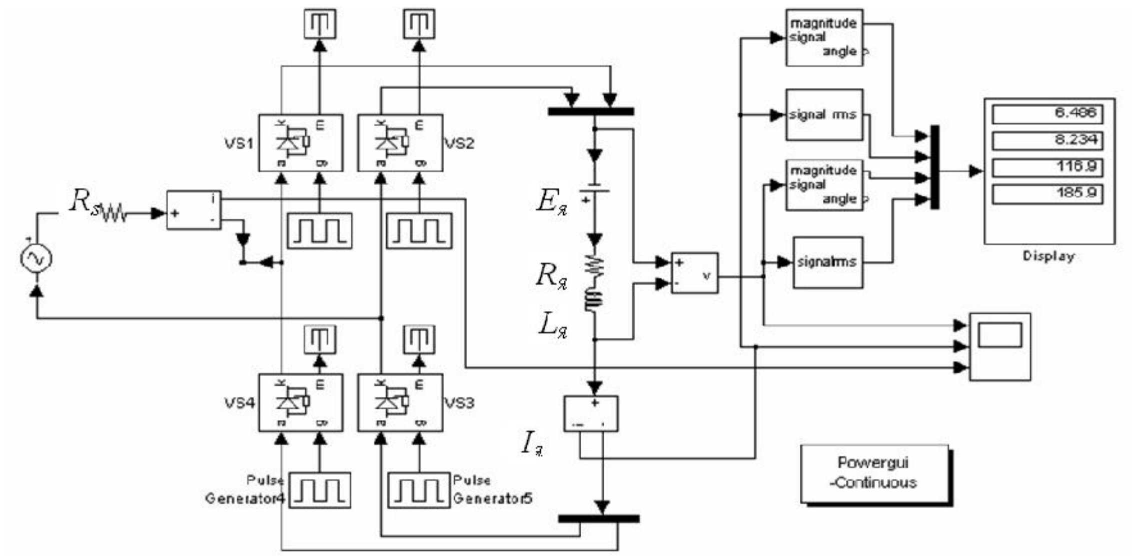

Fig. 1- Scheme model for the calculation of ripple voltage

The model of the equivalent circuit is more convenient that immediately comes to steady engine, which requires less time and work and is more important when a large number of computer experiments. Fig. 2 shows waveforms obtained in models of voltage and current anchor.

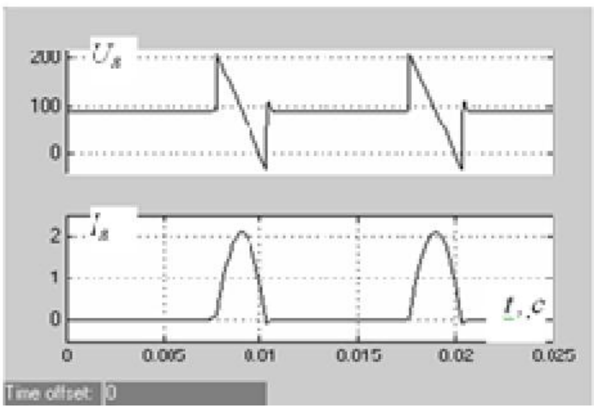

Fig. 2 - Calculated waveforms of voltage and current

Computer experiment is carried out as follows. For the three values of power of DC motors depending on factors which determine the ripple voltage separately from each of the influencing factors (angle control thyristors, electromagnetic time constant circle of anchor and load on the motor shaft) while stabilizing the other two. Angle control thyristor is given by the delay of pulse made by Pulse generation, electromagnetic time constant is set by changing the inductance range of anchor load current is set by changing the speed of change in the EMF anchor as engine speed depends on the load. The stabilization constant current component is realized by reducing engine speed through the appropriate reduction of EMF anchor by iteration, i.e. successive approximation to the required value EMF current value. According to the research related graphics are constructed the corresponding ripple voltage dependence from the angle of control, electromagnetic time constant anchor and load current, which are shown in Fig. 3.

Numerical analysis charts showed that the coefficient of ripple voltage can be taken constant, independent of engine power with an average error of 7%. For approximation depending average values of ripple voltage three influencing factors experiment planning method have been applied.

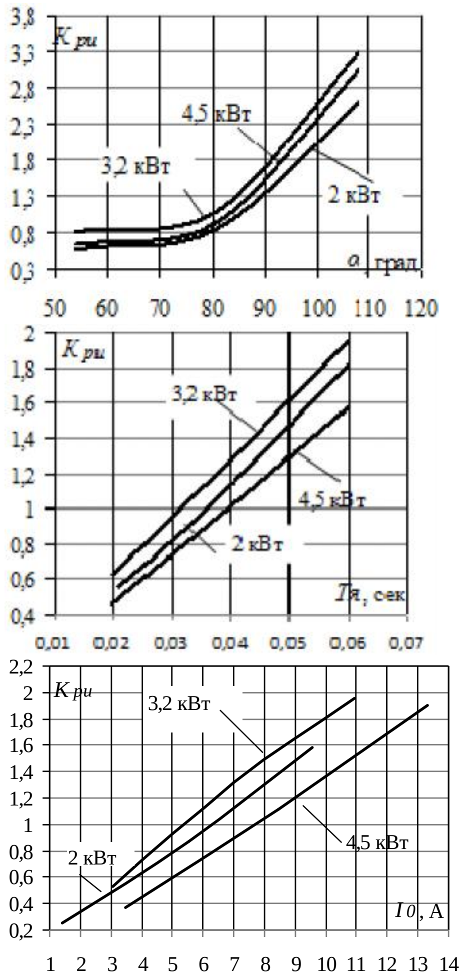

Fig. 3 - Graph of coefficient of ripple voltage thyristor control angle, electromagnetic time constant and load current

After algebraic transformations according to methods [5] get a polinom for the calculation of ripple voltage, which has the form

$$K_{pu} = 2{,}8 + 0{,}06\sim^{2,5} + 236T_я^{1,9} - 10I_0^{*2} - $$
$$- 3\sim^{2,5}T_я^{1,9} - 0{,}09\sim^{2,5}I_0^{*2} - 80T_я^{1,9}I_0^{*2} + $$
$$+ 120\sim^{2,5}T_я^{1,9}I_0^{*2}.$$

Thus, as a result of the research the method of determining the coefficient of ripple voltage single phase thyristor rectifier to the average values of the angle control and engine load current. For this set the relative value of the average speed adjusting $\mu_я^* = \mu_я / \mu_{НОМ}$ voltage and constant component of the engine and motor voltage constant component $U_0^* = U_0 / U_{НОМ}$ which depend on the angle control thyristor $\mu_я^* = U_0^* = f(\sim)$

Therefore, the approximate adjusting characteristics of single-phase thyristor rectifier according to Table 1, obtained on the model.

Table 1

Dependence of constant voltage component on the angle control

Angle of tyrystor control, radian	Relative voltage index
0,942	0,86
1,413	0,65
1,884	0,23

As a result of adjusting the characteristics approximation method of the smallest squares [5] according to Table 1, we obtain an analytical formula relative value constant component voltage

$$U_{o*} = 1{,}512 - 0{,}67 \cdot \sim , \qquad (1)$$

and angle control formula

$$\sim = (1{,}512 - U_{o*}) / 0{,}67 \qquad (2)$$

where α - the angle in radians management.

The relative value of the constant component of current $I_o^* = M_я / M_{НОМ}$ is set according to calculated average load factor. The obtained numerical values is substituted into the formula (1) and the ratio of ripple voltage has been calculated.

Let's determine the relative error of the calculated values of the voltage ripple according to the formula

$$\Delta K_{pU} = (K_{pUф} - K_{pUe}) 100\% / K_{pUe} \qquad (3)$$

where $K_{pUф}, K_{pUe}$ - coefficients ripple voltage calculated by formula (1) and obtained on the model. The calculation results are summarized in Table 2.

Table 2

The calculation of operational margin error

№ of experiment	Exact data	Calculated data	Operational margin error, %
1	0,209	0,329	12
2	0,43	0,51	8
3	0,446	0,386	-6
4	1,446	1,45	4
5	0,626	0,653	3
6	3,27	3,23	-4

Conclusion

As a result of research the technique of determining the coefficient of ripple voltage, which allows you to calculate the parameters Smoothing filters has been developed.

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ВИЗНАЧЕННЯ КОЕФІЦІЄНТА ПУЛЬСАЦІЙ НАПРУГИ ОДНОФАЗНОГО ТИРИСТОРНОГО ВИПРЯМЛЯЧА

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Коефіцієнт пульсацій напруги однофазного тиристорного випрямляча дозволяє визначити діюче значення змінних складових випрямленої напруги для побудови резонансних фільтрів. Складний характер залежності коефіцієнта пульсацій напруги від кута керування тиристорами, електромагнітної сталої часу кола якоря та струму навантаження виключають можливість її отримання в аналітичному вигляді. Тому ця залежність визначена на комп'ютерній моделі та апроксимована аналітичним поліномом.

Ключові слова: *тиристорний випрямляч, пульсації напруги, комп'ютерна модель*

ОПРЕДЕЛЕНИЕ КОЭФИЦИЕНТА ПУЛЬСАЦИЙ НАПРЯЖЕНИЯ ОДНОФАЗНОГО ТИРИСТОРНОГО ВИПРЯМИТЕЛЯ

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Коэффициент пульсаций напряжения однофазного тиристорного выпрямителя позволяет определить действующее значение переменных составляющих прямящего напряжения для построения резонансных фильтров. Сложный характер зависимости коэффициента пульсаций напряжения от угла управления тиристорами, электромагнитной постоянной времени круга якоря и тока нагрузки исключают возможность ее получения в аналитическом виде. Поэтому эта зависимость определена на компьютерной модели и аппроксимированная аналитическим полиномом

Ключевые слова: *тиристорний выпрямитель, пульсации напряжения, компьютерная модель*