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FREQUENCY DIVIDERS LOADED WITH RESISTIVE AND INDUCTIVE ELEMENTS

ABDALOV Sh.I.

Azerbaijan Technical University,

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ABSTRACT

The principle of work of one and three-phase frequency dividers is based on the applied to windings of nonlinear elements voltage with frequency of the controlled thyristors and achievements by periodic change of a magnetic state of magnetic cores, further divisions of frequency twice of this voltage in a spark output circuit.

The circuit of a single-phase frequency divider and signal graph of the block diagram of mathematical model is quoted. Areas of steady subharmonic division of frequency and the external characteristic by the received results on the model and experimentally are constructed. Errors of the received results make up to ten percent.

INTRODUCTION

Nowday for transformation high frequency in low in many industries - automatic control and regulation, radio engineering devices, telemechanics, and also as power supplies of mechanisms, devices and apparatuses of low frequencies the increasing application find frequency dividers.

EXPERIMENTAL REZULTS AND DISCUSSIONS

In Fig.1 the circuit of a frequency divider in 16 times is presented. For maintenance of steady work of operation and reception of the qualitative output voltage, the account by development and research of all operating modes of dividers has the important value.

Such divider of frequency is consist of two ferromagnetic elements, which initial windings w_1 are connected in series and aiding. Secondary windings – field coils with numbers of coils w_2 are connected in series and opposition and together with capacity C form a spark circuit [1]. In series with initial windings is included the controlled thyristor T [1], control of which is carried out from the control block.

The circuit of such divider allows to reduce frequency f_1 of an input voltage in 4, 8, 16 and 32 times, the frequency of a output voltage is determined as $f_2 = \frac{f_1}{4n}$ $(n = 1, 2, 4, 8....)$. It can be achieved with change of frequency of a pilot signal of thyristor and parameters of a spark circuit. The circuit of a three-phase frequency divider turns out application of three in parallel connected thyristors T1, T2, T3; anodes of these thyristors are connected to three A, B, C phases, cathodes are connected in one node, where the initial circuit of a divider is connected. Thus, initial windings of a three-phase divider are connected in a neutral line of a three-phase circuit.

Such divider mains supply with the frequency of 400 Hz, and the controlled signal, acting in an electrode of thyristor, changes with the frequency of 50 Hz, then the frequency of a output voltage is equaled

$$t_2 = \frac{f_1}{4n} = \frac{400}{16} = 25 \text{ Hz}$$

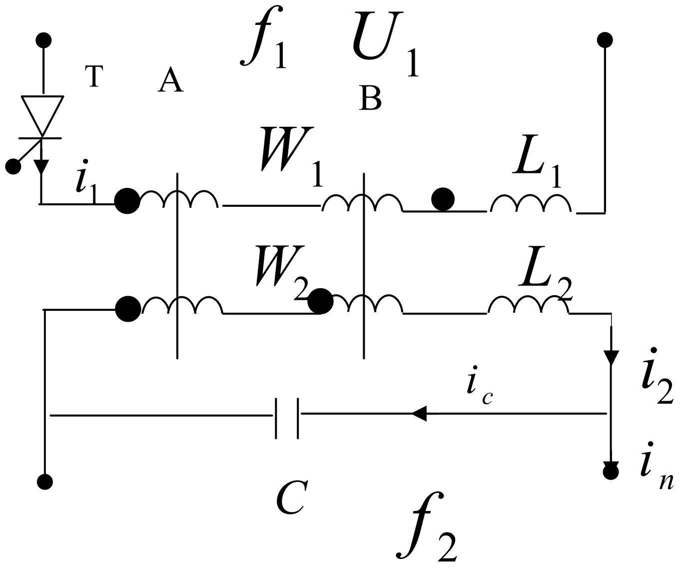

Fig. 1. Frequency divider in 16 times with magnetic thyristor.

In the first, in eight half-cycles of a supply voltage a thyristor opens four times, and in the following eight half-cycles a thyristor all time remains closed. Thus, the applied voltage in an initial winding will change with frequency in eight times less, than frequency of an input voltage, and on an output circuit will take place division of frequency of this voltage twice. In a consequence on an output the voltage with frequency of 25 Hz, i. e. in 16 times of smaller frequency of an input voltage turns out. As a result of an autoparametrical resonance in a spark circuit arises powerful steady subharmonic oscillations, as the output voltage with required frequency is.

For drawing up of the differential equations of a frequency divider the following assumptions are accepted: numbers of coils of initial w_1 and secondary w_2 windings were accepted identical, it was neglected the hysteresis phenomenon, inductance of dispersion of initial and secondary windings (L_1, L_2) are taken into account, active losses in windings and magnetic circuits were represented by the active resistance incorporated with R_1 and R_2. The curve of magnetization of ferromagnetic cores was approximated three pieces of straight lines, a thyristor was modeled in view of a voltage drop on the open thyristor and a leak current of the closed thyristor.

At construction the signal graph of the block diagram of mathematical model of a divider as against [3], [4], all conditions of steady work of the model were taken into account, the number of nodes in one closed contour always is odd, the mark of a signal on an output of tops becomes opposite an input, as in the operational inverter. In mutual-return functional transformations of $F_A(\Phi_A)$ and $\Phi_B(F_B)$ were reproduced in one closed contour. For maintenance of stability of the model the differentiation and integration were carried out in one closed contour. Thus, to construct a graph, it is possible to be convinced preliminary, that work of model will be steady.

The equations for drawing up of the block diagram of model of the divider in 16 times and the directed graph of the block diagram of the divider (Fig. 2) in system of relative units look like:

$$
\begin{aligned}
&\frac{d\overline{\Phi}_A}{dt} = u_1 - u_T - Ri_1 - L_1\frac{di_1}{dt} + \frac{d\Phi_B}{dt}\\
&-L_2\frac{di_2}{dt} = \frac{d\Phi_A}{dt} - \frac{d\Phi_B}{dt} + R_2 i_2 + u_C\\
&F_B = -F_A + 2i_2\\
&u_C = \frac{1}{C}\int i_C dt\\
&i_n = \frac{u_C}{R_n} = \frac{u_n}{R_n}\\
&i_C = i_2 - i_n \qquad\qquad (1)\\
&L_n\frac{di_n}{dt} = u_n - R_n i_n\\
&-i_1 = -F_A + i_2\\
&\Phi_A = \Phi_A(F_A)\\
&F_B = F_B(\Phi_B)\\
&u_T = u_T(i_T)
\end{aligned}
$$

where Φ_A and Φ_B – are magnetic streams of cores A and B, and the dependence between streams and magnetizing forces is expressed by $F_A(\Phi_A)$ and $\Phi_B(F_B)$; u_i - is an input voltage; i_1, R_1, L_1 - are a current, active resistance and inductance of an initial circuit; i_2, R_2, L_2 - are a current, active resistance and inductance of a secondary circuit; i_C, u_C - are a current and voltage in a circuit of capacity; i_n, u_n - are a load current and load voltage; R_n, L_n - are an active resistance and inductance of loading; u_T, i_T - are a voltage on thyristor and a current through it.

In Fig. 3 (a) are presented areas of existence of steady vision of a single-phase frequency divider 16 times, removed on models (continuous lines) and experimentally (dotted lines); in Fig. 3 (b) are presented the external characteristics of such frequency divider removed on models (continuous lines) and experimentally (dotted lines). As a result of researches on the model the areas in which there are steady oscillations with the set frequency of a output voltage have been determined. As from the figure it figure it is visible, that in coordinates $1/\overline{C}$ and $\overline{U}_1$ borders of existence areas of steady division for frequency dividers in 16 times which have been removed on model are quoted, at its work in various modes. From the figure it is visible, that with increase of the load current of at an output of the divider the area of existence decreases, and, it borders is a little displaced aside smaller values of $\overline{C}$ and $\overline{U}_1$. The most powerful subharmonic oscillations in a divider arise near to the left border; therefore, at designing such frequency dividers the operating conditions should be chosen at values $1/\overline{C} = 0{,}04$ and $\overline{U}_1 = 1{,}55$. At reduction of resistance in a circuit of loading up to "critical" values, such mode of a divider at which there is "failure" of subharmonic oscillations to the set frequency acts.

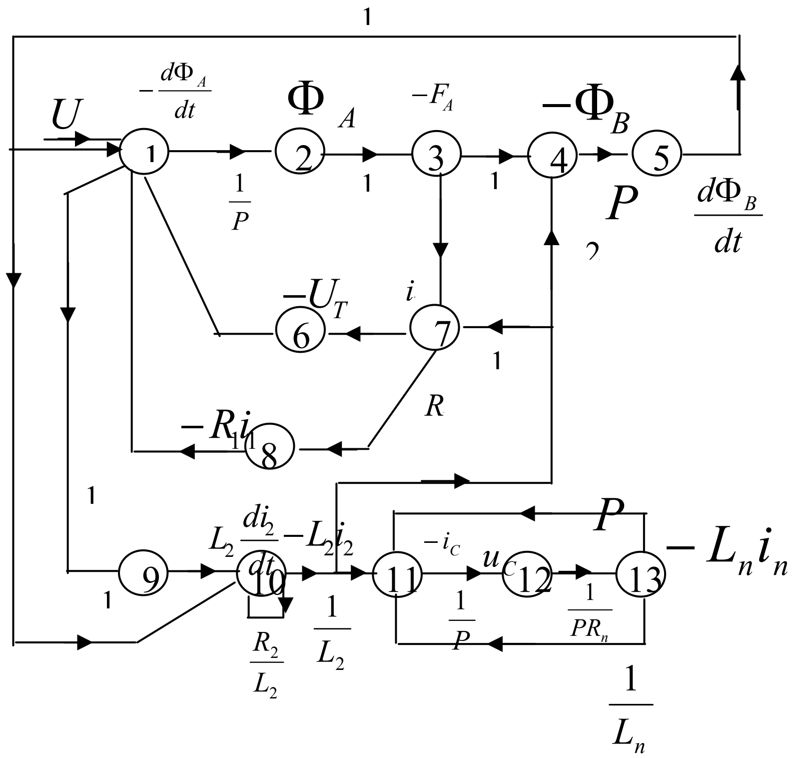

Fig. 2. Signal graph of the block diagram of mathematical model of the frequency divider in 16 times with magnetic thyristor.

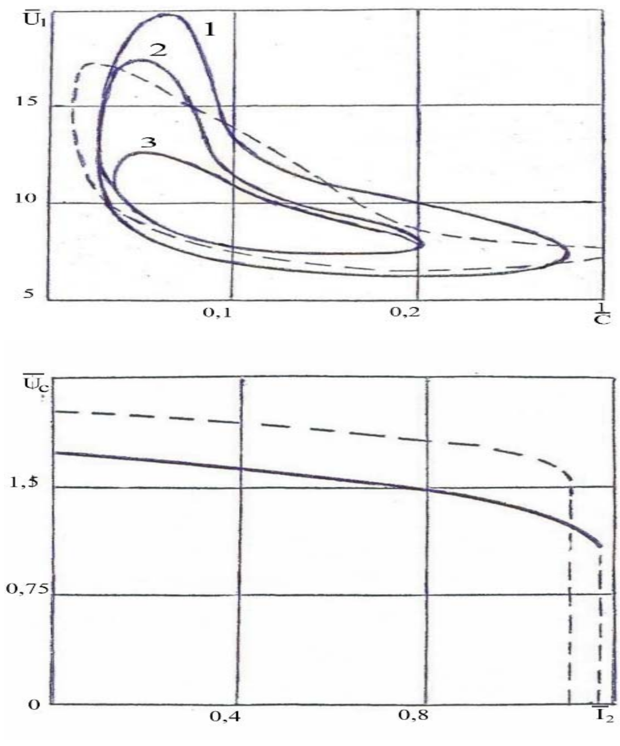

Fig.3. The area of work stability (a) and the external characteristic (b) of the frequency divider in 16 times

Such mode is considered a mode of short circuit of a divider. In this case subharmonic oscillations on an output of a divider do not arise at any values $\overline{X}_C$ and $\overline{U}_1$. At research of areas of existence of steady division in no-load conditions of a divider self-oscillations at the right boundary of area were observed. At transition of a divider from no-load conditions to under-load operation, self-oscillation decrease and at values of resistance in a load circuit smaller $R = 0{,}6\ R_n$ at all disappear (areas 2 and 3). The top part of area and on its left boundary there is a zone of tightening, where steady subharmonic oscillations with output frequency here exist only when the divider during its work in the certain mode, passes in this area at spasmodic change of values $1/\overline{C}$ and $\overline{U}_1$ If to disconnect a divider from a network in its operating time in a zone of tightening, then at repeated inclusion in a network oscillations on an output it is not raised. In the same figure the area boundary of existence of steady division received as a result of an experimental research of a divider in no-load conditions is shown by a dotted line.

From comparison of boundaries of areas of the existence received on the model and experimentally, it is visible, that they differ from each other under the form a little and lay in limits the same values $1/\overline{C}$ and $\overline{U}_1$.

As it is visible from figure 3 (b), the external characteristic of a divider rigid and at transition of a divider from no-load conditions to under- maximal load operation the output voltage decreases only for 7..10 % from nominal value.

For comparison, here the external characteristic removed as a result of an experimental research of a divider in 16 times in the same operating mode and counted in relative units is shown by a dotted line. As it is visible, both characteristics insignificantly differs from each other under the form, the error makes 6 %.

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AKTİV İNDUKTİV YÜKLÜ TEZLİK BÖLƏNİ

ABDALOV Ş.İ.

Bir və üçfazlı tezlik bölənlərinin iş Prinsipi qeyri-xətti elementlərin dolaqlarına tiristorun idarə siqnalının tezliyinə bərabər tezlikli gərginlik tədbiq etməkdən və bu tezliyi iki dəfə yenidən bölməyə əsaslanır. Bir fazlı tezlik böləninin sxemi və riyazi modelinin struktur sxeminin siqnal qrafı verilir. Riyazi model və eksperimentlə alınmış nəticələrə əsasən dəyanətli subharmonik bölmə oblastı və xarici xarakteristika qurulub. Alınmış nəticələr arasında xəta 10 faizə qədərdir.

ДЕЛИТЕЛЬ ЧАСТОТЫ С АКТИВНО ИНДУКТИВНОЙ НАГРУЗКОЙ

АБДАЛОВ Ш.И.

Принцип работы одного и трехфазных делителей частоты основан на приложении с обмотками нелинейных элементов напряжения с частотой управления тиристорами и на достижение периодического изменением магнитного состояния сердечников, далее деление частоты этого напряжения в два раза. Приводится схема однофазного делителя частоты и сигнальный граф структурной схемы математической модели. По полученным результатам модели и экспериментально построены области устойчивого

субгармонического деления частоты и внешняя характеристика. Погрешность полученных результатов составляет до десяти процентов.