ISSN 1815-4840
Himičeskaâ tehnologiâ. Kontrol' i upravlenie
CHEMICAL TECHNOLOGY. CONTROL AND MANAGEMENT
2019, №6 (90) pp.19-25
International scientific and technical journal
journal homepage: https://uzjournals.edu.uz/ijctcm/
Since 2005

UDC 681.586:621.3.013.62

THE STUDY OF DYNAMIC MODES OF CONVERTERS WITH MOVABLE ELECTROMAGNETIC SCREENS AND DISTRIBUTED PARAMETERS

S.F.Amirov[1], O.T.Boltayev[2]

[1]*Tashkent Institute of Railway Transport Engineers, Uzbekistan*
Address: *1 Adilkhodjaev st., 100167, Tashkent city, Republic of Uzbekistan*
E-mail: amirov.sultan@bk.ru, Phone:+998-91-137-02-05;
[2]*Tashkent Institute of Railway Transport Engineers, Uzbekistan*
Address: *1 Adilkhodjaev st., 100167, Tashkent city, Republic of Uzbekistan*
E-mail: otash_be@mail.ru, Phone:+998-97-443-55-66.

Abstract: *In article for research of dynamic characteristics of the created Converter with mobile electromagnetic screens and with the distributed parameters, the parametric block diagram is made. Based on the parametric block diagram, the analytical equation of the output voltage in the operator form is compiled for the dynamic mode. In order to study the dynamic properties of the transducer with moving electromagnetic screens and distributed parameters, the influence of input values on the reaction of the transducer is considered. On the basis of the revealed expressions the nonlinearities of the transient process are considered.*
Keywords: *moving electromagnetic screen, parametric block diagram, angular displacement transducer, dynamic characteristic.*

Аннотация: *Яратилган қўзғалувчан электр-магнит экранли ва тақсимланган параметрли ўзгарткичнинг динамик тавсифларини тадқиқ этиш учун параметрик структурали схемаси тузилган. Ушбу параметрик структурали схема асосида динамик режим учун чиқиш кучланишининг оператор шаклидаги аналитик тенгламаси ҳосил қилинган. Яратилган қўзғалувчан электр-магнит экранли ва тақсимланган параметрли ўзгарткичнинг динамик хусусиятларини ўрганиш мақсадида ўзгарткич реакциясини турлича таъсир этувчи кириш катталиклар асосида тадқиқ этиш кўриб чиқилган. Аниқланган ифодаларга асосан ўткинчи жараён эгри чизиқлари қурилган.*
Таянч сўзлар: *қўзғалувчан электр-магнитли экран, параметрик структурали схема, бурчак силжиш ўзгарткичи, динамик тавсиф.*

Аннотация: *Для исследования динамических характеристик созданного преобразователя с подвижными электромагнитными экранами и с распределенными параметрами составлена параметрическая структурная схема. На основе параметрической структурной схемы для динамического режима составлено аналитическое уравнение выходного напряжения в операторной форме. С целью изучения динамических свойств преобразователя с подвижными электромагнитными экранами и с распределенными параметрами рассмотрено влияние входных величин на реакцию преобразователя. На основе выявленных выражений рассмотрены нелинейности переходного процесса.*
Ключевые слова: *подвижной электромагнитный экран, параметрическая структурная схема, преобразователь угловых перемещений, динамическая характеристика.*

Introduction

Mobile electromagnetic screens (MES) and the distributed parameters (DP) converters are widely used in the device and apparatus of automation and information-measuring equipment[9]. Currently, most of the movable screens used one (MS) in converters. However, research has shown that, the high sensitivity of several MS modifiers for one MES switch is a very small zero signal, and the static characteristic is the width of the linear boundary [8]. When using MES and DP converters in specific rail systems, their dynamic characteristics are in very high demand. As you know, the dynamic character of the MES and DP modifiers is determined by the rapidly changing principle of the input angle (corner shift) and depends on the internal structure and elements of the transformer.

Research Methods and the Received Results

The modified MES and DP corner shift converter (CSHC) comprises the outer and inner core hinge 2, which are located at the same distance from the magnetic system. These layers are subsequently connected to the opposite proceedings w_{m} and measurement w_{me} and the symmetrically mounted syngths 3 are joined together. The transducer is fitted with a mechanically fixed ME 4 on the outer hinge base of the magnetic system (Fig. 1) [1,6].

If a measured corner shift $Q_{\mathrm{m}}(t)$ and source voltage $U_{\mathrm{em}}(t)$, we can describe the dynamic mode of the MES and DP converters by putting them on a differential equation. Voltage of this differential equation $U_{\mathrm{emea}}(t)$ gives a chance to find the expression. $Q_{\mathrm{m}}(t)$, $U_{\mathrm{em}}(t)$ and $U_{\mathrm{emea}}(t)$ it is possible to find the exact output voltage output for the given moment.

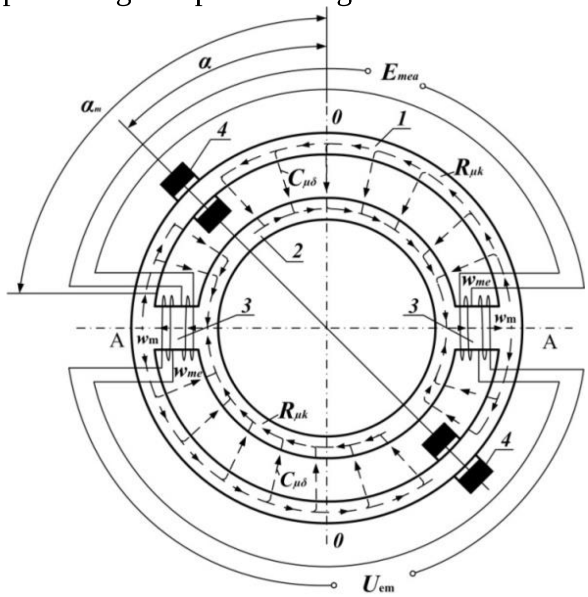

Fig. 1. ***The structure of the corner shift converters.***

Analytic equations of dynamic characterization of the generated MES and DP angle transducers can be easily generated using parametric structural scheme (PSS) (Fig. 2). We give the equations for each elemental pair of PSS. To simplify the calculation of the dynamic mode of the generated MES and DP converters, the electrical impulse $W_e = \dfrac{1}{C_e}$ c it cannot be considered because of small value.

Since the generated transmitter is symmetric, we are limited to reviewing part of the PSS (left part). The equations for the PSS elemental cell are as follows [7]:

$$U^L_{emea}(p) = K_{I_\mu U_{em}} I^L_\mu(p); \tag{1}$$

$$I^L_\mu(p) = pQ^L_{\mu\Sigma}(p); \tag{2}$$

$$Q^L_{\mu\Sigma}(p) = U^L_{\mu\Sigma}(p) C^L_{\mu\delta}; \tag{3}$$

$$U^L_{\mu\Sigma}(p) = U^L_{\mu\mathrm{m}}(p) - U^L_{\mu R}(p) - U^L_{\mu e}(p); \tag{4}$$

$$U^L_{\mu m}(p) = I^L_\mu(p) R^L_{\mu k}; \tag{5}$$

$$U^L_{\mu e}(p) = K_{I_{ee} U_{\mu e}} I^L_{ee}(p); \tag{6}$$

$$I_{ee}^{L}(p)=K_{I_{\mu}U_{ee}}G_{ee}^{L}I_{\mu}^{L}(p); \qquad (7)$$

$$U_{\mu m}^{L}(p)=K_{I_{em}U_{\mu m}}I_{em}^{L}(p); \qquad (8)$$

$$I_{em}^{L}(p)=G_{em}^{L}U_{e\Sigma}^{L}(p); \qquad (9)$$

$$U_{e\Sigma}^{L}(p)=U_{em}^{L}(p)-U_{e\mu}^{L}(p); \qquad (10)$$

$$U_{em}^{L}(p)=I_{\mu}^{L}(p)K_{I_{\mu}U_{e\mu}} \qquad (11)$$

2, 4, 5, 6 and 7 expressions 3 series is created in the form of magnetic flux through the operator the following statement:

$$Q_{\mu\Sigma}^{L}(p)=\frac{C_{\mu\delta}^{L}K_{I_{em}U_{\mu m}}I_{em}^{L}(p)}{1+p(R_{\mu k}^{L}C_{\mu\delta}^{L}+G_{ee}^{L}K_{I_{\mu}U_{ee}}K_{I_{ee}U_{\mu e}}C_{\mu\delta}^{L})}; \qquad (12)$$

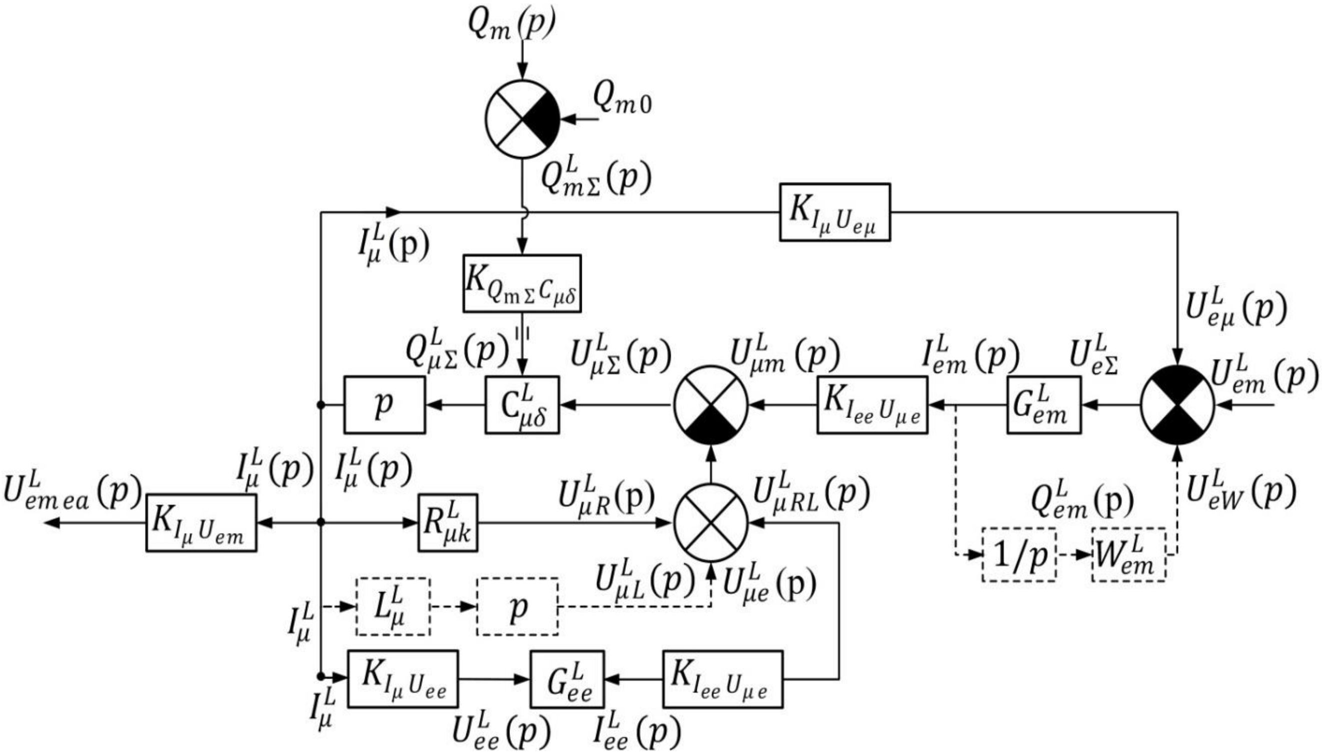

Fig. 2. ***MES and DP converters to determine the dynamic description of the PSS.***

Equations 10, 11 and 12 define the form of operator of the source of electricity in the source:

$$I_{em}^{L}(p)=\frac{[1+p(T_{\mu}+T_{ee})]G_{\mathrm{em}}^{L}U_{em}^{L}(p)}{1+p(T_{\mu}+T_{ee}+T_{em})}, \qquad (13)$$

here is $T_{\mu}=R_{\mu k}^{L}C_{\mu\delta}^{L}$, [s] and $T_{ee}=G_{ee}^{L}K_{I_{\mu}U_{ee}}K_{I_{ee}U_{\mu e}}C_{\mu\delta}^{L}=w_{\mathrm{m}}^{2}C_{\mu\delta}^{L}G_{ee}^{L}=\frac{L_{ee}}{R_{e}}$, [s], $T_{em}=G_{em}^{L}K_{I_{\mu}U_{e\mu}}K_{I_{em}U_{\mu m}}C_{\mu\delta}^{L}=w_{\mathrm{m}}^{2}C_{\mu\delta}^{L}G_{em}^{L}=\frac{L_{em}}{R_{em}}$ – magnetic and electrical circuits in accordance with time constants; L_{em}, L_{ee} - in accordance with the proceedings of the screen, and the movable electric inductivity, [H].

The operator voltage analytic equation for the dynamic mode of the MES and DP corner conversion operation, set forth in equation 1 in equations 12 and 13, is as follows:

$$U_{emea}^{L}(p)=\frac{pG_{em}^{L}C_{\mu\delta}^{L}K_{I_{em}U_{\mu m}}K_{I_{\mu}U_{em}}U_{em}^{L}(p)}{1+p(T_{\mu}+T_{ee}+T_{em})}=\frac{pG_{em}^{L}C_{\mu 0}^{L}K_{I_{em}U_{\mu m}}K_{I_{\mu}U_{em}}U_{em}^{L}(p)}{1+p(T_{\mu}+T_{эе}+T_{эм})}-$$
$$-\frac{pG_{em}^{L}K_{I_{em}U_{\mu m}}K_{I_{\mu}U_{em}}K_{Q_{\mu\Sigma}C_{\mu\delta}}Q_{\mathrm{m}}(p)U_{em}^{L}(p)}{1+p(T_{\mu}+T_{ee}+T_{em})}=\frac{pk_1U_{em}^{L}(p)}{1+pT_{e\mu}}-\frac{pk_2Q_{\mathrm{m}}(p)U_{em}^{L}(p)}{1+pT_{e\mu}} \qquad (14)$$

here is $k_1=G_{em}^{L}C_{\mu 0}^{L}K_{I_{em}U_{\mu m}}K_{I_{\mu}U_{em}}$; $k_2=G_{em}^{L}K_{I_{em}U_{\mu m}}K_{I_{\mu}U_{em}}K_{Q_{\mu\Sigma}C_{\mu\delta}}$; $T_{e\mu}=T_{\mu}+T_{ee}+T_{em}$.

Generated 14 expresses the corner shift transmitter function for recording the source voltage or the measured angular shift. Since the generated MES and DP corner transmitters have two exciting displays, the first complementary compensation generated in equation 14 is compensated. Therefore, when studying a dynamic regime, it is possible to limit the consideration of the second interlocutor of the phrase 14.

In order to study the dynamic properties of the generated converters, we will investigate the following variable-sized magnitudes [2]:

1. Angular shielded and rounded corner shift sensor with sinusoidal voltage $U_{em}=U_{em}\sin\omega_{э}t$ connected to the source and continuously shifting to effect it $Q_{\mathrm{m}}=const$. 14 - statement $Q_{\mathrm{m}}(p)=Q_{\mathrm{m}}$ and $U_{em}^{L}(p)=\frac{U_{emm}\omega_e}{p^2+\omega_e^2}$ setting this equality, Laplace reverse changes through the use of the original output voltage is created as follows:

$$U_{emea}^{L}(p)=\frac{pk_2Q_{\mathrm{m}}U_{emm}\omega_e}{(1+pT_{e\mu})(p^2+\omega_e^2)}=\frac{F_1(p)}{F_2(p)}\risingdotseq U_{emea}^{L}(t)=\sum_{k=1}^{3}\frac{F_1(p_k)}{F_2(p_k)}e^{p_kt}=A_1e^{-\frac{t}{T_{e\mu}}}+A_2\sin(\omega_et+\varphi_e), \qquad (15)$$

Here is $A_1=\frac{k_2Q_{\mathrm{m}}U_{emm}\omega_e}{1+(\omega_eT_{e\mu})^2}$; $A_2=\frac{k_2Q_{\mathrm{m}}U_{emm}\omega_e}{\sqrt{1+(\omega_eT_{e\mu})^2}}$; $\varphi_e=arctg\frac{1}{\omega_eT_{e\mu}}$.

The analysis of 15-matter indicates that the amplitude and phase of the output voltage are the frequency of the source voltage dependent on the ω_e. After a shift of the exponential transient of the angle changeover output voltage, a fixed process is defined by the second addition of the expression 14. The frequency of the source voltage is large $\omega T_{e\mu}>>1$ the transformed transformation will change from the differentiating domain to the proportional one.

2. Overwhelmed filing a movable screens and batch parameters angle converters connected to a constant voltage source $U_{em}=const$ and transformers effect to part of the moving unit $Q_{\mathrm{m}}(t)=Q_{\mathrm{m}}1(t)$. First of all, it should be noted, if $U_{em}=const$ and $\omega=0$ in the $U_{emea}^{L}(p)$ expressions $U_{em}^{L}(p)$ counted as constant coefficient U_{em}. According to the Laplace Replacement Schedule $Q_{\mathrm{m}}(t)=Q_{\mathrm{m}}1(t)$ unit represents the function of $Q_{\mathrm{m}}(p)=\frac{Q_{\mathrm{m}}}{p}$.

In 14 - expression $U_{em}^{L}(p)=U_{em}$ and $Q_{\mathrm{m}}(p)=\frac{Q_{\mathrm{m}}}{p}$ by passing equations and moving to the original, we get the following result:

$$U_{emea}^{L}(t)=\frac{k_2Q_mU_{em}}{T_{e\mu}}e^{-\frac{t}{T_{e\mu}}}. \qquad (16)$$

(16) expression analysis of the output signal power (T_{em}, T_{ee}) and magnetic (T_{μ}) the duration of the chains, (U_{em}) the supply voltage, (Q_m). The output signal related to the progress and the mechanical time constant, ($T_{e\mu}$) which is the value of the exponential law can be seen to reduce zero (Fig. 3) [5].

3. A movable screens and batch parameters angle converters connected to a constant voltage source $U_{em} = const$ and transformers part of the growing shift from linear effect $Q_{\mathrm{m}}(t) = Q_{\mathrm{m}}t$. For this case we'll have the following equality $U^{L}_{em}(p) = U_{em}$ and $Q_{\mathrm{m}}(p) = \frac{Q_{\mathrm{m}}}{p^2}$. By following the last equations in expression 14, we obtain the following result:

$$U^{L}_{emea}(p) = \frac{k_2 Q_m U_{em}}{p(1+pT_{e\mu})} \risingdotseq U^{L}_{emea}(t) = \frac{k_2 Q_m U_{em}}{T_{e\mu}}(1 - e^{-\frac{t}{T_{e\mu}}}) = U^{L}_{emea.o}(1 - e^{-\frac{t}{T_{e\mu}}}) . \quad (17)$$

Equation 17 shows that CSHC's output signal will grow according to exponential law $U^{L}_{emea.o}$ and will try to achieve its own stable value.

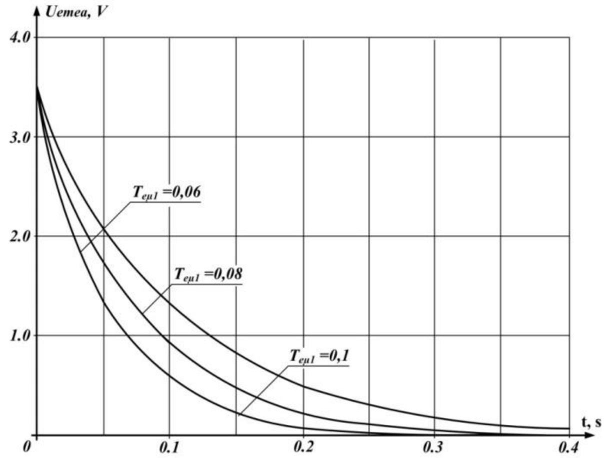

Fig. 3. ***Created CSHC's curve of the transient process***
($U_{em} = const$ and the input size changes to the jump).

4. A movable screens and batch parameters angle converters connected to a sinusoidal voltage source $U_{em}(t) = U_{emm}\sin\omega_e t$ and transformers part of the unit will affect progress $Q_{\mathrm{m}}(t) = Q_{\mathrm{m}}1(t)$ [3].

In this case, it is easy to use the transferring transponder function and it will look like the following:

$$W(p) = \frac{U^{L}_{emea}(p)}{U^{L}_{em}(p)} = \frac{pk_2 Q_m(p)}{1+pT_{e\mu}} = \frac{k_2 Q_m}{1+pT_{e\mu}} \risingdotseq \frac{U^{L}_{emea}(t)}{U^{L}_{em}(t)} = \frac{k_2 Q_m}{T_{e\mu}} e^{-\frac{t}{T_{e\mu}}} , \quad (18)$$

Here, the expression of the voltage output voltage is determined as follows (Fig. 4) [5]:

$$U^{L}_{emea}(t) = U^{L}_{em}(t)\frac{k_2 Q_m}{T_{e\mu}} e^{-\frac{t}{T_{e\mu}}} = \frac{k_2 Q_m U_{emm}}{T_{e\mu}} e^{-\frac{t}{T_{e\mu}}} \sin\omega_e t . \quad (19)$$

5. A movable screens and batch parameters angle converters connected to a sinusoidal voltage source $U_{em}(t) = U_{emm}\sin\omega_e t$ and transformers part of the linear growing influenceto $Q_{\mathrm{m}}(t) = Q_{\mathrm{m}}1(t)$. According to the Laplace Replacement Schedule we have the following equality $Q_{\mathrm{m}}(p) = \frac{Q_{\mathrm{m}}}{p^2}$. For this case, the transfer function is written as follows:

$$W(p) = \frac{U^{L}_{emea}(p)}{L^{-1}\{U^{L}_{em}(t)\}} = \frac{k_2 Q_m}{p(1+pT_{e\mu})}. \quad (20)$$

Original:

$$W(t) = k_2 Q_m(1 - e^{-\frac{t}{T_{e\mu}}}). \quad (21)$$

The output power of the changeover will be as follows:

$$U^L_{emea}(t)=W(t)U^L_{em}(t)=k_2Q_mU_{emm}\sin\omega_e t-k_2Q_mU_{emm}e^{-\frac{t}{T_{e\mu}}}\sin\omega_e t \qquad (22)$$

6. A movable screens and batch parameters angle converters connected to a sinusoidal voltage source $U_{em}(t)=U_{emm}\sin\omega_e t$ and the entrance of transformers connected to the source of the sinusoidal effects it $Q_m(t)=Q_{mm}\sin\omega_e t$ [4]. For this case, the transmission function and its origin are as follows:

$$W(p)=\frac{U^L_{emea}(p)}{L^{-1}\{U^L_{em}(t)\}}=\frac{k_2Q_{mm}\omega_m}{(1+pT_{m\mu})(p^2+\omega_m^2)}\doteqdot\frac{k_2Q_{mm}\omega_m}{1+(\omega_mT_{e\mu})^2}e^{-\frac{t}{T_{e\mu}}}+\frac{k_2Q_{mm}\omega_m}{\sqrt{1+(\omega_mT_{e\mu})^2}}\sin(\omega_m+\varphi_m) \qquad (23)$$

here is $\varphi_m=arctg\,\dfrac{1}{\omega_mT_{e\mu}}$.

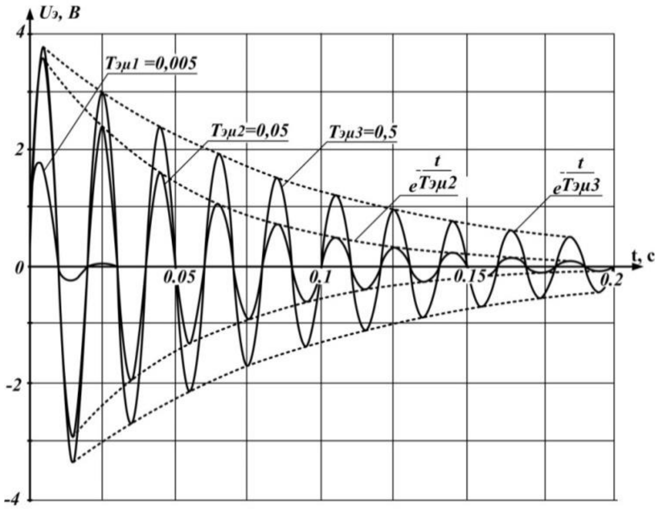

Fig. 4. ***Created CSHC's curve of the transient process***
($U_{em}(t)=U_{emm}\sin\omega_e t$, $Q_m(t)=Q_m1(t)$ *on conditions).*

Output voltage is defined as follows:

$$U^L_{emea}(t)=W(t)U^L_{em}(t)=\frac{k_2Q_mU_{emm}\omega_м}{1+(\omega_mT_{e\mu})^2}e^{-\frac{t}{T_{e\mu}}}\sin\omega_e t+\frac{k_2Q_mU_{emm}\omega_m}{\sqrt{1+(\omega_mT_{e\mu})^2}}\{\cos[(\omega_e-\omega_m)t-\varphi_m]-$$
$$-\cos[(\omega_e+\omega_m)t+\varphi_m]\}=U^L_{emea1}(t)+U^L_{emea2}(t)+U^L_{emea3}(t) \qquad (24)$$

According to the expression of 24 $U^L_{emea}(t)=f(t)$ change in a curve is given in Fig. 5 [5].

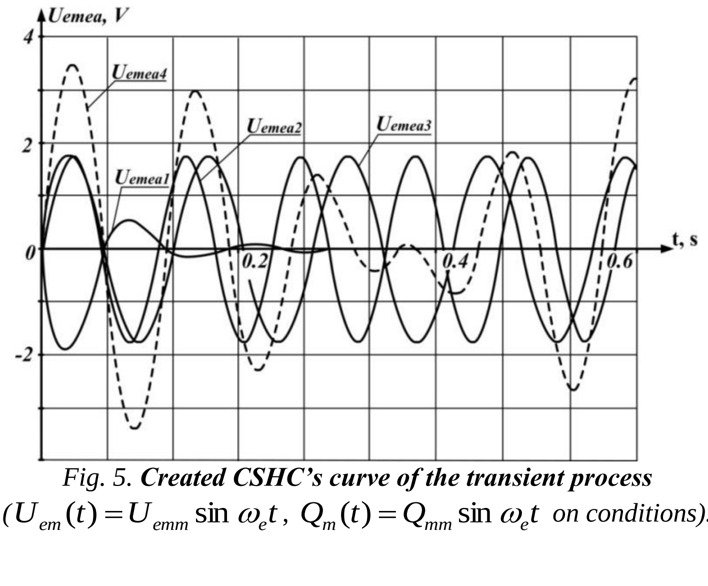

Fig. 5. ***Created CSHC's curve of the transient process***
($U_{em}(t)=U_{emm}\sin\omega_e t$, $Q_m(t)=Q_{mm}\sin\omega_e t$ *on conditions).*

Conclusion

Thus, the study of the dynamic regimes of the new MES and DP CSHC's by different input magnitudes indicates that the converters can be clearly distinguished in the structure of the system, and in the case of the high frequency of the source voltage, in the form of proportional representation.

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