CREATION OF DYNAMIC MODEL OF SYSTEM OF STABLE FLIGHT CONTROL IN PLANES WITH THE AUTOPILOT

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The carried out researches show that occurrence of mechanical fluctuations in a fuselage at change of speed is one of lacks arising during performance of tasks of flight in planes with the autopilot. The first harmonic is the most operating from these mechanical fluctuations, the frequency of this harmonics is rather small and the amplitude is big. For the purpose of elimination of this problem in planes with the autopilot has been used the stabilising gyrocompass and has been created the automatic control system of planes with stabilising gyrocompass. The block diagramme of such control system is shown in figure 1.

Transfer functions of links of the block diagramme are resulted as following.

Taking into consideration the first harmonic of mechanical fluctuations arising during flight transfer function of the plane can be written down in the following form:

$$W_t(p) = \frac{k_{\delta_b}^{\phi}\left(T_c p + 1\right)}{p\left(T^2 p^2 + 2\xi T p + 1\right)} + \frac{k_1}{p^2 + \omega_1^2}$$

Part of the block diagramme in the figure 1, concerning to this transfer function is shaded. The transfer function of the steering machine is:

$$W_{sm}(p) = \frac{k_{sm}}{T_{sm}^2 p^2 + 2\xi_{sm} T_{sm} p + 1},$$

The transfer function of gyroscope which is dempfering mechanical fluctuations arising in a fuselage:

$$W_{st.g}(p) = \frac{k_{dg}}{T_{dg}^2 p^2 + 2\xi_{dg} T_{dg} p + 1},$$

Transfer function of a gyroscope defining a course is:

$$W_{cg}(p) = \frac{U_{cg}(p)}{\tilde{\psi}(p)} = k_{cg}$$

Transfer functions of the correcting devices:

$$\begin{cases} W_{c1}(p) = \dfrac{U_{c1}(p)}{U_{dg}(p)} = \dfrac{T_1 p + 1}{T_2 p + 1} \\ W_{c2}(s) = \dfrac{U_{c2}(p)}{U_{cg}(p)} = \dfrac{T_3 p + 1}{T_4 p + 1} \end{cases}$$

Transfer functions of the intensifying device:

$$W_g(p) = \frac{U_g(p)}{U_e(p)} = k_g$$

For formation of the closed system is used the following equation:

$$U_e(p) = U_t(p) - U_{c1}(p) - U_{c2}(p)$$

Converter:

$$W_c(p) = \frac{k_c}{(T_c p + 1)(T_{IPMS} p + 1)} \approx \frac{k_c}{1 + \tau p}$$

Where: $\tau = T_c + T_{IPMS}$, $T_c = \dfrac{1}{mf}$, f–is frequency , m-number of phases.

Transfer functions rather opposition moment is:

$$W_{om}(p) = \frac{n(p)}{M(p)} = \frac{k_m(1+T_1 p)}{T_m T_1 p^2 + T_m p + 1}$$

Transfer functions of the rectifier:

$$W_{rect}(p) = \frac{U_d(p)}{U_{gyrosc}(p)} = k_{rect}$$

Transfer functions of the operational amplifier:

$$W_{\mathrm{OA}}(p) = \frac{U_G(p)}{U_в(p)} = k_{amp}$$

Transfer functions of the rheostat:

$$W_{rheostat}(p) = \frac{U_r(p)}{x(p)} = k_{rheos}$$

Transfer functions of the reducer and the hydraulic device are:

$$W_{red}(p) = k_{red}$$

$$W_{h.d}(p) = k_{h.d}$$

In the figure 1 is shown the scheme of automatic control of the plane with the autopilot. Using transfer functions of links it is possible to write down the general transfer function concerning the simplified block diagramme.

To receive the general transfer function we must accept some simplifications:

$$W_t' = \frac{1}{p} + \frac{k_1}{p^2+\omega_1^2} = \frac{(p^2+\omega_1^2) + k_1 p}{p(p^2+\omega_1^2)}$$

$$W_0 = \frac{W_{hd} W_{red} W_{TC}}{1 + W_{hd} W_{red} W_{TC} W_{rheos}} = \frac{k_{hd} \cdot k_{red} \cdot k_c}{1 + \tau p + k_{hd} \cdot k_{red} \cdot k_c \cdot k_{rheos}}$$

$$W_1 = \frac{1}{s} W_{con1} W_{stab.dev} W_{plane}$$

$$W_1' = \frac{W_{plane}}{1 + W_1} =$$

$$= \frac{p(T_m T_1 p^2 + T_m p + 1)\left(k_{\delta_b}^{\phi}(T_c p+1)(p^2+\omega_1^2) + k_1 p(T^2 p^2 + 2\xi T p + 1)\right)}{p^2(T_m T_1 p^2 + T_m p + 1)(T^2 p^2 + 2\xi T p + 1)(p^2+\omega_1^2) + k_{con1} k_m (1+T_1 p)\left(k_{\delta_b}^{\phi}(T_c p+1)(p^2+\omega_1^2) + k_1 p(T^2 p^2 + 2\xi T p + 1)\right)}$$

$$W_2 = W_{sm} W_{con2} W_0 W_{rect} \frac{1}{W_{sg}} W_1'$$

$$W_2' = \frac{W_1'}{1 + W_2} = \frac{W_1'}{1 + \dfrac{k_{con2} \cdot k_{rect} \cdot k_{sm} \cdot k_{hd} \cdot k_{red} \cdot k_c}{k_{sg}(T_{sm}^2 p^2 + 2\xi_{sm} T_{sm} p + 1)(1 + \tau p + k_{hd} \cdot k_{red} \cdot k_c \cdot k_{rheos})} \cdot W_1'}$$

$$W_3' = W_{amp} W_{sm} W_2' = \frac{k_{amp} \cdot k_{sm}}{T_{sm}^2 p^2 + 2\xi_{sm} T_{sm} p + 1} \cdot W_2'$$

$$W_4' = \frac{W_3'}{1 + W_3'\left(W_{con2}W_{sg} + W_{con1}W_{st.g}W_{plane}'\right)} =$$

$$= \frac{W_3'}{1 + \left(\dfrac{k_{sg}(T_3p+1)}{(T_4p+1)} + \dfrac{k_{dg}(T_1p+1)\left((p^2+\omega_1^2)+k_1p\right)k_{dg}(T_1p+1)}{p(p^2+\omega_1^2)(T_{dg}^2p^2+2\xi_{dg}T_{dg}p+1)(T_2p+1)}\right)W_3'}$$

$$W_{general} = W_4'W_{con1}W_{st.m} = \frac{k_{con1}\cdot k_m(1+T_1p)}{T_mT_1p^2+T_mp+1}W_4' \tag{1}$$

The equation (1) expresses dynamic model of a control system of flight providing stability and compensating mechanical fluctuations arising during flight of the plane with the autopilot.

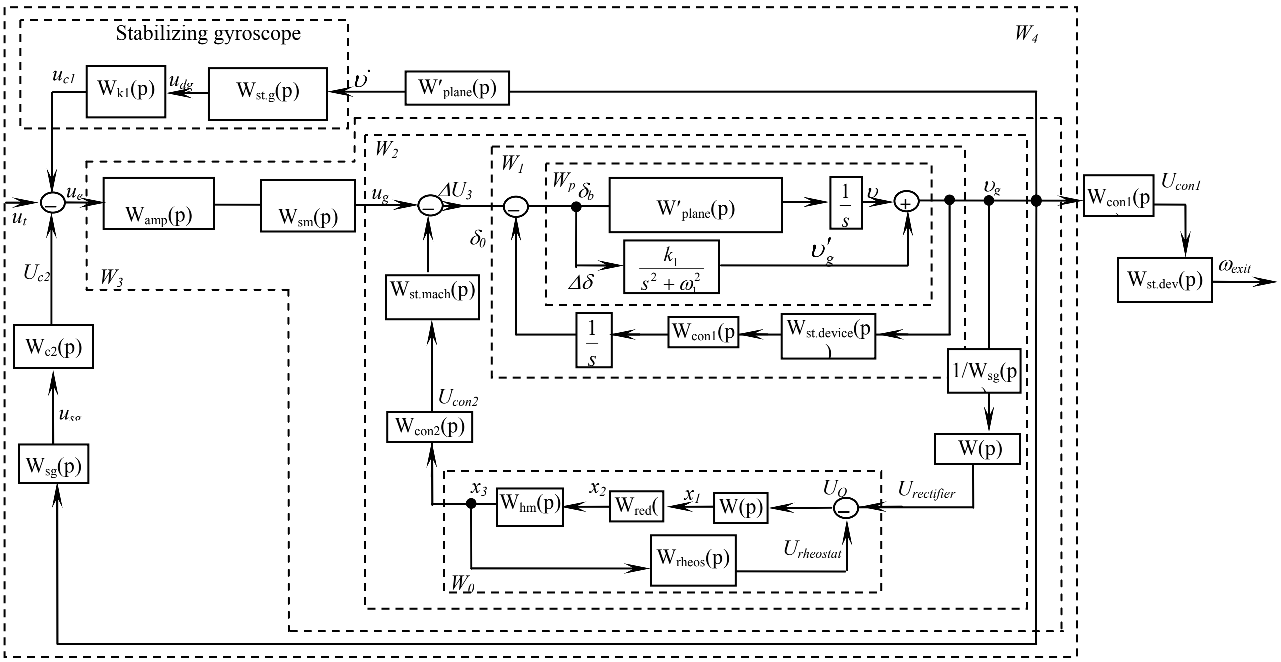

Fig. 1. The general block -diagramme of simplified dynamic model of a plane with the autopilot

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