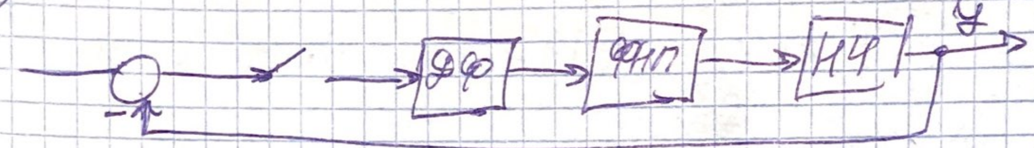
1)



$k=2$; $t_p \le 1$; $T=0{,}01$

$$W_н = \frac{s+12}{(s-5)(s+8)} \text{ — НЧ} \qquad W_ф(s) = \frac{1-e^{-Ts}}{s} \text{ — ФНП}$$

$$W_п(s) = W_ф \cdot W_н = \frac{1-e^{-Ts}}{s} \cdot \frac{s+12}{(s-5)(s+8)}$$

$$W^*_н(s) = Z_T\{W_п\} = \frac{z-1}{z} \cdot Z_T\left\{\frac{W_н(s)}{s}\right\} =$$

$$= \frac{z-1}{z} \cdot Z_T^{(1)}\left\{\frac{s+12}{s(s-5)(s+8)}\right\}$$

~~[illegible]~~. Сумма простейших:

$$\frac{s+12}{s(s-5)(s+8)} = \frac{A}{s} + \frac{B}{s-5} + \frac{C}{s+8} \Rightarrow$$

$$\Rightarrow \quad s+12 = A(s-5)(s+8) + Bs(s+8) + Cs(s-5)$$

$s=5$: $\quad 17 = B \cdot 5 \cdot 13 \Rightarrow 17 = 65B \Rightarrow B = \frac{17}{65}$

$s=-8$: $\quad 4 = C \cdot (-8) \cdot (-13) \Rightarrow 4 = 104C \Rightarrow C = \frac{1}{26}$

$s=0$: $\quad 12 = A \cdot (-5) \cdot 8 \Rightarrow 12 = -40A \Rightarrow A = -\frac{3}{10}$

$$(1) = Z_T\left\{-\frac{3}{10} \cdot \frac{1}{s} + \frac{17}{65}\frac{1}{s-5} + \frac{1}{26} \cdot \frac{1}{s+8}\right\} =$$

$$= -\frac{3}{10} \cdot \frac{z}{z-1} + \frac{17}{65}\frac{z}{z-e^{5T}} + \frac{1}{26}\frac{z}{z-e^{-8T}}$$

2)

$$W_{\Pi}^{*}(s) = \frac{\cancel{z-1}}{\cancel{z}}\cdot\left(-\frac{3}{10}\cdot\frac{\cancel{z}}{\cancel{z-1}}+\frac{17}{65}\frac{\cancel{z}}{z-e^{5T}}+\frac{1}{26}\frac{\cancel{z}}{z-e^{-8T}}\right)=$$

$$=\left(-\frac{3}{10}+\frac{17}{65}\cdot\frac{z-1}{z-e^{5T}}+\frac{1}{26}\cdot\frac{z-1}{z-e^{-8T}}\right)=$$

= ... раскроем скобки и приведём к общему зн-лю ... =

$$=\frac{650e^{-8T}z+5060e^{5T}z-5070z-5070e^{-3T}+4420e^{-8T}+10e^{5T}}{16900\left(z^{2}-ze^{-8T}-ze^{5T}+e^{-8T}\right)}=W_{\Pi}^{*}(z)$$

$$=\frac{65e^{-8T}z+506e^{5T}z-507z-507e^{-3T}+442e^{-8T}+e^{5T}}{1690\left(z^{2}-ze^{-8T}-ze^{5T}+e^{-8T}\right)}$$

3)

Синтез регулятора

$$W_н(s) = \frac{s+12}{(s-5)(s+8)}$$

$$W(s) = \frac{\beta^+(s)\cdot\beta^-(s)}{\alpha^+(s)\cdot\alpha^-(s)}$$

$\alpha^+(s) = s-5$ $\qquad$ $\beta^+(s) = 1$

$\alpha^-(s) = s+8$ $\qquad$ $\beta^-(s) = s+12$

$r = 2$ – порядок астатизма

$t_p \leq 1$

$k = 0$ – кратность полюса $s=0$

$\nu = r-k = 2$

$n_\alpha = 2$ $\qquad$ $n_\beta = 1$

$n_{\alpha^+} = 1$ $\qquad$ $n_{\beta^+} = 0$

$n_{\alpha^-} = 1$ $\qquad$ $n_{\beta^-} = 1$

$n_\gamma \geq n_{\alpha^+} + \nu - 1 - n_{\beta^-} + n_\alpha$

$n_\gamma \geq 1 + 2 - 1 - 1 + 2$

$n_\gamma \geq 3$

Пусть $n_\gamma = 3$

4)

$$\begin{cases} n_{\alpha^-} + n_M \leq n_{\beta^-} + n_N + 2\varrho \\ n_\gamma \leq n_N + n_M + 1 \\ n_\gamma = n_N + n_{\alpha^+} + 2\varrho \end{cases}$$

$$\begin{cases} 1 + n_M \leq 1 + n_N + 2 \\ 3 \leq n_N + n_M + 1 \\ 3 = n_N + 1 + 2 \end{cases} \Rightarrow$$

$n_N = 0$

$$\left.\begin{array}{l} 3 \leq n_M + 1 \\ 1 + n_M \leq 3 \end{array}\right\} \Rightarrow \begin{cases} 2 \leq n_M \\ n_M \leq 2 \end{cases} \Rightarrow n_M = 2$$

$\gamma(s) = \gamma_3 s^3 + \gamma_2 s^2 + \gamma_1 s + \gamma_0$

$N(s) = N_0$

$M(s) = M_2 s^2 + M_1 s + M_0$

$\gamma(s) = \beta^+(s) \cdot M(s) + \alpha^+(s) \cdot s^{2\varrho} \cdot N(s) =$

$= M_2 s^2 + M_1 s + M_0 + (s-5) \cdot s^2 \cdot N_0 =$

$= M_2 s^2 + M_1 s + M_0 + N_0 s^3 - 5 N_0 s^2 =$

$= N_0 s^3 + s^2 (M_2 - 5N_0) + M_1 s + M_0$

5)

$\gamma_3 = N_0$; $\gamma_2 = (M_2 - 5N_0)$; $\gamma_1 = M_1$; $\gamma_0 = M_0$

В кач-ве стандартной ПФ выберем нормированную ПФ с одинаковыми полюсами порядка 3:

$$W(q) = \frac{1}{(q+1)^3} = \frac{1}{q^3 + 3q^2 + 3q + 1}$$

При $n = 3$ имеем $\tau_p = 6{,}2 \Rightarrow \alpha = \frac{t_p}{\tau_p} = \frac{1}{6{,}2}$

$$\left.\begin{array}{l|l} \gamma_3 & a_0 = \alpha^3 = \frac{1}{6{,}2^3} \\ \gamma_2 & a_1 = \alpha^2 \cdot 3 = \frac{3}{6{,}2^2} \\ \gamma_1 & a_2 = \alpha \cdot 3 = \frac{3}{6{,}2} \\ \gamma_0 & a_3 = 1 \end{array}\right\} \Rightarrow \gamma(s) = \frac{1}{6{,}2^3} s^3 + \frac{3}{6{,}2^2} s^2 + \frac{3}{6{,}2} s + 1$$

$$\begin{cases} N_0 = \frac{1}{6{,}2^3} \\ M_2 - 5N_0 = \frac{3}{6{,}2^2} \Rightarrow M_2 = \frac{3}{6{,}2^2} + \frac{5}{6{,}2^3} \\ M_1 = \frac{3}{6{,}2} \\ M_0 = 1 \end{cases}$$

$$N(s) = \frac{1}{6{,}2^3}$$

$$M(s) = \frac{3}{6{,}2^2} s^2 + \frac{5}{6{,}2^3} s^2 + \frac{3}{6{,}2} s + 1 =$$

$$= \left(\frac{3}{6{,}2^2} + \frac{5}{6{,}2^3}\right) s^2 + \frac{3}{6{,}2} s + 1$$

6)

$$R(s) = \frac{\alpha^- \cdot M}{\beta^- \cdot N \cdot s^{2e}} =$$

$$= \frac{(s+8) \cdot \left[\left(\frac{3}{6{,}2^2} + \frac{5}{6{,}2^3}\right) s^2 + \frac{3}{6{,}2} s + 1\right]}{(s+12) \cdot \frac{1}{6{,}2^3} \cdot s^2}$$

7) ~~Пере~~ Дискретизация $R(s)$

$$R(s) = \frac{(s+8)\cdot\left[\left(\frac{3}{6{,}2^2}+\frac{5}{6{,}2^3}\right)s^2 + \frac{3}{6{,}2}s + 1\right]}{(s+12)\cdot\frac{1}{6{,}2^3}\cdot s^2}$$

$$R^*(z) = Z_T\{W_\phi \cdot R\} = \frac{z-1}{z}\cdot Z_T\left\{\frac{R}{s}\right\}$$

$$Z_T\left\{\frac{R}{s}\right\} = Z_T\left\{\frac{(s+8)\cdot\left[\left(\frac{3}{6{,}2^2}+\frac{5}{6{,}2^3}\right)s^2+\frac{3}{6{,}2}s+1\right]}{\frac{1}{6{,}2^3}\cdot s^3(s+12)}\right\} =$$

= ... разложение дроби на сумму простейших ... =

$$= Z_T\left\{\frac{992789}{12869712}\cdot\frac{1}{s} + \frac{391}{1116}\cdot\frac{1}{s^2} + \frac{8}{12}\cdot\frac{1}{s^3} + \frac{281611}{12869712}\cdot\frac{1}{s+12}\right\} =$$

$$= \frac{992789}{12869712}\cdot\frac{z}{z-1} + \frac{391}{1116}\cdot\frac{Tz}{(z-1)^2} + \frac{8}{12}\cdot\frac{1}{2}\cdot\frac{T^2 z(z+1)}{(z-1)^3} +$$

$$+ \frac{281611}{12869712}\cdot\frac{z}{z-e^{-12T}} \Rightarrow$$

$$\Rightarrow R^*(z) = \frac{992789}{12869712} + \frac{391}{1116}\cdot\frac{T}{z-1} + \frac{8}{24}\cdot\frac{T^2(z+1)}{(z-1)^2} +$$

$$+ \frac{281611}{12869712}\cdot\frac{z-1}{z-e^{-12T}}$$