A Simulation of I-PDA Controller for Induction Motor

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Abstract:PID controller is applied mostly to two-order system. In third-order or higher- system, it's impossible to get high response quality because of having more zero point than the number of zero point being in the PID controller. To solve those, Jung & Dorf suggested a new type of PIDA controller and solved problen of a third-order system.. But, as the result of getting step response using PIDA controller, rising time is very quickly but wide overshoot is happened. Beside designing PIDA controller with using CDM(Coefficient Diagram Method) of Shunji Manabe decreases overshoot to desired but rising time is very slow. Therefore this paper suggest a I-PDA controller for low overshoot and fast responsibility. This paper applied designed PD-PIDA controller to position control of 3-Phase induction motor.

Keywords: PIDA, CDM, Induction Motor, Jung&Drof

1. INTRODUCTION

PID controller is applied mostly to two-order system. In third-order or higher- system, it's impossible to get high response quality because of having more zero point than the number of zero point being in the PID controller. To solve those, Jung & Dorf suggested a new type of PIDA controller and solved problem of a third-order system. That is, We can take desired PIDA controller, if designed characteristic equation and system transfer function containing controller is solved and they are considered as equal wanted PIDA controller can be designed. But, as the result of getting step response using PIDA controller, rising time is very quickly but wide overshoot is happened. Also, In case of designing PIDA controller using CDM method suggested by Shunji Manabe, CDM decreases overshoot that desired in response but rising time is very slow. And Mathematical definition of stability exponents (γi), equivalent exonents using in CDM is not precise because of that is empirical value. Therefore this paper suggest a I-PDA controller for low overshoot and fast responsibility. This paper applied designed PD-PIDA controller to position control of 3-Phase induction motor.

2. DESIGN OF I-PDA CONTROLLER

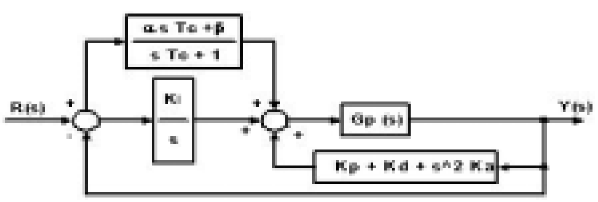

Fig. 1. A structure of I-PDA control system with FFC

Controller designed by CDM has safety and strength to step response. Fig. 1. is structure of I-PDA control system. A CDM to SISO(Single-Input Single-Output). system transfer function for each block's polynomial is same to equation (1a), (1b)

$$\mathrm{G_D}(s) = P_k s^k + P_{k-1}s^{k-1} + \cdots + P_0 \qquad (1a)$$

$$G_N(s) = q_m s^m + q_{m-1}s^{m-1} + \cdots + q_0 \qquad (1b)$$

Controller's polynomail is same to equation (2a), (2b).

$$C_D(s) = l_\lambda s^\lambda + l_{\lambda-1}s^{\lambda-1} + \cdots + l_0 \qquad (2a)$$

$$G_N(s) = k_\lambda s^\lambda + k_{\lambda-1}s^{\lambda-1} + \cdots + k_0 \qquad (2b)$$

$$C_0(s) = k_0 \qquad (2c)$$

In equation (1) and (2), $G_D(s)$: a denominator system, $G_D(s)$: a numerator of system, : $C_D(s)$: a denominator of controller, $C_N(s)$: a numerator of controller.

Where, $\lambda < k$, $m < k, C_0(s)$ is selected k_0 . Specific polynomial of control system is same to equation (3) shown Fig. 1.

$$\begin{aligned} P(s) &= C_D(s)G_D(s) + C_N(s)G_N(s) \\ &= a_n s^n + a_{n-1}s^{n-1} + \cdots + a_0 \\ &= \sum_{i=0}^{n} a_i s^i \end{aligned} \qquad (3)$$

Where, $a_0, a_1, \cdots, a_n$ is coefficients of sfecific polynomial. A safety exponent γ_i, equivalence time constant τ , and limit exponent of safety γ_i^* .

$$\gamma_i = \frac{a_i^2}{a_{i+1}a_{i-1}} \qquad (4)$$

(only, where $i = n-1$)

$$\tau = \frac{a_1}{a_0} \quad (5)$$

$$\gamma_i^* = \frac{1}{\gamma_{i+1}} + \frac{1}{\gamma_{i-1}} : \gamma_0, \gamma_n = \infty \quad (6)$$

From above equation, standard value of safety exponent and equivalence time constant is selected,

$$t_s = 2.5\tau \sim 3\tau \quad (7)$$

$$\gamma_{n-1} = \cdots = \gamma_3 = \gamma_2 = 2, \gamma_1 = 2.5 \quad (8)$$

Customary Transfer function of PIDA controller $C(s)$ is same to eqation (9).

$$C(s) = K_P + \frac{K_I}{s} + K_D s + K_A s^2 \quad (9)$$

$$C(s) = \frac{k_3 s^3 + k_2 s^2 + k_1 s + k_0}{s} \quad (10)$$

where,

$$k_3 = K, k_2 = K(a+b+z), k_1$$
$$= K[(a+b)z + ab],$$
$$k_0 = K(abz)$$

Comparing equation (2a) with (2b), we ca get coefficient of controller $C_D(s)$, $l_3 = l_2 = l_0 = 0$, $l_1 = 1$. Thus, $C_D(s) = s$ and , coefficient of $C_N(s)$ is equal to the other.

3. A SIMULATION RESULT

Figure.2 is system response to input step waveform using The Jung & Dorf method. Big overshot occur in Figure. 2 . Figure. 3 is system response to input step waveform using The Shungji Manabe method and overshot is smaller than Jung & Drof method but long delay time occur. The I-PDA controller of this paper has not overshot and has very fast response.

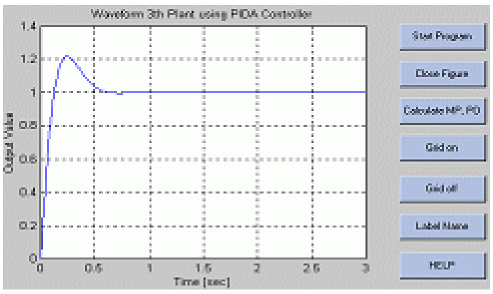

Fig. 2 system response to input step waveform using PIDA controller

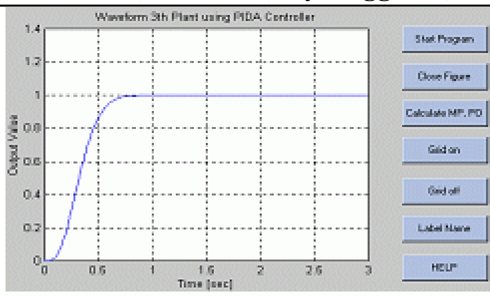

Fig. 3. response to input step waveform using Shunji Manabe

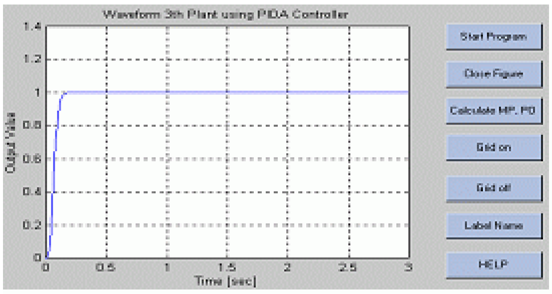

Fig. 4. system response to input step waveform using I-PDA controller

4. CONCLUSIONS

PID controller is applied mostly to two-order system. In third-order or higher- system, it's impossible to get high response quality because of having more zero point than the number of zero point being in the PID controller. To solve those, Jung & Dorf suggested a new type of PIDA controller and solved problen of a third-order system.. But, as the result of getting step response using PIDA controller, rising time is very quickly but wide overshoot is happened. Beside designing PIDA controller with using CDM(Coefficient Diagram Method) of Shunji Manabe decreases overshoot to desired but rising time is very slow. Therefore this paper suggest a I-PDA controller for low overshoot and fast responsibility. This paper applied designed PD-PIDA controller to position control of 3-Phase induction motor.

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