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Design of PI and PID Control System for Induction Motor Control on Gamma Irradiator Characterization Prototype Using a Modified Ziegler-Nichols Method

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Abstract — *The irradiator simulator's induction motor drive control system is carried out to maintain safety and accuracy in the loading/unloading process and product transportation system. Control is done by maintaining the speed of the induction motor at a certain speed so that the travel time for the loading/unloading process is predetermined. This study aims to answer the existing problems using the PI and PID control systems and prove that using the control system will give better results than the current system applications. In this study, the gain configuration for the PI controller that best fits the design requirements is obtained at a Kp value of 0.038, a Ki of 2.18, and a Phase Margin (ϕ_b) of 70°, resulting in a motor rotational speed that can achieve stability at the set point determined by the setting time is 0.90 seconds. The maximum overshoot is 0% and has a steady state error value of 0.00013. Then the gain configuration for the PID controller that best fits the design requirements is obtained at a value of Kp of 0.0066, Ki of 10.85, Kd of 9.9x10-7 and with a Phase Margin (ϕ_b) of 50°, resulting in a motor rotational speed that is high. Able to achieve stability at the specified set point with a setting time of 0.63 seconds and a maximum overshoot of 0%, the steady state error value of 0.00013. From the results obtained, it can be seen that this PI and PID control method can be used as an alternative control system on the induction motor drive system on the irradiator simulator. The controller can control the system according to the specified conditions so that the irradiation process time accuracy improves or increases.*

Keywords: *Gamma Irradiator, Induction Motor, PI, PID*

I. Introduction

Indonesia is a tropical country that is rich in diversity of agricultural products. However, the tropical climate causes agricultural products and processed products to be easily damaged. Or spoilage of food is generally caused by microorganisms due to post-harvest handling and packaging that does not meet the requirements. Utilization of technology through radiation with gamma rays in the right dose can be used for the preservation of agricultural products safely and reliably, without residual radiation or harmful chemical residues. Research related to food irradiation has been developed since 1968, and until now, the research and its application continue to increase. The principle of food preservation is by irradiating the product using gamma rays or other ionizing rays. Exposure energy produced by gamma rays will result in the death of microorganisms that cause food spoilage but do not damage the food itself. In Indonesia, the commercialization of irradiated foodstuffs is based on the regulations of the Minister of Health of the Republic of Indonesia No. 701/MENKES/PER/VIII/2009 [1]. In addition to utilization in agriculture, irradiation technology can also be used for fishery preservation, health sterilization equipment, quality improvement of materials (semiconductors or polymers), and phytosanitary. This irradiation technology is not only cheap but also offers advantages compared to other preservation techniques, such as not requiring chemicals and not causing heat that can damage the material. Although irradiated with gamma rays, the

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irradiated material does not contain any radioactive hazards [1].

BATAN in 2017 has built a Gamma Red and White Irradiator (IGMP) to anticipate the need for the use of gamma irradiators in Indonesia[2]. The IGMP development was carried out with a scheme in which there was a technology transfer process from state vendors with a reverse engineering strategy. This strategy has succeeded in shortening the maturation time of the adopted gamma irradiator technology. The ability to master technology and the power of the national industry to provide gamma irradiator components are benchmarks for the success of technology transfer. The leading indicator of achievement is the achievement of local component content (TKDN) of 85%. One of the most significant components of imported components is the gamma irradiator safety system.

BATAN in 2018 has developed a gamma irradiator simulator that aims to process technology acquisition from IGMP [3]-[4]. This simulator is designed and built for the inside of bunker, which supports the irradiation process. This simulator will be used for various needs, including testing the use of domestic components and training and certification of gamma irradiator officers.

The development of the irradiator simulator is focused on the manufacture of electrical parts (power supply and lighting), mechanical parts (irradiation passage systems, compressor and pneumatic systems, and source lifting systems), dosimetry parts (simulation with MCNP and IGMP dosimetry characterization), as well as instrumentation parts (main panel control module, pneumatic module and related PLC module) [3]-[4]. For details on the development of the instrumentation section, apart from those previously mentioned, it also includes the development of safety systems, one of which is PLC hardware, sensor module construction and irradiation processes, and PLC programming. Instrumentation and control system using PLC and several sensors that are used to operate the irradiator simulator that is connected to pneumatics as a back and forth movement or up and down from the driven tote, so we need a ladder diagram programming of product transportation movements, source rack lifters and loading/unloading using PLCs[5]. In the irradiator simulator, there are 4 product transportation systems, including Loading and unloading, source rack lifters, conveyors and totes in the frame. In this paper, what will be discussed is the design of a controller for an induction motor with a loading/unloading system on an irradiator simulator; the floor plan and working principle of a gamma irradiator is shown in Fig. 1 [6].

The journey of the product when irradiated follows the product transport system. This transportation system is divided into three parts: the loading and unloading section, the bunker feed section (rail system through the maze and goods access), and the Irradiation passage section (source pass mechanism). The loading and unloading section of the tote is an area outside the bunker to prepare to fill the tote with the product to be irradiated and to unload the irradiated product from the tote.

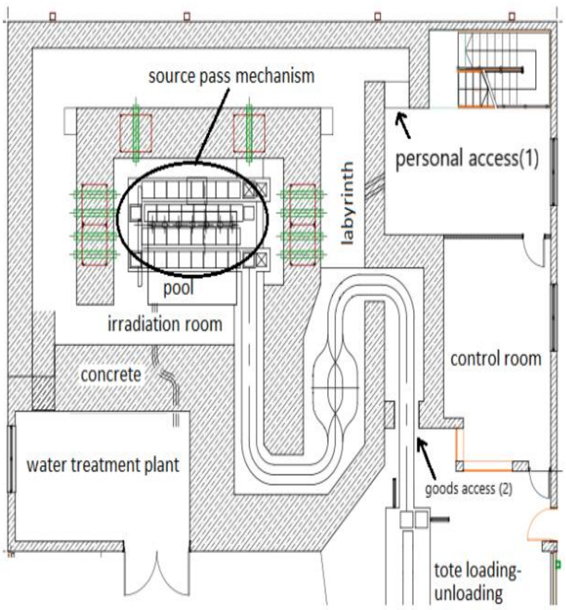

Fig. 1. Working principle of Irradiator [6]

In the bunker feed section, the tote is then sent to the bunker with the product to be irradiated. In this section, the totes are transported by lorries pulled on chains by electric motors. As one tote enters, another tote that has finished irradiating is transported out of the bunker—entrance and exit through the same door (goods access). The tote is in the bunker following the irradiation passage. In this section, the bag surrounds the radiation source to obtain a uniform radiation dose. Dosage uniformity is a critical point. Ideally, the ratio of the maximum amount to the minimum dose is close to 1 [7][8][9].

II. Method

In this section, the methods used to solve the problems that have been described previously will be explained.

The design and simulation of this control begin with tuning the *PI* and *PID* controller parameters, namely *Kp*, *Ki* and *Kd*, then controlling the system so that the system response is obtained with the *PI* and *PID* controllers. The tuning is done by a Modified Ziegler-Nichols method. The design of the induction motor control consists of input values for motor control, *PI* or *PID* control which will control each of the three induction motor state variables to be fed back, as well as the mathematical model of a three-phase motor induction simplification with the Laplace transformation method, from now on referred to as a transfer function, which is used as a plant. A *PI* or *PID* controller will control this transfer function (Fig. 2).

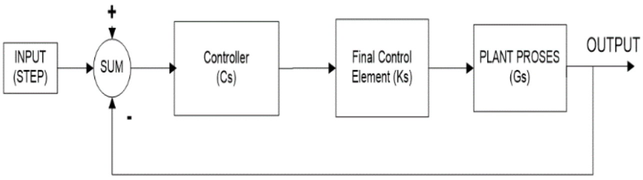

Fig. 2. Block diagram of a three-phase induction motor control system on a Gamma Irradiator Characterization Prototype

II.1. PID controller

PID (Proportional, Integral, Derivative) is controlled with parameters *P*, *I* and *D* with a mathematical model consisting of input Gain + Integral + Derivative [10]. *PID* is a control method with an excellent mathematical model because the error can be changed to near zero, and stability control can be achieved by equating the value of the process variable with the set point value. Although *PID* is a control method that can be said to be superior, the three elements *P*, *I*, and *D*, each of which has advantages and disadvantages, can stand alone or can be paired, which will affect each other to produce the best output signal or controller response from the controlled system. [11].

The definition of *PID(t)* as a result of control output, while as a standard *PID* algorithm is:

$$u(t) = K_p e(t) + K_i \int_0^t e(\tau)dt + K_d \frac{d}{dt} e(t) \qquad (1)$$

Where *e(t)* is the input signal, and u(t) is the output signal. Then, based on Equation (1), the transfer function of the *PID* controller is:

$$G(s) = \frac{U(s)}{E(s)} = K_p + \frac{K_i}{s} + K_d s \qquad (2)$$

II.2. Tuning PID

A Modified Ziegler-Nichols Method. Two classic tuning methods for *PI/PID* controllers were proposed by Ziegler and Nichols [12]. In [13], the Ziegler-Nichols frequency method for obtaining control parameters, the critical point can be defined as the point where the curve intersects the negative axis and is moved to a certain point. In general, which combines the classical ZN tuning method and the ZN frequency method, it was formulated and named by Astrom and Hagglund as the a Modified Ziegler-Nichols (MZN) method [14]. This is briefly described as follows.

Given point A on the Nyquist curve of the process (s): $G(j\omega_0) = r_a e^{j(\pi+\phi_a)}$, Suppose that point A is moved to A1, which is represented by $G_1(j\omega_0) = r_b e^{j(\pi+\phi_b)}$, It is assumed that the PID controller is on the frequency ω_0 is $G_c(s) = r_c e^{j\phi_c}$. Then it can be determined:

$$r_b e^{j(\pi+\phi_b)} = r_a r_c e^{j(\pi+\phi_a+\phi_c)} \qquad (3)$$

So, $r_c = r_b / r_a$ and $\phi_c = \phi_b - \phi_a$. So, based on the above analysis, the PI and PID controllers can be designed as follows.

II.2.1. PI controller

The control system can be designed as follows:

$$K_p = \frac{r_b \cos(\phi_b - \phi_a)}{r_a} \qquad (4)$$

$$T_I = \frac{1}{\omega_0 \tan(\phi_b - \phi_a)} \qquad (5)$$

With a note that $\phi_a > \phi_b$ for T_I positive value. For special conditions, the Ziegler-Nichols algorithm design can be designed with the following formula:

$$K_p = K_c r_b \cos \phi_b \qquad (6)$$

$$T_i = -\frac{T_c}{2\pi \tan \phi_b} \qquad (7)$$

Where,

$$T_c = \frac{2\pi}{\omega_c}; r_a = \frac{1}{K_c}; \text{and } \phi_a = 0$$

II.2.2. PID controller

The control system can be designed as follows:

$$K_p = \frac{r_b \cos(\phi_b - \phi_a)}{r_a} \qquad (8)$$

$$\omega_0 T_d = \tan(\phi_b - \phi_a) \qquad (9)$$

Note that the controller gain value K_p Obtained from equations (4) and (6) are unique, but the value of T_i and T_d is not unique. Additional conditions must therefore be introduced to define these last two parameters uniquely. The general method for determining the relationship between T_i and T_d is as follows:

$$T_i = \frac{1}{2\alpha\omega_0}\left(\tan(\phi_b - \phi_a) + \sqrt{4\alpha + \tan^2(\phi_b - \phi_a)}\right) \quad (10)$$

$$T_d = \alpha T_i \quad (11)$$

Where the recommended value of α is ¼ [14].

The Ziegler – Nichols tuning equation can be rewritten as follows:

$$K_p = K_c r_b cos\phi_b \quad (12)$$

$$T_i = \frac{T_c}{\pi}\left(\frac{1+sin\phi_b}{cos\phi_b}\right) \quad (13)$$

$$T_d = \frac{T_c}{4\pi}\left(\frac{1+sin\phi_b}{cos\phi_b}\right) \quad (14)$$

Where,

$$r_a = \frac{1}{K_c}, \phi_a = 0 \text{ and } \alpha = 1/4$$

It is seen that the *PI* and *PID* controllers can be designed based on the appropriate choice of r_b and ϕ_b. Then what affects the controller design is the selection of suitable values for these two parameters to provide the appropriate performance. Then this *PI* or *PID* controller tuning method is called *"A Modified Tuning Ziegler – Nichols"*.

II.3. Three Phase Induction Motor Modeling

In this induction motor control design, the first step is to do mathematical modelling for the induction motor system. The type of induction motor used in this design is a squirrel cage-type motor. The stator-rotor voltage equation of an induction motor is a function of the stator and rotor currents, as well as a function of the flux involved in the coil. The dynamic analysis process of the induction motor is used to obtain a mathematical model of the induction motor; the following is the reference voltage equation [15]:

$$V_{sd}(t) = R_s i_{sd}(t) - n_p\omega_m(t)\lambda_{sq} + \frac{d}{dt}\lambda_{sd} \quad (15)$$

$$V_{sq}(t) = R_s i_{sq}(t) - n_p\omega_m(t)\lambda_{sd} + \frac{d}{dt}\lambda_{sq} \quad (16)$$

$$V_{rd}(t) = 0$$
$$= R_r i_{rd}(t) - n_p\omega_m(t)\lambda_{rq} + \frac{d}{dt}\lambda_{rsd} \quad (17)$$

$$V_{rq}(t) = 0$$
$$= R_r i_{rq}(t) - n_p\omega_m(t)\lambda_{sq} + \frac{d}{dt}\lambda_{rq} \quad (18)$$

$$V_{rd}(t), V_{rq}(t) = 0$$

The rotary field equation for a squirrel-cage type motor is as follows [13]:

$$\lambda_{sd} = L_s i_{sd}(t) + L_m i_{rd}(t) \quad (19)$$

$$\lambda_{sq} = L_s i_{sq}(t) + L_m i_{rq}(t) \quad (20)$$

$$\lambda_{rd} = L_r i_{rd}(t) + L_m i_{sd}(t) \quad (21)$$

$$\lambda_{rq} = L_r i_{rq}(t) + L_m i_{sq}(t) \quad (22)$$

Where,

V_{rd}, V_{rq} = axis rotor voltage d-q (Volt)
V_{sd}, V_{sq} = axis stator voltage d-q (Volt)
i_{sd}, i_{sq} = Axis stator current d-q (Ampere)
i_{rd}, i_{rq} = Axis rotor current d-q (Ampere)
$\lambda_{rd}, \lambda_{rq}$ = Axis rotor flux d-q (webber)
$\lambda_{sd}, \lambda_{sq}$ = Axis stator flux d-q (webber)
R_r = rotor resistance (Ohm)
R_s = stator resistance (Ohm)
L_r = Rotor inductance (Henry)
L_s = Stator inductance (Henry)
L_m = Magnetic Inductance (Henry)
ω_m = Rotor mechanical rotating speed (rad/s)

Equation (15) and (18) can be described as follows:

$$\frac{d}{dt}i_{sd}(t) = \beta n_p\omega_m(t)\lambda_{rq} + \eta\beta\lambda_{rq}(t) + \frac{1}{\sigma L_s}V_{sd}(t)$$

$$\frac{d}{dt}i_{sq}(t) = -\beta n_p\omega_m(t)\lambda_{rq} + \eta\beta\lambda_{rq}(t) - \gamma i_{sq}(t) + \frac{1}{\sigma Ls}V_{sq}(t)$$

$$\frac{d}{dt}\lambda_{rd}(t) = -n_p\omega_m(t)\lambda_{rq} + \eta\lambda_{rd}(t) + \eta L_m i_{rd}(t)$$

$$\frac{d}{dt}\lambda_{rq}(t) = -n_p\omega_m(t)\lambda_{rq} + \eta\lambda_{rd}(t) + \eta L_m i_{rq}(t)$$

Where,

$$\eta = \frac{R_r}{L_r}; \sigma = 1 - \frac{L_m^2}{L_s L_r}; \beta = \frac{L_m}{\sigma L_s L_r};$$

$$\gamma = \frac{L_m}{\sigma L_r^2} + \frac{R_s}{\sigma L_s}; \mu = n_p\frac{L_m}{J_{eq}L_r}$$

The electromagnetic torque can be described as follows:

$$T_{em} = n_p \frac{L_m}{L_r}(\lambda_{rd} i_{sq}(t) - \lambda_{rq} i_{sq}(t)) \quad (23)$$

The equation for electrodynamics is as follows:

$$J_{eq}\frac{d}{dt}\omega_m(t) = T_{em}(t) - T_b(t) - T_L(t) \quad (24)$$

$$T_b(t) = B_m\omega_m(t) \quad (25)$$

$$\frac{d}{dt}\theta_m(t) = \omega_m(t) \quad (26)$$

Then the transfer function is obtained by making one of the reference voltage inputs, and $T_L(t)$ must be equal to 0 (zero).

From equation (26) above, it is obtained:

$$(J_{eq}s + B_m)\omega_m(t) = T_{em}(t) - T_L(t) \quad (27)$$

$$\omega_m(s) = \frac{T_{em}(s)}{(J_{eq}s+B_m)} = \frac{n_pL_m\left(\lambda_{rd}i_{sd}(s)-\lambda_{rq}i_{sd}(s)\right)}{L_r(J_{eq}s+B_m)} \quad (28)$$

Where,

T_{em} = Electromagnetic torque (N.m)
J_{eq} = Moment of inertia (kg.m^2)
ω_m = rotor mechanical rotation speed (rad/s)
θ_m = angle position (rad)

The parameters or specifications of the three-phase induction motor used to design the model are listed in table 1.

TABLE I
SPECIFICATIONS OF THREE PHASE INDUCTION MOTOR

V	Source voltage	220	$Volt$
p	Pole	4	-
f	Frequency	50	Hz
I_{eq}	Moment of inertia	31,3	$kg.cm^2$
$cos\phi$	Cos phi	0,79	-
P	Power	1,5	kW
HP	Horse Power	2	HP
i	Current	6,3	$Ampere$
rpm	Motor speed	1400	r/min

Furthermore, the comparison of $\omega_m(t)$ as output, $V_{sd}(t)$ and V_{sq} as the input of two orthogonal and polar coordinates and substituting the value of these parameters into the transfer function equation, the following equation is obtained:

$$V_{sd}(t) = n_p\beta\omega_m(t)\lambda_{rq} + \eta\beta\lambda_{rd} + \gamma i_{sd}(t)\frac{d}{dt}i_{sd}(t)\sigma L_s \quad (29)$$

When β, η and γ are substituted into equation (29), then the equation becomes:

$$V_{sd}(t) = n_p\frac{L_m}{L_r}\omega_m(s)\lambda_{rq} + \frac{R_rL_m}{L_r^2}\lambda_{rd} + \left(\frac{L_m}{L_r} + R_s + \sigma L_s s\right)i_{sd}(s) \quad (30)$$

Furthermore, the differential equation for the three-phase induction motor mentioned above is transformed into the Laplace form as obtained from previous studies, which can be seen in equation (31) [16]:

$$\frac{\omega_m(s)}{V_{sd}(s)} = \frac{1.78}{0,72x10^{-3}s^2+0,0157s+3,168}$$

$$G_m(s) = \frac{2470}{s^2+21,79s+4400} \quad (31)$$

III. Results and Discussion

This section will describe the results of the PI and PID control system designers for the induction motor drive system on the irradiator simulator using the A Modified Ziegler-Nichols method and analysis of the performance of the control system results. The transfer function of the plant model used is contained in equation (31). The control system design parameters used are as follows:

Settling time: ≤ 10 s.
Maximum Overshoot: ≤ 20%.
Motor speed set-point: 4.56 rad/s.

III. 1. System Stability Analysis

By using the mathematical model of the three-phase induction motor system in equation (31), then an analysis of the $G_m(s)$ plant mathematical model in the frequency domain is carried out before the control system is given to obtain the transient response and the bode plot as shown in Fig. 3 and 4.

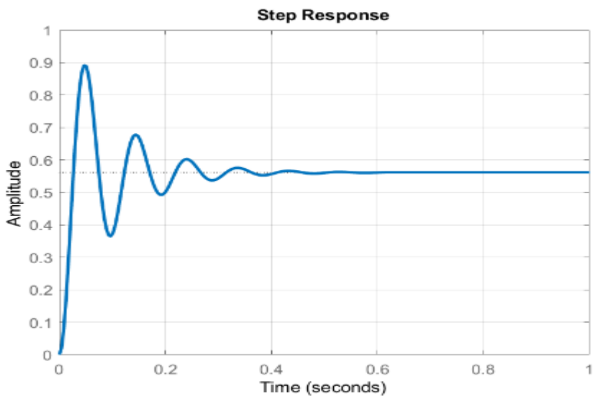

Fig. 3. Transient response of Gm system without a controller

From the bode plot shown in Fig. 4, the Gain margin value is 68.2 dB; Margin frequency: 2520 rad/s; Phase margin: 43.9 deg; Frequency phase: 78,60. Therefore, based on the transient response and the bode plot, it can be seen that the $G_m(s)$

system is stable but cannot reach the setpoint, so we need a control system that can make the system have good stability and can get the specified setpoint.

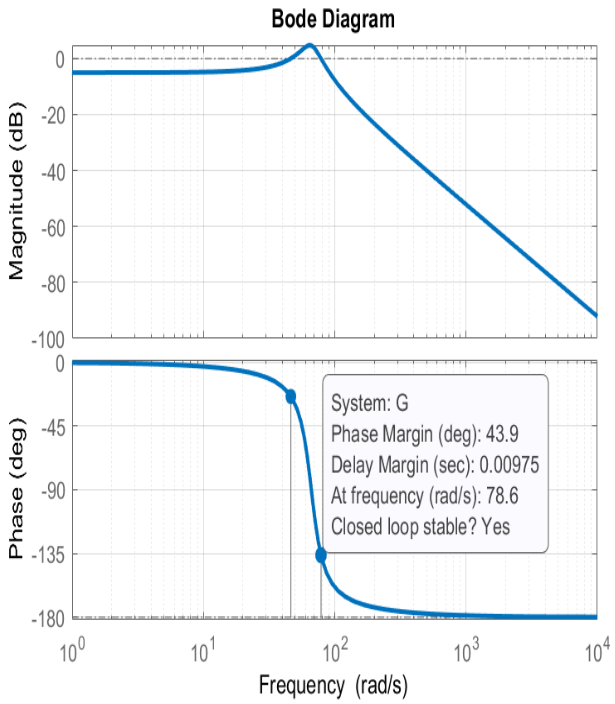

Fig. 4. Bode plot of Gm system without a controller

III. 2. PID Controller

The design of the PID controller is carried out using the *A Modified Tuning Ziegler – Nichols* method. The condition parameters used for tuning include the following:

$K_c = 68{,}2\ dB,$

$\omega_c = 2520\frac{rad}{s};\ \omega_p = 78.60\frac{rad}{s}$

$r_b = 0{,}0001;\ \alpha = 0.25$

$\phi_b = 50° - 70°$

So we get:

$r_a = \frac{1}{K_c} = 0{,}0147$

$T_c = \frac{2\pi}{\omega_c} = 0{,}0025$

Furthermore, by using equations (12), (13) and (14), the PID controller parameter tuning is calculated. The tuning results can be seen in Table 2, and the transient response and the bode plot can be seen in Fig. 5 and 6.

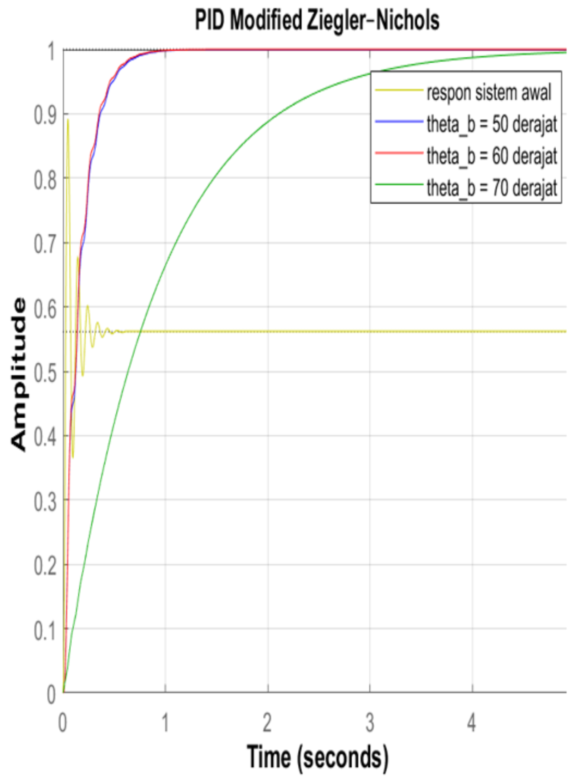

Fig. 5. Transient Response of Gm System with PID Controller using a Modified Tuning Ziegler – Nichols Method with various values ϕ_b = 50° – 70°

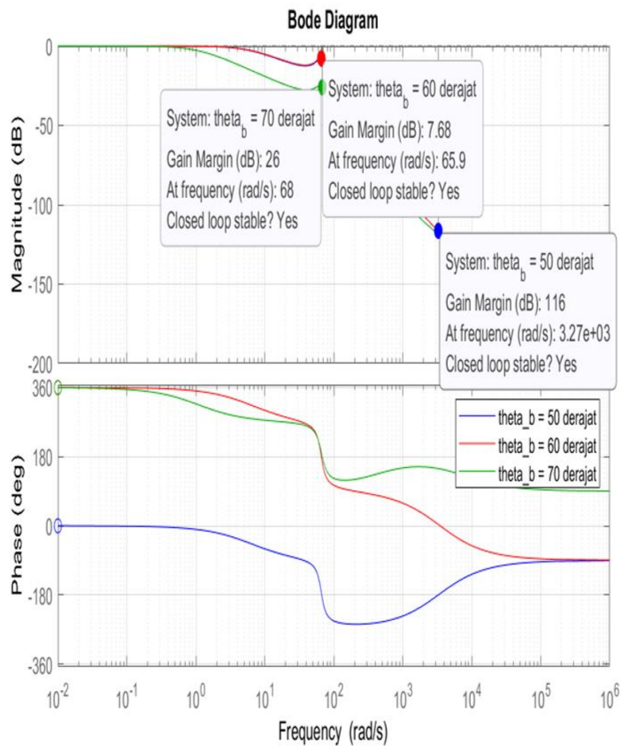

Fig. 6. Bode Plot of Gm System with PID Controller using a Modified Tuning Ziegler – Nichols Method with various values ϕ_b = 50° – 70°

TABLE II
THE RESULTS OF THE PID CONTROLLER RESPONSE WITH VARIATIONS IN THE VALUE OF $\phi_b = 50° - 70°$

ϕ_b	$K_p(P)$	$K_i(I)$	$K_d(D)$	Rise Time (s)	Max. Overshoot (%)	Settling Time (s)
50°	0,0066	10,85	9,9x10^{-7}	0,33	0	0,63
60°	-0,0065	11,21	9,4x10^{-7}	0,32	0	0,61
70°	0,0043	1,94	-6,2 x10^{-7}	2,01	0	3,58

III. 3. PI Controller

The design of the *PI* controller is carried out using the same method as the design of the *PID* controller, namely: *A Modified Tuning Ziegler – Nichols*. The condition parameters used for tuning are the same as those in the *PID* controller design. For tuning the *PI* controller, equations (4) and (5) are used, the tuning results can be seen in Table 3, and the transient response and the bode plot can be seen in Fig. 7 and 8.

TABLE III
THE RESULTS OF THE PI CONTROLLER RESPONSE WITH VARIATIONS IN THE VALUE OF $\phi_b = 50° - 70°$

ϕ_b	$K_p(P)$	$K_i(I)$	Rise Time (s)	Maks. Overshoot (%)	Settling Time (s)
50°	0,067	0,47	8,52	0	15,05
60°	-0,063	1,28	2,94	0	5,26
70°	0,038	2,18	1,83	0	0,90

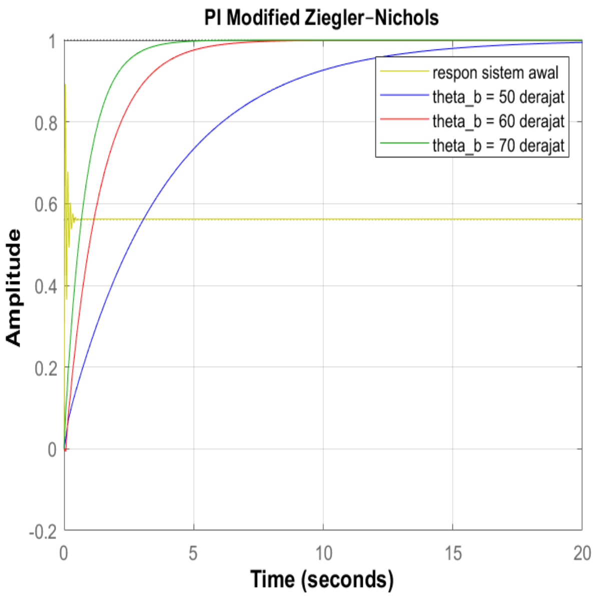

Fig. 7. Transient Response of Gm System with PI Controller using a Modified Tuning Ziegler – Nichols Method with various values $\phi_b = 50° - 70°$

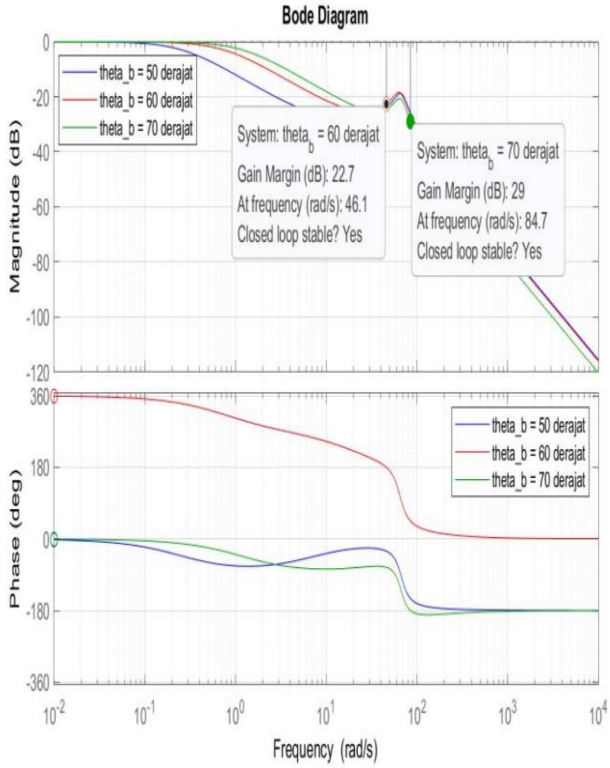

Fig. 8. Bode Plot of Gm System with PI Controller Using a Modified Tuning Ziegler – Nichols Method with various values $\phi_b = 50° - 70°$

In addition, the steady-state error for the G_m system is also calculated using the previously obtained *PID* and *PI* controllers. The results of the calculation of the steady-state error value can be seen in Table 4.

TABLE IV
CALCULATION OF THE STEADY-STATE ERROR OF THE GM SYSTEM WITH PID AND PI CONTROLLERS WITH VARIATIONS IN THE VALUE OF $\phi_b = 50° - 70°$

ϕ_b	$K_p(P)$	$K_i(I)$	$K_d(D)$	*ess*
G_m System without a controller				0,4416
50°	0,0066	10,85	9,9x10^{-7}	0,000025
60°	-0,0065	11,21	9,4x10^{-7}	0,0031
70°	0,0043	1,94	-6,2 x10^{-7}	0,000075
50°	0,067	0,47	-	0,0017
60°	-0,063	1,28	-	0,00036
70°	0,038	2,18	-	0,00013

From the results shown in Tables 2, 3 and 4, the best transient response using a *PID* controller is obtained with a *Kp* value of 0.0066, Ki of 10.85, *Kd* of 9.9x10^{-7} and with Phase Margin (ϕ_b) of 50° where the rotational speed of the motor can achieve stability at the specified set point with a setting time of 0.63 seconds and with a maximum overshoot of 0%. From the simulation results, it can be seen that the G_m system given the *PID* controller has the appropriate settling time and maximum overshoot or is still within the specified design limits and has a steady state error value of 0.000025 which means the system with the *PID* controller in achieving a steady state condition that is close to the set point value produces a smaller error value when compared to the G_m system that is not given a *PID* controller.

Furthermore, for the best transient response using a *PI* controller with a *Kp* value of 0.038; a *Ki* value of 2.18 and a Phase Margin (ϕ_b) of 70° where the rotational speed of the motor can achieve stability at the specified set point with a settling time of 0.90 seconds and with a maximum overshoot of 0%. From the simulation results, it can be seen that the G_m system given the *PI* controller has the appropriate settling time and maximum overshoot or is still within the specified design limits and has a steady-state error value of 0.00013, which means the system with the *PI* controller in achieving a steady-state condition that is close to the set point value produces a smaller error value when compared to the Gm system that is not given a *PI* controller.

The difference in the transient response of the initial G_m system without a controller and the G_m system that has been given *PI* and *PID* controllers can be seen in Fig. 9 below.

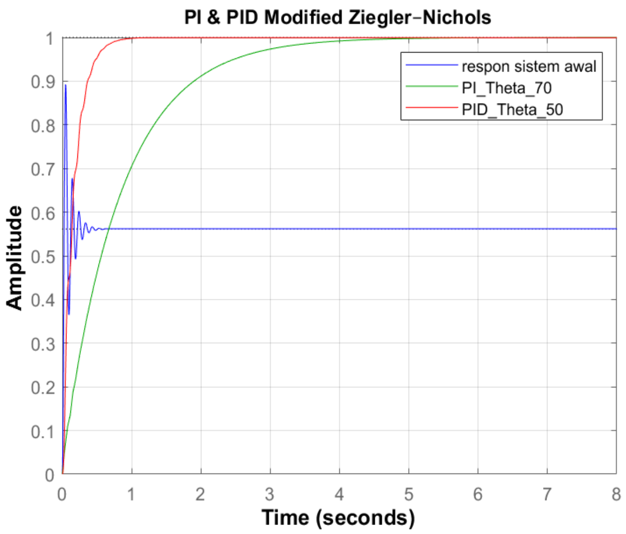

Fig. 9. Transient response of Gm system without controller and Gm system which has been given PI and PID controller

Based on the simulation results that have been carried out through the transient response in Fig. 9, it can be seen that if one of the PI control systems or PID control systems is used in the induction motor control system on the gamma irradiator characterization prototype, it will provide a system response that can control the system according to the specified conditions, so that the accuracy of the irradiation process time becomes better or increases. Therefore, with the increase in the accuracy of the irradiation process, the accuracy of the DUR of each irradiated product will increase.

IV. Conclusion

When applied to the induction motor drive control system on the irradiator simulator, *PI* or *PID* controllers can make the system respond better when compared to before the control system was given. The *PI* or *PID* controllers can minimize the maximum overshoot, speed up the system time to reach a steady-state, get the specified set-point value and reduce the error steady-state.

This *PI* or *PID* control method can be used as an alternative control system on the induction motor drive system on the irradiator simulator because the controller can control the system according to the specified conditions so that the accuracy of the irradiation process time becomes better or increases.

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