ANALYSIS OF SPEED ESTIMATION OF TWO MASS DRIVE SYSTEMS USING PID CONTROLLER BY MATLAB AND MODEL SIM

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Abstract- This paper is a research work summary on two mass drive system speed estimation using different types of controllers readily available in software as well as in hardware. The complete analysis begins with a basic idea behind the block diagram modeling presented in early papers related to two mass modeling. After the closed loop diagram implementation, another novelty has been proposed identified with controllers in the complete demonstrating. Two different error reduction controllers namely PI and PID in discrete form as a controller are taken for speed synchronization of two drives. The time constant taken for drive 2 is 203e-3 and 406e-3, similarly for drive 1 the time constant 203e-3. After repeated experiment in MATLAB and SIMULINK by taking one additional parameters namely resonance frequency as $w_r = 30s^{-1}$ and $w_r = 40s^{-1}$. Another imperative point is the complete experiment is partially taken on verilog HDL using MATLAB HDL verifier. The discrete controllers are converted to HDL block and then these blocks replaces actual simulation block of PI and PID controller. The experiments done MATLAB/SIMULINK and then a hybrid experiment using MATLAB/SIMULINK with modelsim shows a good level of accuracy of speed estimation between two drives. Thus conclusion of this research paper is that PID controller is performing better than PI controller. Error achieved with PI is approximately -24.29 similarly with PID is -.00545 and modelsim PID is -.0025.

Keywords- PI Controller , PID Controller, Drive System.

I. INTRODUCTION

In the late years necessities for the perfect action in continuing and component states of current electrical drives are getting the opportunity to be more stringent. The purpose of such frameworks is to minimize the time allotment of the transient process, the ideal after of the provided guidance of the pace (or position), energy to parameter change of the controlled framework [1]. The necessities indicated above lead the designers to develop new techniques and control computations of the drives. Additionally, they oblige exact exhibiting and working conditions to secure high exactness of control, which is consistently connected with transfer of the streamlining assumptions. A drive framework is made out of an engine associated with a heap machine through a pole. In numerous modern drives, such as moving plant drives or robot arms, the mechanical part of the framework containing a long shaft between the engine and the heap machine must be considered. Particularly in the drive frameworks with elite rate and torque regulation, the engine the item and can impact the security of the control framework. So the reasonable control structure guaranteeing the vibration dumping must be utilized, which require extra responses from such state variables as tensional torque, load speed and/or unsettling impact torque [2].

In this Paper, to expel complex scientific displaying to decrease expense of drive framework and to upgrade the framework dependability[4] relative Integral-subsidiary (PID) controller in course with corresponding indispensable controller is utilized with advanced torque control. The principle target of this proposition is to execute PID controller for the Speed Estimation[3] of the Two-Mass Drive System that diminishes the distinction in velocity of two engine i.e drive side and load side as contrast with PI controller speed.

II. PI CONTROLLER

The PI controller is cascade of I controller and P controller. The advantage of both controller is fast reaction and compensation of system deviation. The PI controller can be used in many types of controls or drive sytems. With Proportional gain corresponding addition, the PI controller has a numerous different qualities that demonstrates the conduct of the I part: the reset time (integral action time).
PI controller is calculated as-

$$G_c = k_p + k_i/s$$
$$G_c = K_p\,(1+1/sT_i)$$

Reset Time.
The reset time is a measure as the number of times per minute that the proportional part of the response is duplicated. In other words: the reset time is the period by which the PI controller is faster than the pure I controller. The inverse of integral time is called reset time.

III. MATHEMATICAL MODEL

In this paper, the for the most part used exploratory model of the drive framework with the adaptable coupling is considered. Usually, such drive is inspected as a framework made out of two masses joined with adaptable shaft, where the principal mass addresses the snippet of inactivity of the drive and the second mass alludes the snippet of idleness of the stack side. The structure is delineated by the going with state numerical proclamation (in each unit framework), where nonlinear marvels, like backfire or contact are rejected [2].

$$\tau_1\, d\omega_1(t)/dt = T_e(t) - T_s(t) \quad (1)$$
$$\tau_2\, d\omega_2(t)/dt = T_s(t) - T_L(t) \quad (2)$$
$$\tau_c\, dT_s(t)/dt = \omega_1(t) - \omega_2(t) \quad (3)$$

where, ω1 and ω2 are motor and load speeds , Te , T_s , T_L are electromagnetic, shaft, and load torques [in per unit system] τ_1, τ_2 are the mechanical time constants of the motor and load machine, and τc is the stiffness time constant.

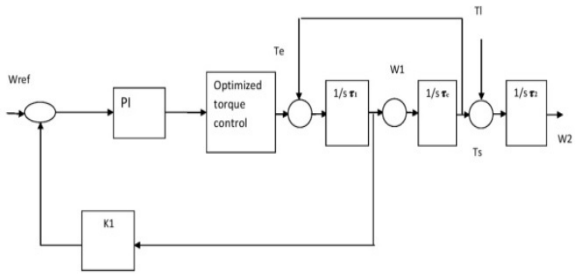

Fig 1: The block diagram of the drive system with PI controller.

The electrical drive framework is regularly controlled in the built up course structure, which includes two control circles: the inward control loop encases the torque controller, the force converter, and the electromagnetic part of the motor. The PI torque controller is typically adjusted by understood modulus premise, to give adequately fast torque direction likewise, frequently is approximated by a first-arrange channel with little time steady [5, 6]. The outside control circle joins the mechanical bit of the drives, speed sensor, and PI speed controller (Fig. 1). This set up structure works honorably only for some inertia ratio (T1/T2) of the two-mass framework [7]. The heap machine speed must be surveyed by the neural velocity estimator in light of estimations of the motor electromagnetic torque (current) and driven motor rate. Along these lines, this improved part of the control structure, with the ignoring time consistent, can be represented to by the transfer functions.

G(s) = 1

Reading of the outer velocity control feedback loop are planned utilizing the pole placement method. Due to which the PI speed controller reading and gain of additional feedback from the load speed are as follows:

$$KP = 4\epsilon_r\omega_r\tau_1/1+k_1 \quad (4)$$
$$KI = \tau_1/(1+k_1)^2\,\tau_2\,\tau_c \quad (5)$$
$$k1 = \epsilon_r^2 4\tau_1 - \tau_2/\tau_1+\tau_2 \quad (6)$$

where ωr, Ɛr are assumed resonance frequency and dumping factor of the closed-loop system. The equations describing the several gains in the control structure are dependent on the chosen values of the damping coefficient Ɛr and the resonance pulsation ω1 of the system. Therefore, there is a chance for adjusting the performance of the drive systems.

In addition to this we derived the resonance frequency from the control structure of two mass drives system model to get the approximate speed which helps in error estimation of two mass drive system. The equation is.

$\boldsymbol{\omega r < \sqrt{(\tau_1+\tau_2)} / \sqrt{(2\tau_1\tau_2\tau_c)}}$ (7)

With the help of equation (7) we easily calculate the resonance frequency for the two mass drive system at different time constants. In this paper, the two mass drive system run with two cases when time constant is equal for both drive system and second when twice of time constant (inertia) of the load side, to check its accuracy to parameter changes of the drive systems.

Case 1: When $\tau_1=\tau_2$=203ms and τ_c=2.6ms, then according to equation (7)

$\boldsymbol{\omega r < \sqrt{(203+203)}/\sqrt{(2\times203\times203\times2.6)}}$

$\boldsymbol{\omega r < \sqrt{(406\times10^{-3})}/\sqrt{(214286.8\times10^{-9})}}$

$\boldsymbol{\omega r < 0.63710/.0146}$

$\boldsymbol{\omega r < 43.54\ s^{-1}}$

From above equation we find that in this case ωr should be less than "43.54 s^{-1} "for good synchronization speed of two mass drive systems. So we are using "40 s^{-1} "resonance frequency in this research.

Case 2: When τ_1 = 203ms, τ_2 = 406ms and τ_c = 2.6ms, then according to equation (7)

$\boldsymbol{\omega r < \sqrt{(203+406)}/\sqrt{(2\times203\times406\times2.6)}}$

$\boldsymbol{\omega r < \sqrt{(609\times10^{-3})}/\sqrt{(428573.6\times10^{-9})}}$

$\boldsymbol{\omega r < 0.7803840/.020702}$

$\boldsymbol{\omega r < 37.69\ s^{-1}}$

From above equation we find that in this case ωr should be less than " 37.69 s^{-1}"for good synchronization speed in two mass drive systems. So we are using "30 s^{-1} "resonance frequency in this research.

IV. METHODLOGY

In this paper we are doing execution of two mass frame work on MATLAB capacity called SIMULINK. Simulink, created by MathWorks, is an information stream graphical programming dialect apparatus for displaying, recreating and examining multi domain dynamic frameworks. Its essential interface is a graphical square charting apparatus and an adjustable arrangement of piece libraries. There are three noteworthy strides in this paper:

1. Execution of two mass frame work with PI controller in Simulink programming as indicated in fig1. With the assistance of differents blocks present

in simulink library, actualize two mass framework model with the assistance of Matlab project utilizing capacities gensim and trainlm and so on. At that point run the simulink display and get the distinctive waveform results as appeared in results area.

2. Second step is to actualize the two mass framework with PID controller as appeared in fig 2 in Simulink programming with various squares in simulink library and in the wake of running this model we get the distinctive frameworks waveform with blunder estimation further more figure the mistake esteem through matlab programming. Figures of waveform is appeared in results.

3. In conclusion, we demonstrate this PID controller Simulink model with ModelSim SE6.5 programming which gives the equipment environment of two mass framework. ModelSim pieces are produced at the info of the framework with arrange HDL plan and Launch HDL test system. With the assistance of cosimWizard and vsim capacity we Starts and designs the ModelSim test system (vsim) for use with the MATLAB and Simulink components of HDL Verifier.

In the wake of running simulink model of PID controller modelsim two mass framework the diverse waveforms will appear with aggregate of mistake worth which demonstrate the virtual environment execution of two mass framework these waveforms are appeared in results.

V. PROPOSED WORK

As we realize that there are numerous worthwhile elements of NNs (like the guess, speculation of information, parallel processing) that bring about they are a helpful computational device by and by. Inspite of this Neural Network estimation technique have a few issues like it required the scientific model and parameter learning of the framework. They generally delicate to parameter changes that causes steadiness issue once in a while. In addition their planning strategy and viable acknowledgment is exceptionally perplexing and exorbitant. To beat these issues Proportional Integral Derivative (PID) controller is utilized as a part of course with Proportional Integral controller (PI) with streamlined torque control circle as appeared in Fig 2. The point of utilizing PID controller is to expand the strength and stability of the framework by enhancing control since it has a capacity to predict the future mistake.

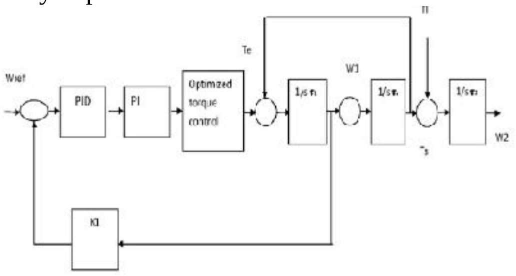

Fig 2: The block diagram of the drive system with PID controller.

We also make block diagram of drive system of PID Controller in Virtual Environment of Model Sim shown in fig 3.

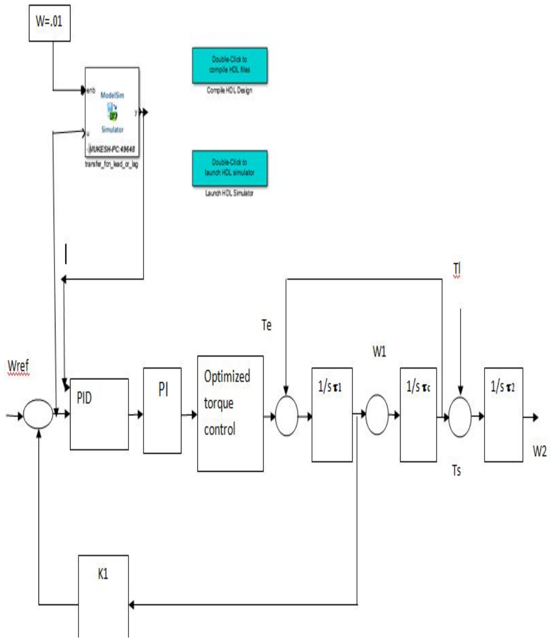

Fig 3 . Block diagram of drive system in model sim virtual environment.

PID controller.

The PID controller is combination of proportional, integral and derivative control action is called PID control action and the controller known as three controller .

In the event that the framework deviation is extensive, the D part guarantees a transient greatly high change in the controlled variable. While the impact of the D segment falls of promptly, the impact of the I part increments gradually. In the event that the adjustment in framework deviation is slight, the conduct of the D component is immaterial. This controller has the benefits of fast response also, faster pay of framework deviation in the occasion of changes or unsettling influence variables. The drawback is that the control circle is a great deal more inclined to oscillation and that setting is in this way more troublesome. Time response shown in fig 4

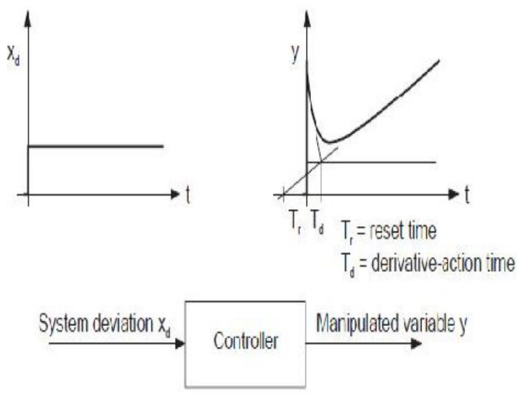

Fig 4 Time response of PID controller

VI. RESULTS AND DISCUSSION

We tested for nominal (τ_2=τ_{2N}) and twice bigger (τ_2=2τ_{2N}) mechanical time constant (inertia) of the load side, to check its strength to parameter changes of the drive frame work. Model of drives are implemented in a feedback arrangement so that a speed estimation is done for two drives. A PI and PID controller is put at the beginning of a model in the feedback which checks the error and reduces the error, so their correct position placement is imperative.
we execute the Wave Form with PI Controller, PID controller with both time constant.

A. PI Controller with Simulation Results

Case1- When τ_1 =203ms, τ_2= 406ms and ωr =30s^{-1}

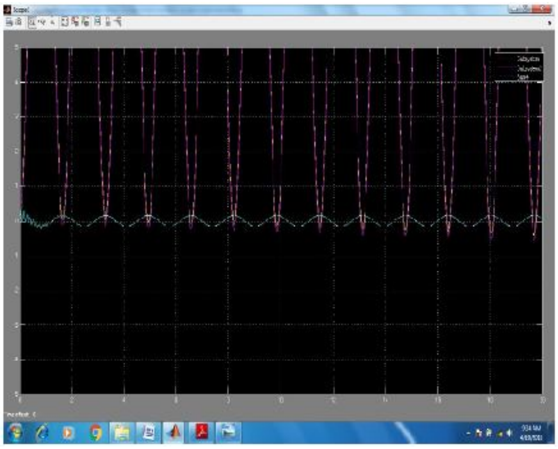

Fig 5. Error of load speed and shaft torque for τ_1 = 203ms, τ_2= 406ms is .0608

Here in Figure 5 error of load speed with shaft is calculated at two dive time constant τ_1 = 203ms, τ_2= 406ms. Error calculation done between them is 0.0608. Good error value in this regard has enabled the research to extend this over modelsim.

Case2- When τ_1 = 203ms, τ_2= 203ms and ωr = 40s-^{1}.

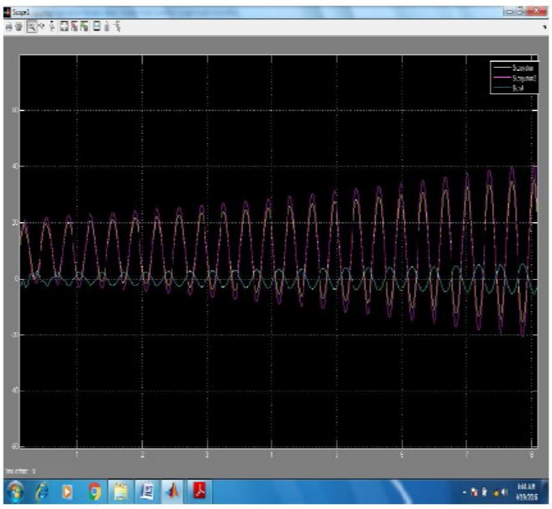

Fig 6. Error of load speed and shaft torque for τ_1 = 203ms, τ_2= 203ms is -24.29

Figure 6 is a error estimation graph with speed of two drives overlapping on one another. This part shows that speed estimation with PI controller is high enough that results could not pretend to be used for actual implementation.

B. PID Controller with Simulation Results

Case1- When τ_1 = 203ms, τ_2= 406ms and ωr = 30s-^{1}.

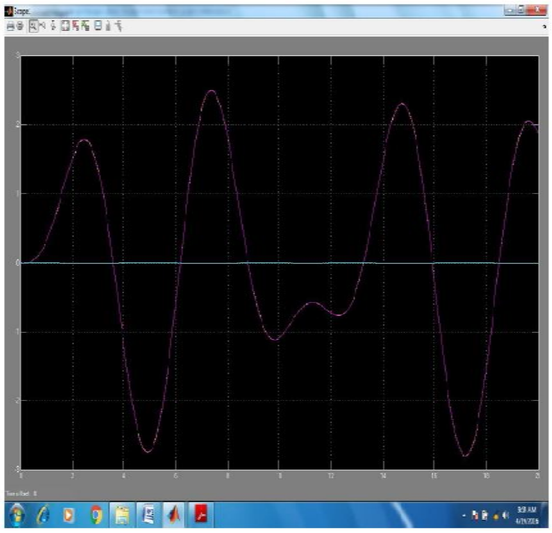

Fig 7.Error of load speed and shaft torque for τ_1 = 203ms, τ_2= 406ms is -.00266

PID controller taken in this experiment proves to be the main stay of this research. The experiment conducted with time constant of drive 1 is either 203 ms and 406 ms. Now experiment conducted in this closed loop experiment with PID shows a similar trend of increase in error when time constant is increased. But discrete PID controller results in figure 6 and 7 indicates a low value of error in comparison to PI. Thus research extended the concept of PID controller beyond MATLAB/ SIMULINK using modelsim in attachment to SIMULINK platform using HDL verifier.

Case2- When τ_1 = 203ms, τ_2= 203ms and ωr = 40s^{-1}.

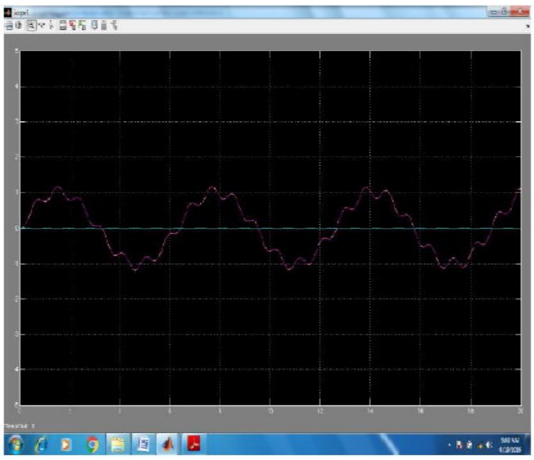

Fig 8.Error of load speed and shaft torque for τ_1 = 203ms, τ_2= 406ms is .-.00545

C. Model Sim Results.

The final simulation of PID controller with Modelsim that creates virtual hardware environment for error estimation of load speed and shaft torque of two mass drive framework. In this paper we are utilizing ModelSim SE6.5 edition that offers superior and progressed debugging capabilities.

ModelSim SE is used in large multi-million gate designs, and is supported on Microsoft Windows in 32-bit and 64-bit architectures Simulation is done for both values of time constant as we have done before. Here we show modelsim environment of version 6.5se of PID controller. After running simulink model of PID controller modelsim two mass system the different waveforms will appear with sum of error value which show the virtual hardware implementation of two mass system. Fig 9 shows the virtual enivironment of Model sim.

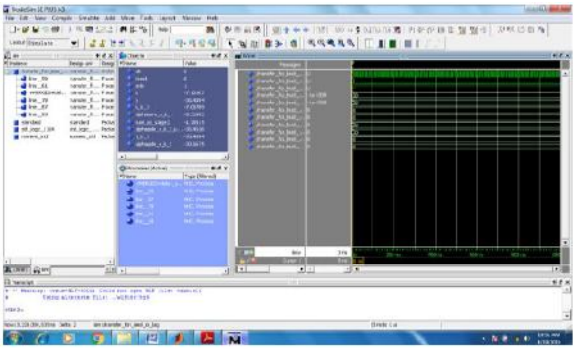

Fig 9. Virtual Enivironment of model sim.

PID Controller with Model Sim Results

Case1- When τ_1 = 203ms, τ_2= 406ms and ωr = 30s-^{1}.

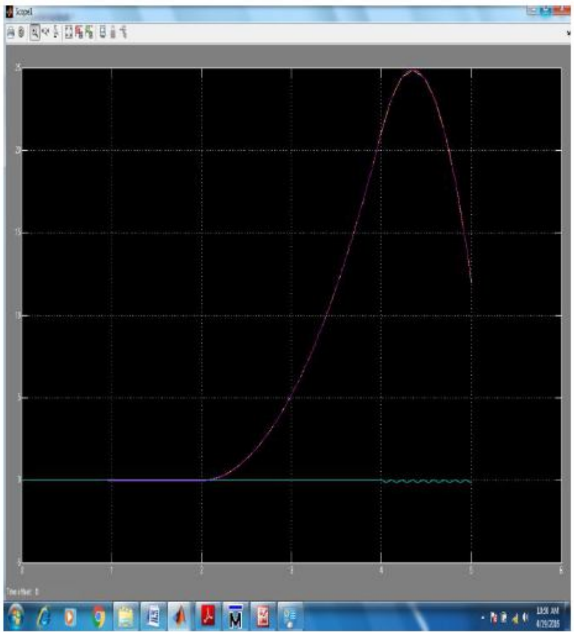

Fig 10.Model Sim Response Error of load speed and shaft torque for τ_1 = 203ms, τ_2= 406ms is -.1256.

Figure 10. is a hybrid Model Sim response of PID controller with rest model implemented in SIMULINK. Here speed error has increased to 0.1256 as compared to 0.00545. This comparative increase in error is because model Sim implementation is not optimum in design. Similarly when two mass drive system with same time constant are taken with angular resonance frequency is ωr = 40s-^{1,} in figure 11, then the error between two drives in the simulink model has increased to 0.0025 thus the error has increased slightly. So the complete modelling of this research paper has been done on two different methods PI and PID with PID on modelsim. Evalaution of error is also done using MATLAB and SIMULINK for error performance analysis.

Case2- When τ_1 = 203ms, τ_2= 203ms and ωr = 40s-^{1}.

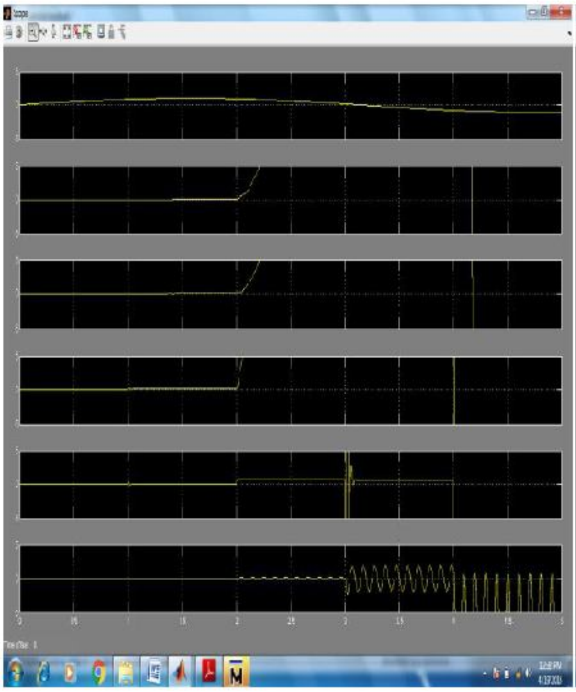

Fig 11.Model Sim Response Error of load speed and shaftt torque for τ_1 = 203ms, τ_2= 203ms is -.0025

D. Comparison of Error

Case 1- When τ_1 =203ms, τ_2=406ms and ωr = 30s^{-1}

PI Controller	PID Controller	Model Sim Error Of PID Controller
.0608	-.00266	-.1256

Case 2- When τ_1 = 203ms, τ_2= 203 ms and ωr = 40s-^{1}

PI Controller	PID Controller	Model Sim Error Of PID Controller
-24.29	-.00545	-.0025

This also shows that PID controller two mass drive system results are greatly better than PI controller error results. In evaluation to both tables we saw that case 1 having τ_1 = 203ms, τ_2 = 203ms so we take ω_r

=40 $s-^1$ and case 2 having τ_1 = 203ms, τ_2 = 406ms and ωr =30 $s-^1$according to equation (7) we saw that as the time constant doubles the error estimation also slightly increases but in case of PI controller it increase more than PID controller which indicate that two mass drives system with PID controller is more stable and good performance to changes of the load side.

CONCLUSION

Use of PID Controller in the drive framework with versatile coupling empowers great estimation quality There are numerous favorable components of PID Controller applications, for instance, moving factory drives, mechanized arms, transport lines that bring about they are a valuable computational apparatus practically speaking. PI Controller produces low estimate power inspite of this strategy have a few issues like it required the scientific model and constraint information of the system. They normally weak to parameter changes that causes steadiness issue here and there. Besides their planning technique and pragmatic acknowledgment is extremely intricate and unreasonable. In this way, to defeat these issues or to increase the stability and reduce the error of two mass drive framework PID controller is utilized. The two mass drive frame work has been demonstrated in Simulink where the engine, load and shaft are displayed as vital components. Consequently, we get little estimated error if there should arise an occurrence of PID controller than PI Controller. Not with standing this we are doing simulation of PID controller with Modelsim SE6.5 for virtual equipment environment of two mass drive framework dc engine and we evaluated little error.

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