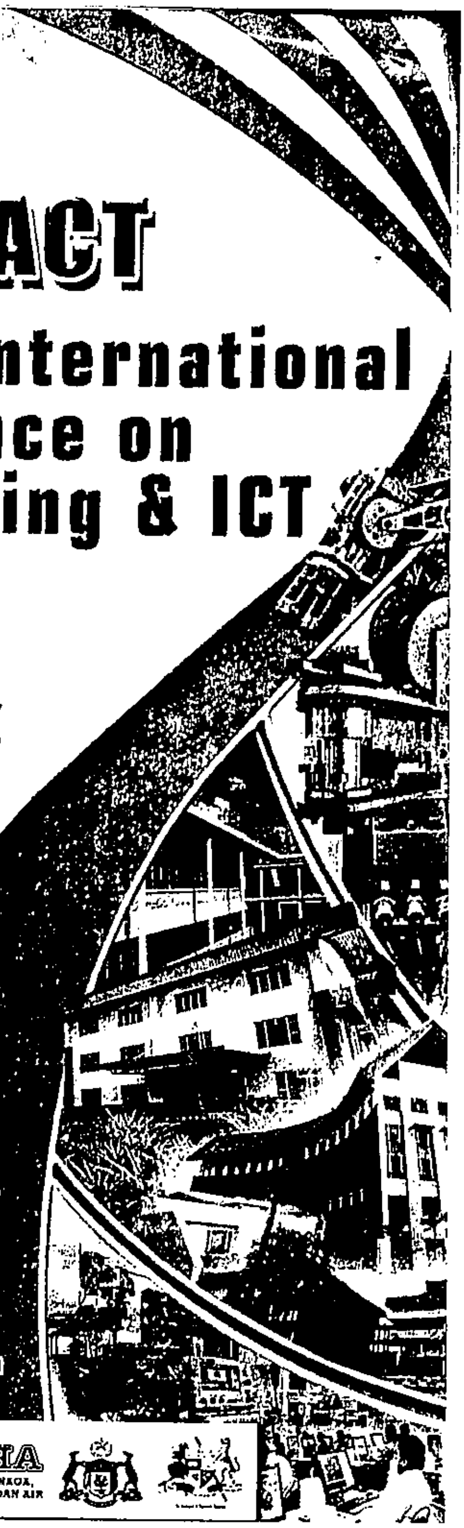
49

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ICEI 2012

# ABSTRACT

# The 3rd International Conference on Engineering & ICT



*"Green Technology For Sustainable Development"*

http://icei2012.utem.edu.my

Date : 4 - 5th April 2012

Venue : Mahkota Hotel Melaka
World Heritage City Malaysia

*Organized by :*
Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka

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KeTTHA KEMENTERIAN TENAGA, TEKNOLOGI HIJAU DAN AIR

**PARALLEL SESSION 4A**

Track: System Engineering
Sub track: Mechanical System

Date : 5 April 2012
Time : 8.45 am - 10.45 am
Venue : Jasmine 1
Session Chairman : Dr. Hamzah bin Sakidin

| No | Time | Title/Author | Ref. No |
|---|---|---|---|
| 1 | 8.45am - 9.00am | **Concentration Measurements Of Bubbles In A Vertical Water Column Using An Optical Tomography System** *Sallehuddin Ibrahim, Mohd Amri Md Yunus and Robert Garnett Green* | ET601 |
| 2 | 9.00am - 9.15am | **Development Of A Low Cost Wireless Inertial Measurement Unit** *Zhengyu Yu, Xiaoying Kong and Tich Phuoc Tran* | ET602 |
| 3 | 9.15am - 9.30am | **Development Of A Magnetic Levitation System** *Nik Syahrim Nik Anwar, Khairul Ridza Ramli and Mohd Najib Ali Mokhtar* | ET603 |
| 4 | 9.30am - 9.45am | **Recycle Folded Cacsode OTA With Current Control Circuit** *Nordiana Mukahar and Siti Aishah Che Kar* | ET802 |
| 5 | 9.45am - 10.00am | **Overview: Process Parameters For Hydrothermal Synthesis Of Hydroxyapatite** *Fatimah, M., Shaaban, A., Tolbah, A R. and Seliman, S.* | ET201 |
| 6 | 10.00am - 10.15am | **Preliminary Study Sodium Silicate – Borax Mixtures As Flux Addition In Ceramic Surface Enamel Formulation for Carbon Steel** *Mohammad 'Izzat Mohd Radzi* | ET217 |
| 7 | 10.15am - 10.30am | **Employment Of Swirling Flow Technique To Reduce Turbulenence Of Molten Metal In Thin Section Casting Of (Al-7Si-0.3Mg) Alloy** *Zaid Ali Subhi, Rosle Ahmed, Sulaiman Hasan and Badrul Omar* | ET218 |
| 8 | 10.30am - 10.45 am | **A Theoretical Model Of Pitting Corrosion Using A General Purpose Finite Element Package** *Suhaila Salleh and Nicholas P.C. Stevens* | ET219 |

**PARALLEL SESSION 4B**

Track: System Engineering
Sub track: Mechanical System

Date : 5 April 2012
Time : 8.45 am - 10.45 am
Venue : Jasmine 2
Session Chairman : Dr. Zamberi bin Jamaludin

| No | Time | Title/Author | Ref. No |
|---|---|---|---|
| 1 | 8.45am - 9.00am | **Design of Proportional-Integral-Derivative Wall Follower Robot** *I. Hidayah, M.Z. Hilwa ,W.H. Ahmas, A. Razali and N.I. Tusiman* | SE310 |
| 2 | 9.00am - 9.15am | **Modelling and Validation of Six-Bar Rack And Pinion Steering Linkage System** *Mohd Zakaria Mohammad Nasir, Mohd Zubir Amir, Khisbullah Hudha, Mohd Azman Abdullah, Muhammad Zahir Hassan and Masjuri Musa@Othman* | SE311 |
| 3 | 9.15am - 9.30am | **Motion Synthesis of Planar Four Linkage Movement For Part Flipping Application** *A.M.M. Najib, N.S.N. Anwar, M.N. Muhammad, M.A. Akiah and S.H. Yahaya* | SE312 |
| 4 | 9.30am - 9.45am | **Bus Accidents Prevention With An Integrated Steering** *V.K. Kher, Chee Fai Tan and Ranjit Singh Al Sarban Singh* | SE313 |
| 5 | 9.45am - 10.00am | **Half Car Active Suspension System** *Amat A. Basari, Saifullah Salam, Khairul A.A. Aziz and Redzuan A. Manap* | SE314 |
| 6 | 10.00am - 10.15am | **Design And Fabrication For Semi-Automatic Gear Shifter For Formula Varsity Race Car** *Ammar Alfaiz M.A., Muhd Ridzuan M., Syahibudil Ikhwan A.K., Mohd Azli S. And Mohd Afzanizam M.R.* | SE315 |
| 7 | 10.15am - 10.30am | **Development of PD Controller For Comparison Stability Study In Multiple Difference Disturbances** *M.A Nur Huda, H.A Kasdirin and A.G Mohd Ruddin* | SE316 |
| 8 | 10.30am - 10.45 am | **Design And Development Of Microcontroller Based Localised Air Heater** *M.Z.Hilwa, W.L.Fu and I.Hidayah* | SE309 |

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# DEVELOPMENT OF PD CONTROLLER FOR COMPARISON STABILITY STUDY IN MULTIPLE DIFFERENCE DISTURBANCES

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*Abstract*— **This paper discusses the development of PD controller for comparison stability study in multiple difference disturbances. The multiple difference disturbances in this paper are added to the inverted pendulum model that based on robotic leg application such as pendubot. By applying the pendubot model via simulink block diagram, the performances between the model and disturbances are compared for stability in the simulation results. The simulation results show that the PD controller play the main role to reduce or eliminate disturbances.**

*Keywords*—**Inverted pendulum; pendubot; PD controller; Disturbance.**

## I. INTRODUCTION

Technology development growth fast onward through over the world including Malaysia. Each part of engineering tools is used to build and design the technology such as robot, all types vehicle, building and others. These technology especially robot application, need a control system approach to organize, monitor and stabilize any movement. Within this control system approach, the robot would operate smoothly. In case, the stability in control system is studied for the robotic leg application.

Robotic leg application gives advantage in pendubot at which also called arm-driven that doing tasks like manipulating, moving, and painting. The tasks usually found in industrial automation, architecture and artistic. For industrial automation as example, the high quality products are primary goal to achieve. To achieve the goal, the arm-driven robots are developed more than workers to maintain the products quality. This quality based on stability [1] in control system that is being explained by James Clerk Maxwell, Edward John Routh, William Kingdon Clifford, Adam Prize, and Alexandr Michailovich Lyapunov in the latter half of the 19th century. The stability of the robotic leg application in this paper is the main problem for the study purposes with the PD type controller in multiple difference disturbances.

The PD type controller refers to the familiarity terms of Proportional (P), Integral (I) and Derivative (D) in PID controller that well-known as conventional controller since the last few years ago. These terms quite importance in define gains P, I and D in root-locus techniques. The root-locus techniques are based on the development of advanced control systems from state-space model. The state-space model refers to the inverted pendulum as apply in a robotic leg application such as pendubot. In a robotic leg application, PID controller not depends by self. Looking through from previous research, the adapting idea of PID controller [2] preferred to use PD than PID controller based on human naturally acts. Considerably from other authors paper: the study of the development of PI controller for disc speed [3], shows that PI controller is also quite useful in eliminate and reduce disturbance.

Sometimes, the researcher looking for a wide view of research study, as posted in article of observer control improves motion [4] by Kristin, found that the observer control enable to eliminate ringing and overshoot, and also solve the problem of PID loops disable to do. By the way, this paper is focusing on PD controller development for comparison stability in multiple difference disturbances. Based on a few review of the introduction, the minority contents of the paper included the disturbances in general view, inverted pendulum model, simulation results, conclusion, acknowledgement and references as following.

## II. DISTURBANCES

Generally, disturbance ($d_1$ or $d_2$) place at the plant input or output, or both points. These disturbances [5, 6] effected to the results output (y) at which considered closed and open loop in control system. The block diagram in Fig. 1 shows the proposed model of the control system:

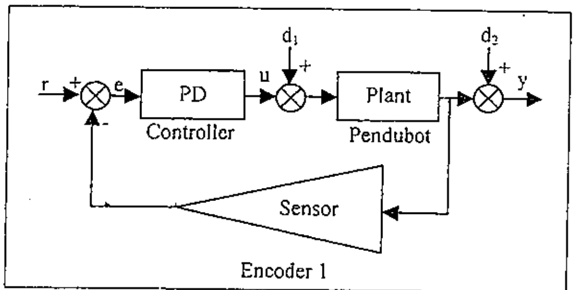


**Figure 1.** Block diagram for the proposed model of the control system

In control system, disturbances consist like the rejection or unused power sources such as sine, pulse generator and step, environmental source such as wind, machinery source such as vibration, and others. The sources of disturbances place in the proposed model, with the cascaded [7] loop in control system, give high performance to the results output. From the results output produce, this shows that the algebra equation of inverted pendulum model used the actual measured parameters.

## III. INVERTED PENDULUM MODEL

The algebra equation of inverted pendulum model is derived based on fourth physical model separately as following. By the way, the inverted pendulum model in this paper used cascade loop with two encoders connected to dc motor and pendulum rode.

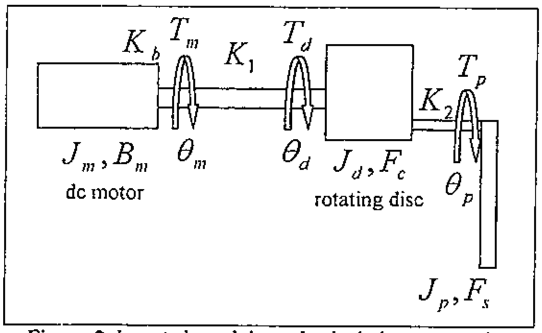


**Figure 2.** Inverted pendulum physical plant on rotating disc

$$T = T_m + T_d + T_p \qquad (1)$$

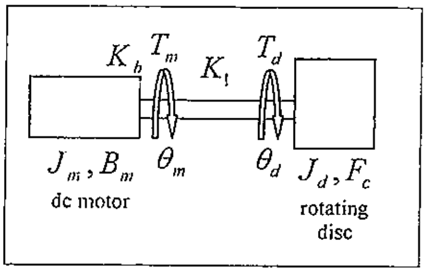


**Figure 3.** DC motor and rotating disc physical plant

$$T_m = J_m\ddot{\theta}_m + B_m\dot{\theta}_m + K_1[\theta_m - \theta_d] \qquad (2)$$

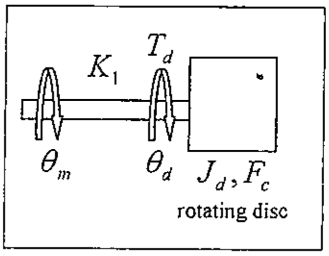


**Figure 4.** Rotating disc physical plant

$$T_d = J_d\ddot{\theta}_d - K_1[\theta_m - \theta_d] + F_c\frac{\dot{\theta}_d}{|\dot{\theta}_d|} \qquad (3)$$

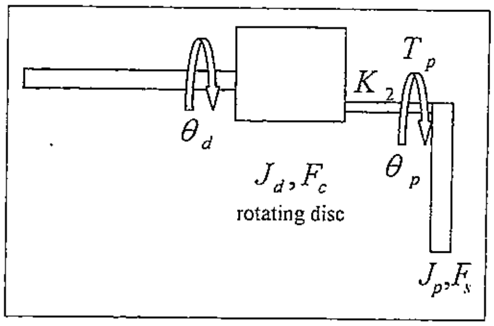


**Figure 5.** Rotating disc and pendulum physical plant

$$T_p = J_p\ddot{\theta}_p + K_2[\theta_d - \theta_p] \pm (F_s)|_{\dot{\theta}=0} \qquad (4)$$

Based on the algebra equation of inverted pendulum model, the variable of parameters is summarized in Table 1 as below:

**Table 1.** The parameters of inverted pendulum model

| | |
|---|---|
| motor torque | $T_m$ |
| disc torque | $T_d$ |
| pendulum torque | $T_p$ |
| motor moment inertia | $J_m$ |
| disc moment inertia | $J_d$ |
| pendulum moment inertia | $J_p$ |
| viscous friction | $B_m$ |
| motor angle | $\theta_m$ |
| disc angle | $\theta_d$ |
| pendulum angle | $\theta_p$ |
| torque constant/ back e.m.f | $K_1/K_t/K_b$ |
| spring constant | $K_2$ |
| Coulomb friction | $F_c$ |
| static friction | $F_s$ |

## IV. SIMULATION RESULTS

From the physical plant, the step power source of the disturbance is added in Fig.6 to produce the simulation results output. The step disturbance is placed at the plant input.

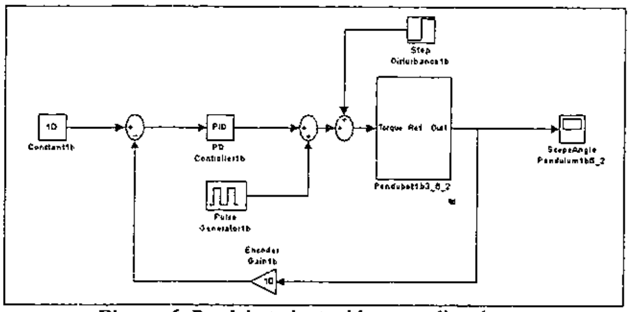

**Figure 6.** Pendubot plant with a step disturbance

By placing the step disturbance at the plant input, the simulation results output presented as following. The simulation results output in Fig.7 show that the output follow the disturbance input ($d_1$) from the plant input with a stable condition. This stable condition also proved that the response in the steady state error.

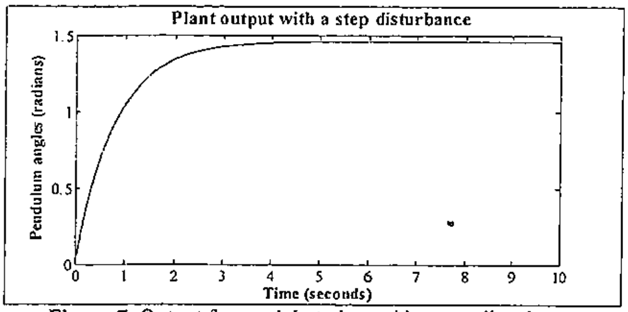


**Figure 7.** Output for pendubot plant with a step disturbance

The first pendubot plant in Fig.6 shows that the single disturbance of the simulation results output follow the plant input in Fig.7. By adding multiple disturbances to the proposed model as given in Fig.8, the response of the simulation results output change based on the disturbances points.

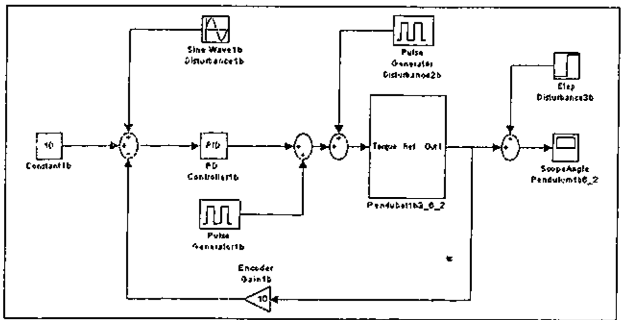

**Figure 8.** Pendubot plant with sine, pulse and step disturbances

This multiple disturbances in Fig.8 give the quick response to the simulation results output in Fig.9. The response almost achieved the steady state error in about a second at which close to the stability. As a comparison of stability study, the response of the simulation results for Fig.7 looks more stable than Fig.9.

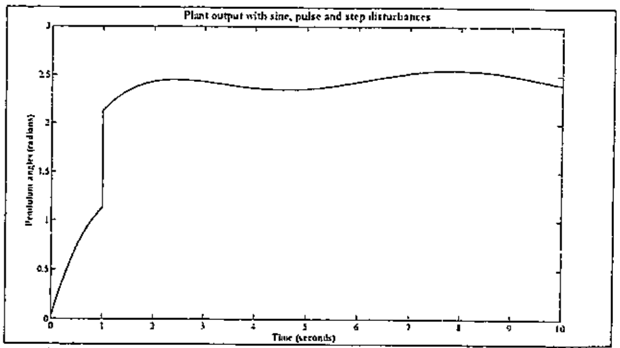


**Figure 9.** Output for pendubot plant with sine, pulse and step disturbances

For the last pendubot plant, the disturbances are placed at the PD controller input, pendubot plant input and pendubot plant output as shown in Fig.10. In Fig.10, the disturbances mostly from periodic sources such as pulse generator and two sine waves.

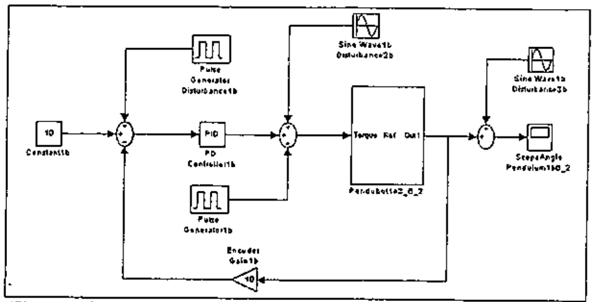

**Figure 10.** Pendubot plant with pulse, and two sine disturbances

The periodic sources of disturbances in Fig.10 presented the repeating simulation results output in Fig.11. Based on Fig.11, the response of the simulation results achieved the steady state error for a long period and might not stable at all. This pendubot model might cause problem to the hardware implementation for the real-time system.

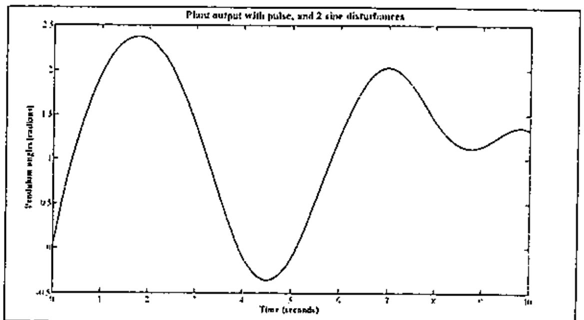

**Figure 11.** Output for pendubot plant with pulse, and two sine disturbances

## V. CONCLUSIONS

The multiple disturbances for the proposed model give a better response of the simulation results output with the cascaded loop. Within the PD controller also, the response give less noise or disturbance for the inverted pendulum proposed model. By the way, this simulation results output not deny at all that a single disturbance give less problems to the response compared to multiple disturbance for the stability study.

## ACKNOWLEDGEMENT

We would like to express our most gratitude and acknowledgement to the supervisor and researchers from the Faculty of Electrical Engineering, UTeM for their guidance and continuous effort as well as motivation throughout the project and not exempted also to Universiti Teknikal Malaysia Melaka (UTeM), for their financial support.

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