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PID Control Position of a Linear Actuator

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Abstract **-** In this article, a PID Controller position is proposed for a linear actuator, which will be used for a Stewart platform; an identification of the sensor was developed in order to characterize ten linear actuators, and a linear relation was found between the resistance and the position of the actuator. The PID algorithm was implemented on a data acquisition target model STM32F4 Discovery using a publicly available "waijung1504" MatLab/Simulink and a power stage. Furthermore, laboratory real-time experiments were conducted to verify the optimal performance of the proposed control system.

Keywords**:** PID controller, Linear Actuator, Real-time experiments.

1. Introduction

Proportional-integral-derivative (PID) control consists of three coefficients, proportional, integral, and derivative, which are adjusted to achieve an optimal response [1]. It is employed by approximately 90% of control loops in an industry. A PID controller reads a sensor and computes the actuator's desired output by computing and lumping proportional, integral, and derivative actions; the resulting control is applied to the actuator of the system by a power stage. Combinations of actions, for example, P, PI, and PD, can be used depending on the system to control and the task to solve. Today, PID is combined with different algorithms, such as non-linear control, adaptative control, intelligent control, etc. Different actions, as well as the Antiwind up, were developed to increase the performance of the systems.

The Stewart Platform, a unique six-degree-of-freedom parallel robot manipulator, is free from kinematic singularities. Its workspace boundaries are defined by the limits of its linear actuators, which introduce force singularities, leading to a loss of constraint. The platform is composed of a triangular mobile platform, supported by ball joints over three legs of adjustable lengths, connected to the base platform through two-axis joints. [2]

The Stewart Platform has unique capabilities and offers the advantages of wide workspaces, maneuverability, a force and weight ratio, and positioning accuracy [3]. An adequate position controller can avoid damage to the platform due to force constraints. This technology can be used in rehabilitation, making robotics easy to execute in various treatments. Robotic-assisted treatment can aid in the recovery of motor control and disability in patients. An investigation is being developed to improve functional recovery in stroke patients with the help of robotics and virtual reality [4].

A Stewart-type platform simulates the movement of a canoe, exercising hemiplegic patients to stimulate their motor recovery. It is essential to incorporate additional rehabilitation interventions; however, the clinical implementation of this technology is a feasible approach to enriching robot-assisted rehabilitation training [5].

2. Linear actuator

In order to control the position and orientation of Stewart Platform, the position of the linear actuator is required.

A Glideforce MD122012 Medium-Duty Linear Actuator with 100kgf, 12" Stroke (11.8" Usable), velocity of 0.58"/s, and it is driven by a 12V DC motor [6], It was selected as main actuator to move the Stewart Platform. This linear actuator provides a linear analogic sensor to measure the actuator position. The linear actuator from Pololu products is shown in figure 1.

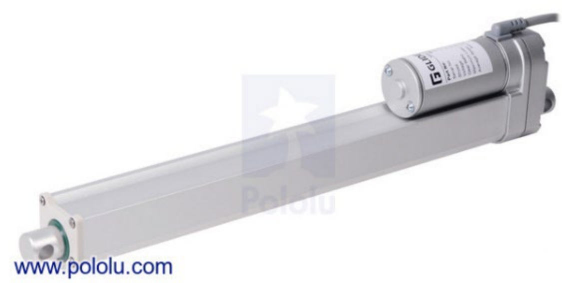

Fig 1. Linear actuator from Pololu products[6]

3. PID control design

A PID controller is proposed to control the position of linear actuator

$$u = kp\, e + ki \int e\ dt + kd\, \dot{e} \quad (1)$$

We define the error $e = r - x$ where r is the reference and x in the position of the actuator in meters which are measured by a analog sensor. The PID algorithm was implemented on a data acquisition target model STM32F4 Discovery using a publicly available “waijung1504” MatLab/Simulink [7]. Figure 2 shown the Simulink Blocks used to implement the PID algorithm, with the number 1) Waijung block configuration setting the real-time options, 2) Initialize botton to enable the system, 3) ADC module to read the analog signal of position, 4) filter to reduce the noise, 4) voltage to position conversion gain to calibrate the position obtained. The Figure 3 depicts 1) USB block communication to read the signal on a computer, 2) PID control block programmed 3) direction of motor block configuration outputs. Figure 4 the PID implementation by Simulink blocks with antiwind-up and PWM configuration.

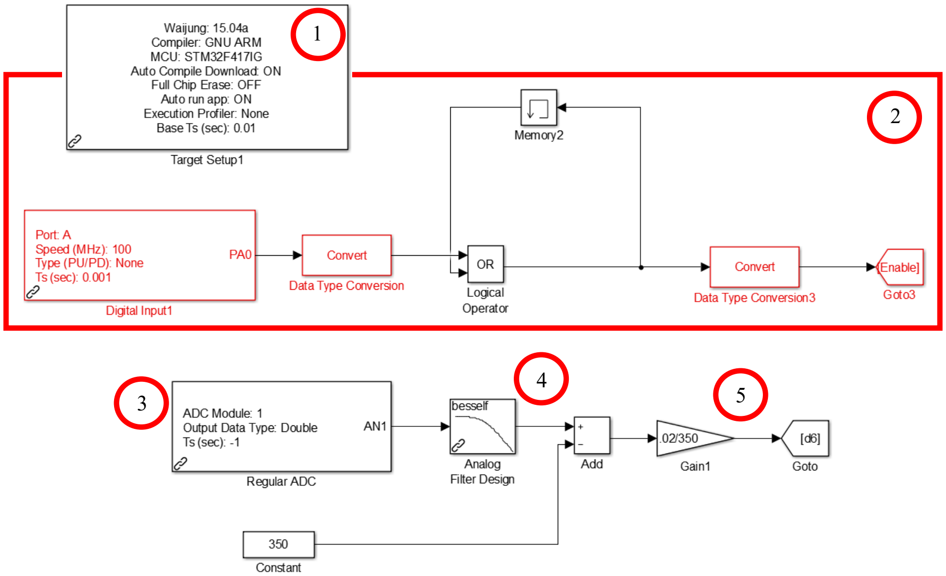

Fig. 2: Waijung block configuration[1], initialize botton[2], ADC module[3], filter[4], voltage to position conversion gain[5].

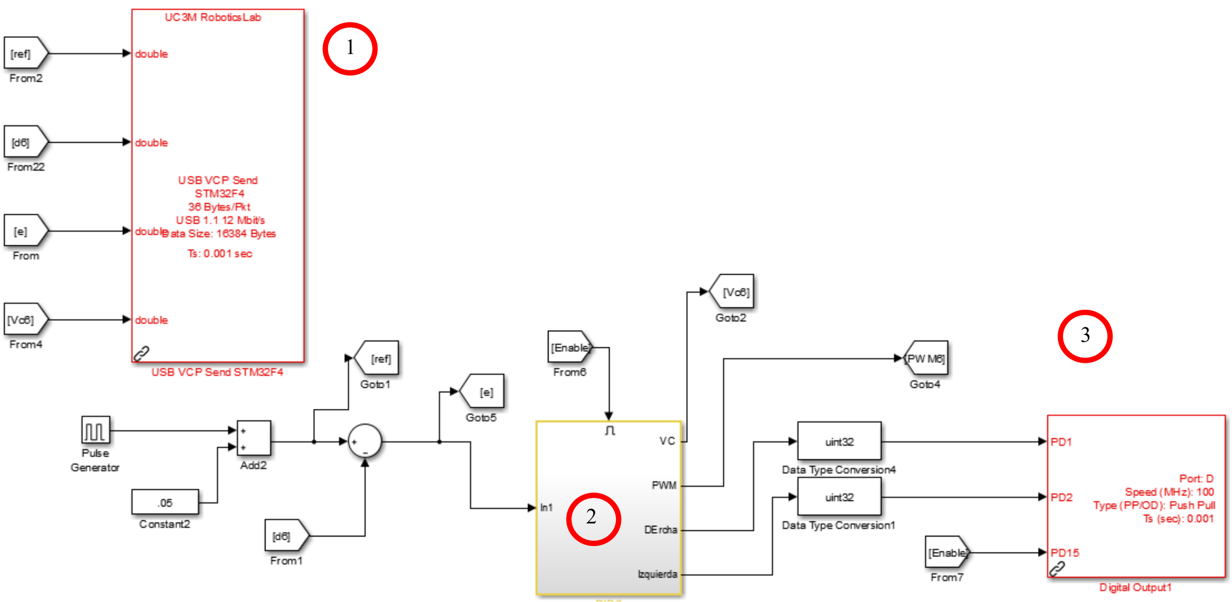

Fig. 2: USB block communication[1], PID Control[2] y PWM Outputs[3].

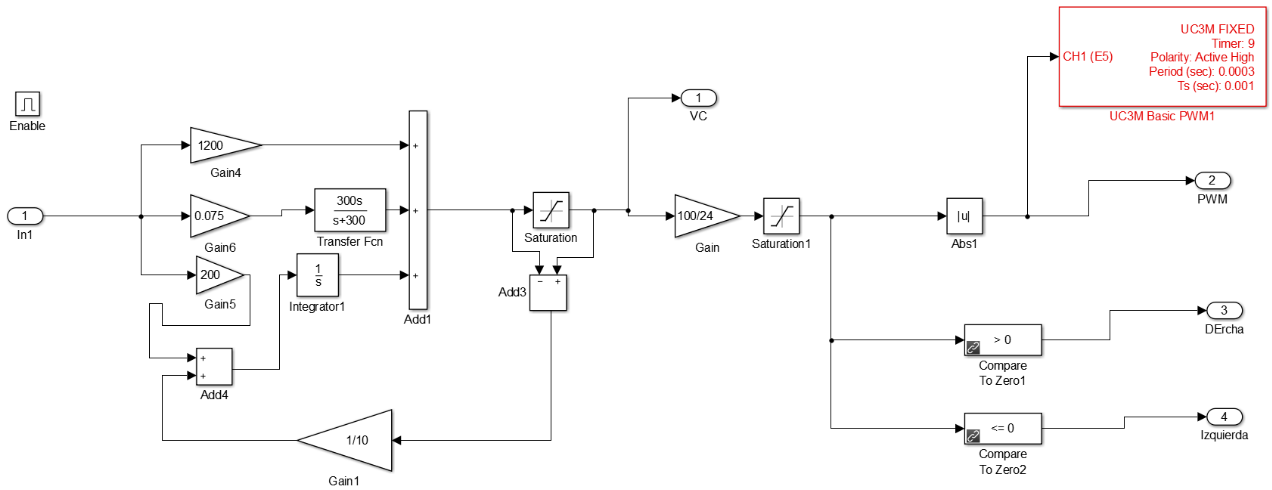

Fig. 3: PID Controller with antiwind up implementation.

4. Experimental Results

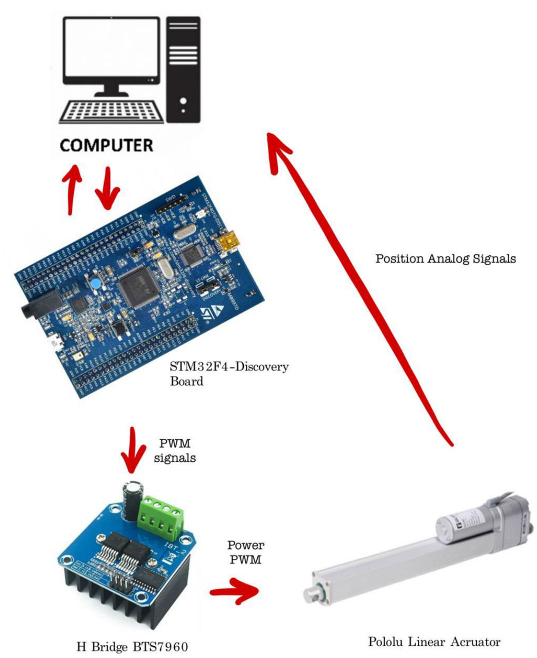

Fig. 4 Experimental block diagram

The control strategy was implemented in the MATLAB-Simulink Software using a sampling time of 0.001 [s] with Euler solver algorithm with the following PDI gains which were chosen with heuristic methodology with the main goal of get the better performance of the system $k_p = 1200$, $k_d = 0.075$, $k_i = 200$. And the tracking time for antiwind-up , $Tt = 10$. Figure 4 shows the experimental implementation with a block diagram where the computer receive the signals, data acquisition target model STM32F4 Discovery obtain the position of the linear actuator, compute the PID controller, and send control signals to the power stage via H bridge which is used to provide power to the DC motor and the linear actuator is used to regulate its position. Figure 5 to Figure 7 show details of the pin connexion in Figure 4. The performance of the linear actuator position using the PID scheme is shown in Figure 8, the tracking error is depicted in Figure 9 and the Figure 10 shows PID control voltage .

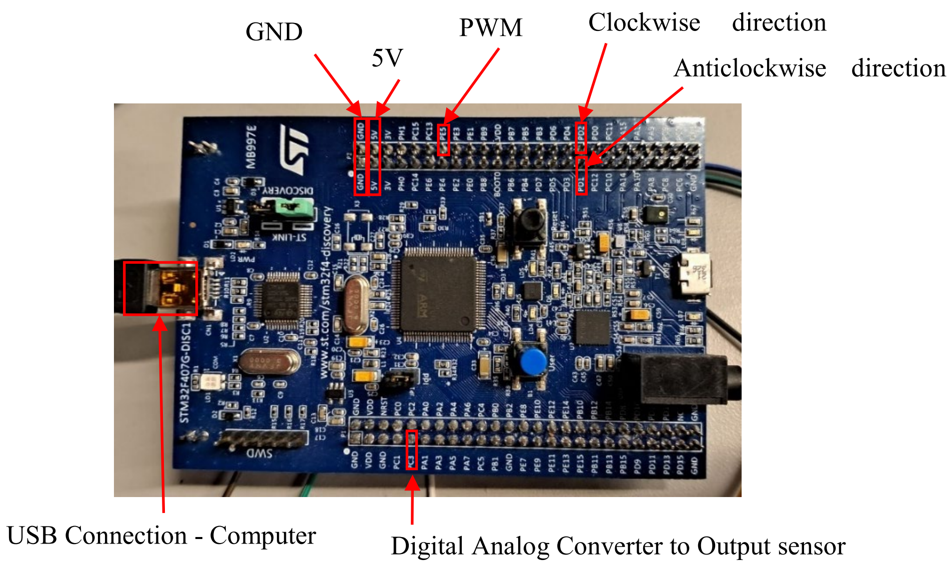

Fig. 5: Mapping of connections in card STM32F4.

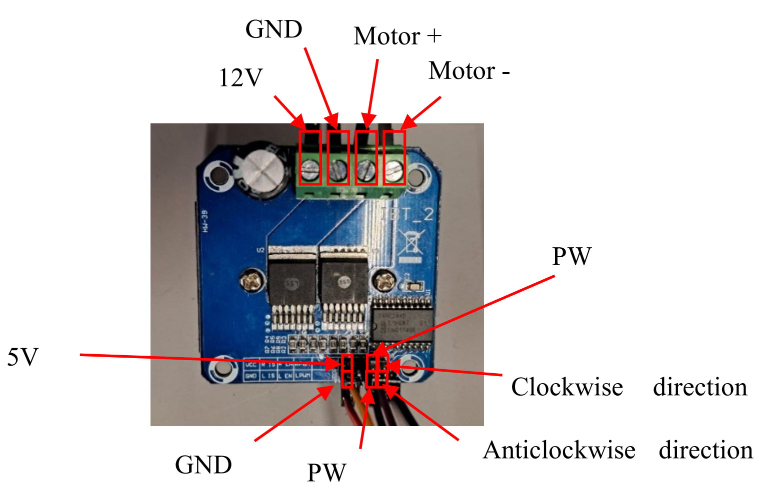

Fig. 6: Mapping of connections H Bridge BTS7960

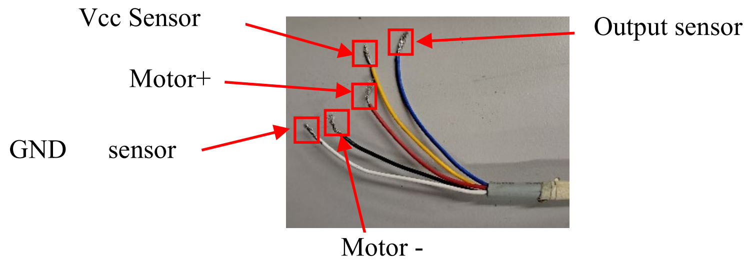

Fig. 7: Mapping of connections of the sensor of linear actuator

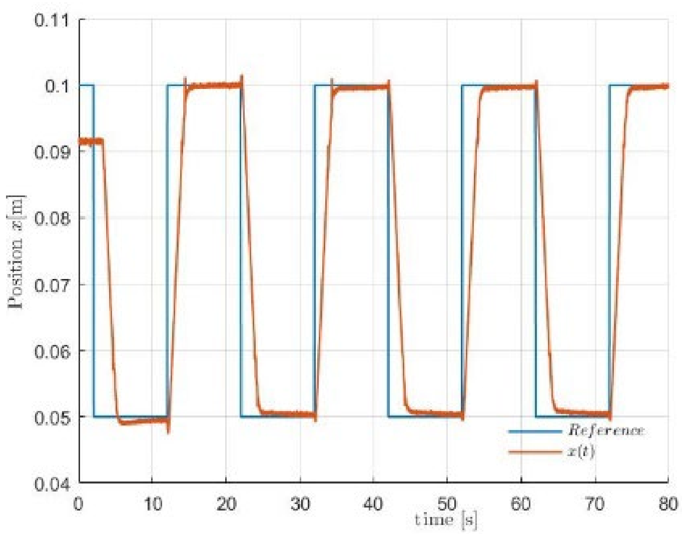

Fig. 8: Position trajectory tracking.

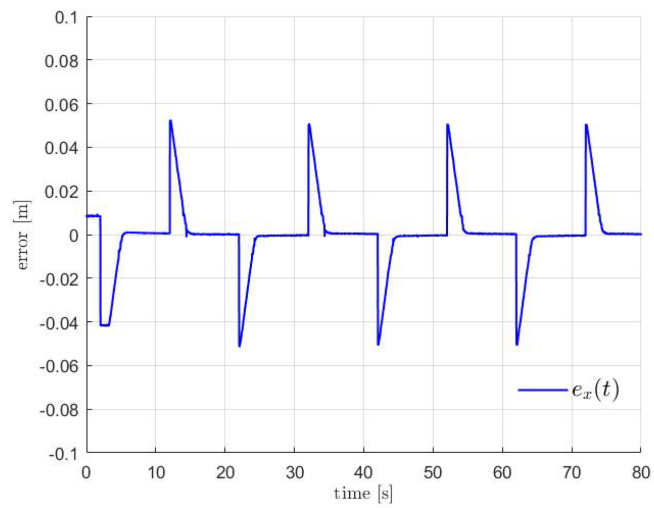

Fig. 9: Tracking Error.

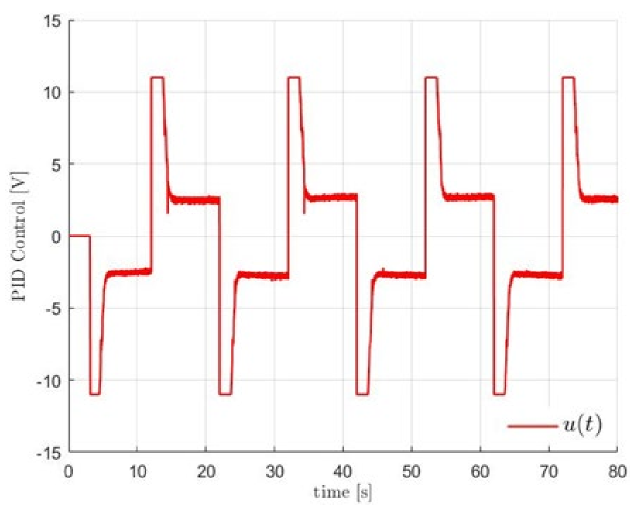

Fig. 10: PID control voltage

5. Conclusions

In this article, a PID controller with antiwind up is implemented to control a linear actuator driven by a dc motor. The PID algorithm was implemented in a real time using data acquisition target model STM32F4 Discovery using a publicly available “waijung1504” MatLab/Simulink the experimental results show good performance in the position regulation task. Six of this PID controllers will be implemented in order to control the position and orientation of a Stewart platform;

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