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Development of Solar Tracking System Using Imc-Pid Controller

[1]Bamigboye O. Oladayo and [2]Adewunmi O. Titus
Department of Electrical and Electronics Engineering, The Federal Polytechnic OFFA, Kwara State , Nigeria

ABSTRACT : *In the past, solar cells are hooked with fixed elevating angles, and it does not track the sun. Therefore the efficiency of the power generation is low. A solar panel receives the most sunlight when it is perpendicular to the sun's rays, but the sunlight direction changes regularly with changing seasons and weather. There is therefore the need to track the solar panel to increase its efficiency. The stability and improved speed of response can only be achieved with appropriate controller to take care of external disturbances and design uncertainty associated with a conventional controller. The IMC controller would be used to allow good tracking ability and good load disturbance rejection*

Unconventional controller like fuzzy logic can be used to tune the PID controller andthe result compared with using a conventional controller like ZN. The internal model control based proportional integral derivative design procedure can be implemented in industrial processes using existing proportional integral derivative control equipment. Modeling of a dual axis solar tracker. An IMC-PID controller was developed for a dual axis solar tracker. The result of this work showed that the IMC-PID controller provided an efficient and commendable improvement in the relative stability, disturbance attenuation, set point tracking and an improved speed of response for the system.

Keywords: *Dual Axis, Solar Tracker, IMC-PID, Solar Cells*

I. Introduction

Solar tracking system is an electromechanical device that is used to turn the solar devices to face the sun as it moves across the sky. By accurately tracking the sun, the incident solar irradiance can be effectively increased (Abdallaha *et al*, 2008). There are three major approaches for maximizing power extraction in solar systems. They are active tracking (fixed control algorithm) method, passive tracking (dynamic tracking) method and the combination of both methods. All these methods needs some form of controller which will be able to control their operation. (Abdallah*et al*, 2014). The proportional-Integral-Derivative (PID) controller which has been implemented successfully in various engineering system is the most widely used in feedback control of industrial processes. However, due to poor tuning by traditional method such as Ziegler-Nichols (1942) and cohen-coon (1953), it has been noticed that the conventional PID controllers may not perform well for the complex processes, such as the higher- order and time-delay systems (Zhao, Liu & Zhang, 2011). Poor tuning of PID controller can lead to mechanical wear associated with excessive control activity, poor control performance and even poor quality products (Adarsh2013). In order to overcome some problems that is faced with PID controller, in this work internal model control (IMC) is employed in tuning PID parameters for the developed model of the sun tracker

The impact of external disturbances and nonlinearities on the dual axis tracker is a risk to the stability of the closed loop system. The solar tracker control using the conventional PID controllers have been used in the past, but the result proved inadequate. Although, a PID controller has only three adjustable parameters, finding appropriate settings for effective control performance is not simple. Therefore there is the need to use a more effective tuning control approachedfor the PID controller in order to overcome this difficulties.

II. Review of Related Works

El-Moghany(2013) designed and constructed a bi-directional solar tracking system. The constructed device was implemented by integrating it with 900V inverter and 12volts, 100AH battery. The amount of power available from a photovoltaic panel was determined by three parameters, the type and area of the materials, the intensity of the sunlight and the wavelength of the sunlight. With advancement in solar panel technology, parameter one, the type and area of the material had been fully improved upon and standardized. In this research work the other two parameters were fully addressed, as this device ensures maximum intensity of sun rays hitting the surface of the panel from sunrise to sunset. Due to the atmosphere the sun energy is not as great in the morning and evening compared to noontime

Farhan*et al,* (2013) designed and constructed an automatic irrigation system powered by PV panels on a laboratory level. A humidity sensor in the soil and temperature sensors in the air were used to check the need for irrigation in order to operate a pump powered by the PV system. This PV system is a two axis solar tracking one. Sensors were installed on PV panels to check the position of the sun so that PV panels are always perpendicular to the sun. This control was made by means of a microcontroller. The whole system was first simulated by ISIS simulation software to validate the final control algorithm to be implemented. A particular attention has been given to the solar tracking system. Experimental study was carried out to evaluate the performance of the tracking system in laboratory by using a light source to simulate the sun. These results showed the validity of the control of the irrigation system and the PV panels were always normal to the light source.

III. Methodology

The simplified block diagram representation of a solar tracking system is shown in Figure 3.1. The solar tracker system requires movement in different directions, and uses electric motors as prime mover, based on this; solar tracker system motor control is simplified to an electric motor motion control. In solar tracking system design, any light sensitive device can be used as input sensor unit. It generates the voltage used to command the circuit to drive the motor; the output gives the rotational displacement of electric motor, which is the motion of solar tracking system

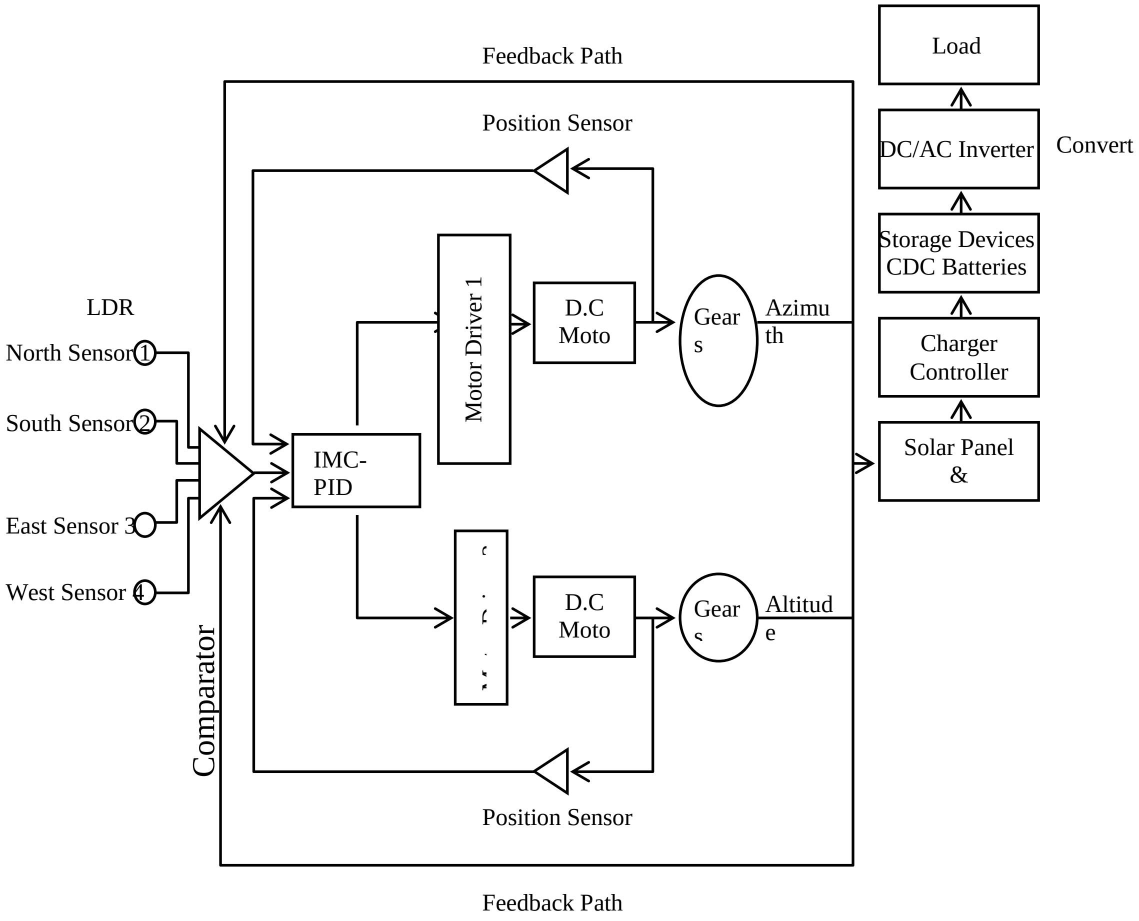

Figure 3.1 Simplified block diagram of a dual axis solar tracker

3.1 Modelling the Solar Tracker

Solar Tracking system is identified based upon the behavior of various dynamic inputs applied to it. The mathematical model of the system was derived from the true behavior of the system for various inputs.

3.1.1 DC Motor

To model a DC motor, simple circuit of its electrical diagram is considered in Figure 3.2DC motor circuit with Torque and Rotor Angle are considered.

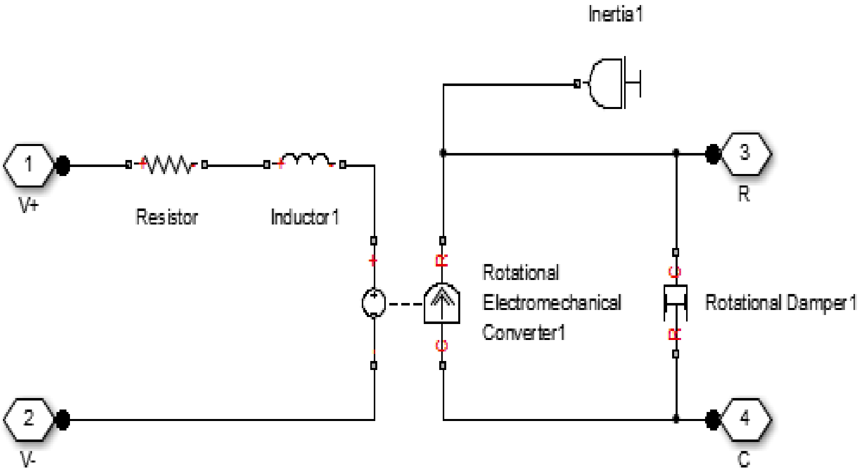

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Figure 3.2: Circuit diagram of the DC motor

The motor torque T is related to the armature current, i, bya torque constant K;

T = K_i 3.1

The generated voltage,e_a, is relative to angular velocity by;

$$e_a = K\omega_m = K\frac{d\theta}{dt} \qquad 3.2$$

From the electric motor circuit diagram we can write the following equations based on the

Newton's law combined with the Kirchhoff's law:

$$J\frac{d^2\theta}{dt^2} + b\frac{d\theta}{dt} = Ki \qquad 3.3$$

$$L\frac{di}{dt} + Ri = V - K\frac{d\theta}{dt}$$

The simulation of the system models was carried out in MATLAB®software environment. MATLAB codes were written to process the stages of the system. By putting these values in the simulink PID controller, theresponse for the step input is obtained. MATLAB is considered for this research because of its ease of use and graphical presentation of results. Figure 3.4 is the complete simulink model for response of PID controller using IMC, CHR, ZN and TL method for time response.

Figure 3.5 is the complete flowchart of the dual axis solar tracker from sensor stage to the

IMC-PID controlling stage.

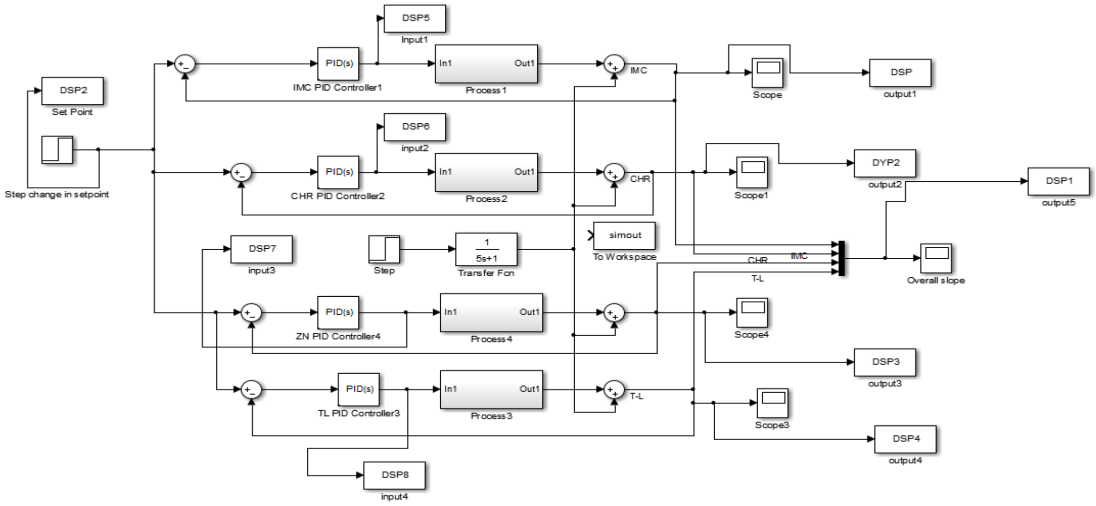

Figure 3.4: simulink model for response of PID controller comparing IMC tuning with CHR, ZN and TL.

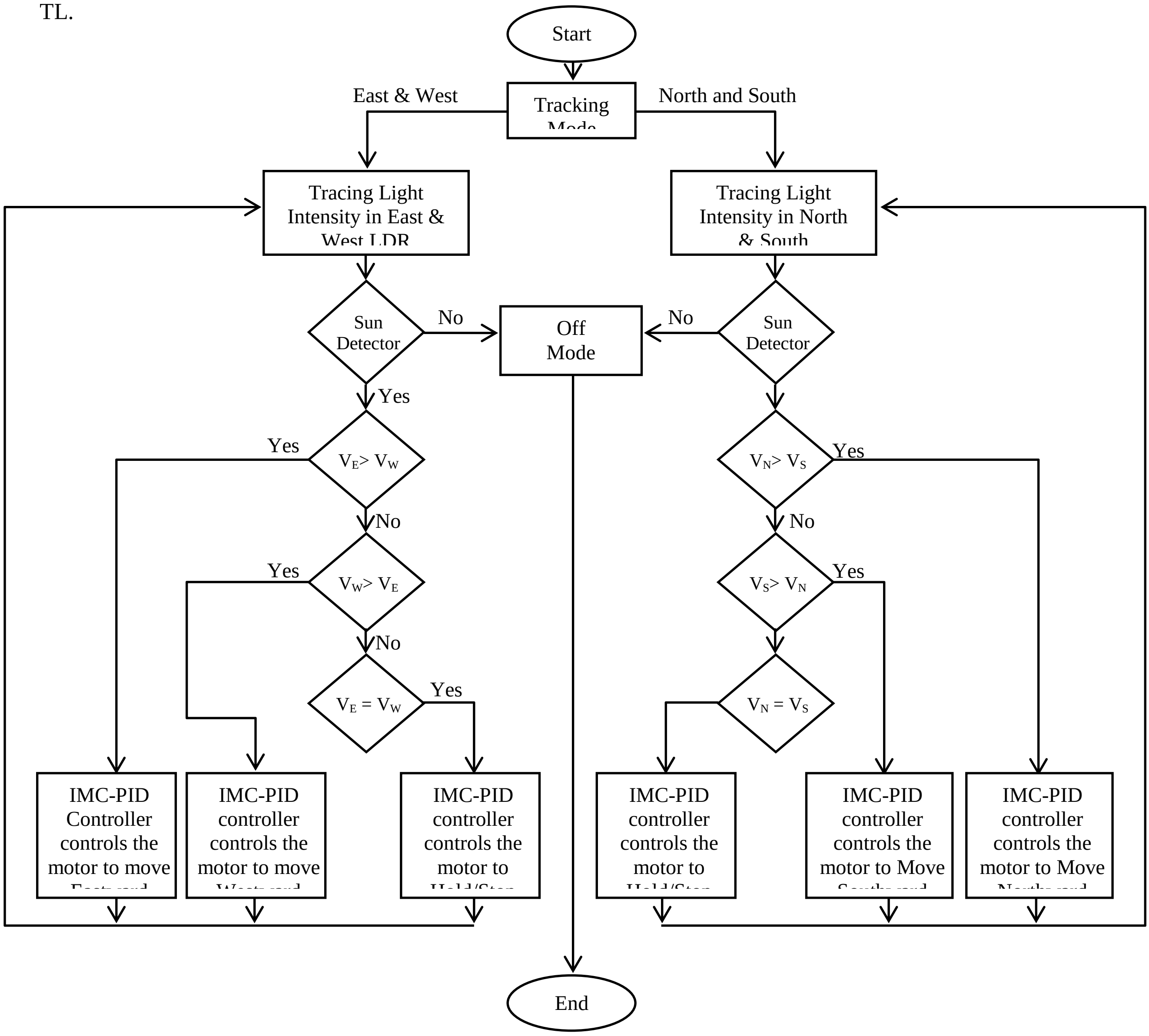

Figure: 3.5 Flowchart of solar tracker

IV. Results and Discussion

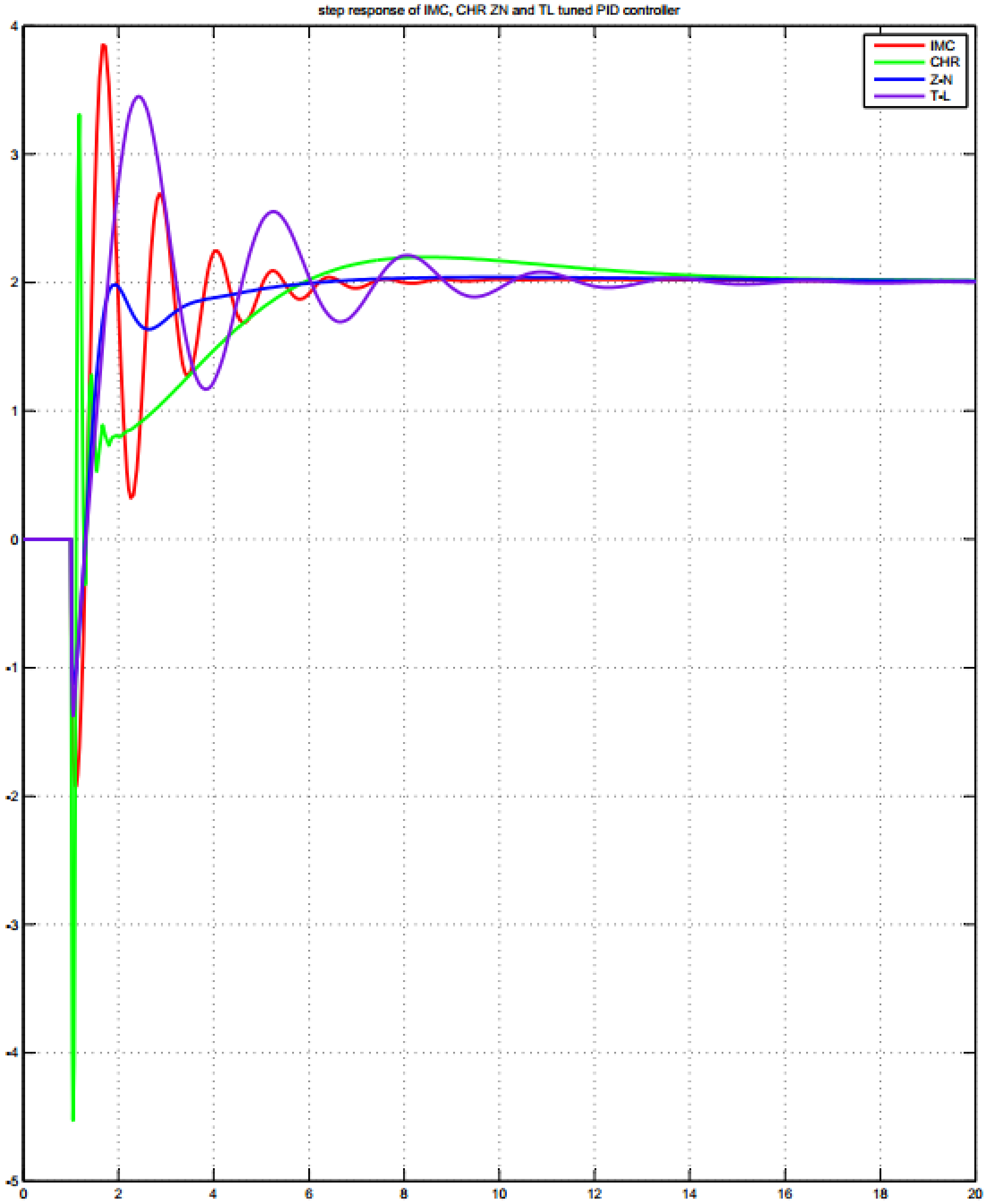

Figure 4.1.5: step response of IMC, CHR ZN and TL tuned PID controller

Figure 4.2.1 show the simulation result for the system rise time and settling time in reference tracking mode for IMC-PID, CHR-PID, ZN-PID, TL-PID. The result gives the rise time and settling time for IMC-PID the fastest at 1.8 seconds and 5.58 seconds respectively. TL-PID gives the slowest rise time and settling time at 9.38 seconds 10.1 respectively.

Figure4.2.2 show the simulation result for the system rise time and settling time for the input disturbance rejection mode for IMC-PID, CHR-PID, ZN-PID, TL-PID. The result gives the rise timeandsettling time for IMC-PID the fastest at 0 second and 7.22 seconds respectively. TL-PID gives the slowest rise time at 4 seconds and CHR-PID gives the slowest settling time at 12.4 seconds.

Figure 4.2.3 show the simulation result for the system rise time and settling time at the input disturbance rejection mode for IMC-PID, CHR-PID, ZN-PID, TL-PID. The result gives the rise time andsettling time for IMC-PID the fastest at 1.8 second and 1.78 seconds respectively.

ZN-PID gives the slowest rise time at 15.9 seconds and TL-PID gives the slowest settling time at 10.1 seconds.

Figure 4.2.4 show the simulation result for the system rise time, settling time and overshoot in controller effort mode for IMC-PID, CHR-PID, ZN-PID, TL-PID.The result gives the rise time andsettling time for IMC-PID the fastest at 1.27 second and 4.72 seconds respectively.

TL-PID gives the slowest rise time at 10.38 seconds and ZN-PID gives the slowest settling time at 26.92 seconds.

Figure 4.2.5 shows the Simulation Result of Overshoot in Reference Tracking, Input Disturbance Rejection, Output Disturbance Rejection and Controller Effort modes. IMC-PID gave the lowest overshoot when the four controllers were compared with the highest and the lowest of the four modes at 7.83% and 1% for controller effort mode and disturbance rejection modes respectively. Likewise in IMC-PID controller, the controller effort mode presented the highest overshoot but presented the least overshoot in other controllers.

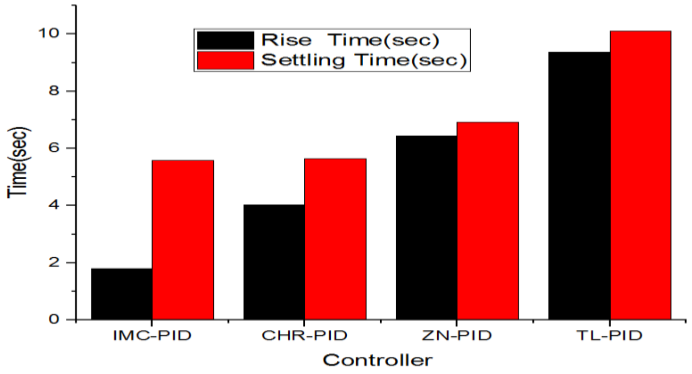

Figure 4.2.1: simulation result for the rise time and settling time for reference tracking model

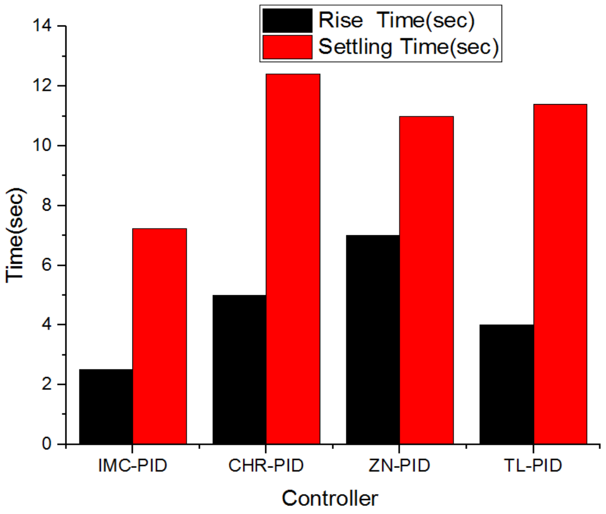

Figure 4.2.2 simulation result for the Rise Time and Settling Time for input disturbance rejection model

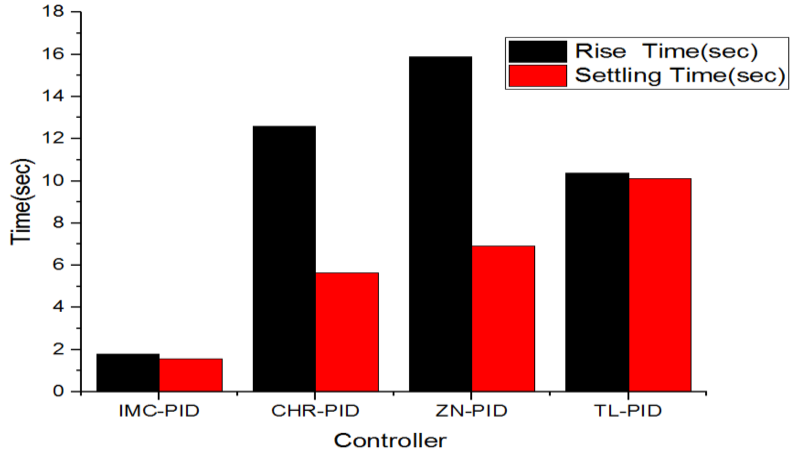

Figure 4.2.3 Simulation result for the Rise Time and Settling Time atoutput disturbance rejection mode

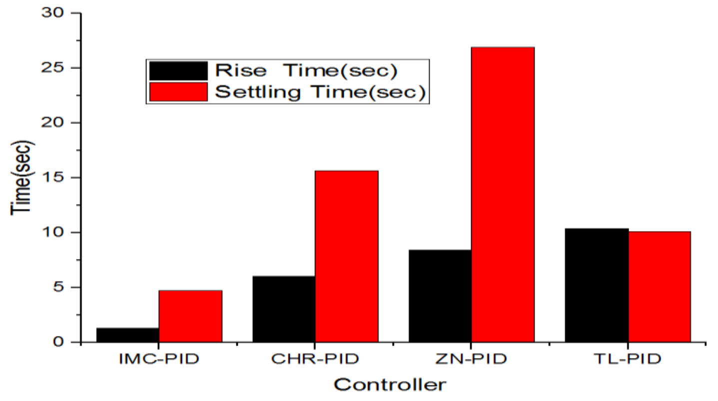

Figure 4.2.4 simulation result for the Rise Time and Settling Time in controller Effort Mode

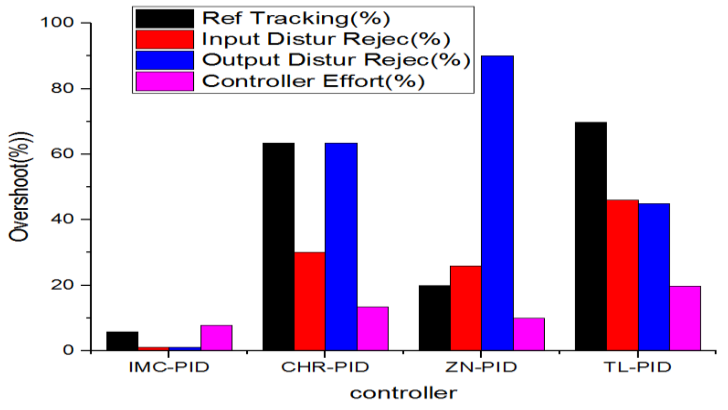

Figure 4.2.5 Simulation Result of Overshoot in Reference Tracking, Input Disturbance Rejection, Output Disturbance Rejection and Controller Effort modes

V. CONCLUSION

This thesis concludes that the Internal Model Controller tuned Proportional Integral Derivative Controller gave the best response in terms of stability and speed of response (rise time and fall time) when compared with CHR, ZN and TL tuned PID for a dual axis solar tracker. The internal model control provides a transparent frame work for control system design and tuning. The internal model control based proportional integral derivative controller design is simple and robust to handle the model uncertainties and disturbances and less sensitive to noise than proportional integral derivative controller for an actual process in industries.

Modeling of a dual axis solar tracker. An IMC-PID controller was developed for a dual axis solar tracker. The result of this work showed that the IMC-PID controller provided an efficient and commendable improvement in the relative stability, disturbance attenuation, set point tracking and an improved speed of response for the system

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