



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 5, May 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

 9940 572 462

 6381 907 438

 ijirset@gmail.com

 www.ijirset.com

Motor Speed Control with Split Range Control Using Labview Myrio

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ABSTRACT: Split-range control for motor speed control is implemented in LabVIEW and on the myRIO embedded device. Split-range control improves motor performance by using various control algorithms in the low and high speed ranges. The paper describes the development of a LabVIEW programme that Simulates the control approach and discusses how it may be extended for real-time hardware interaction with a motor and driver using myRIO.

KEYWORDS: Motor Driver, Split Range, MyRio, Low Speed, High Speed, DC Motor.

I. INTRODUCTION

A Speed motor control station is a system designed to regulate the rotational speed of an electric motor. It typically consists of various components working together to achieve precise and reliable control over the motor's speed.

In General Motor Control Station "PID is a popular feedback control technique that uses the difference between desired and actual values (e.g., speed) to calculate an error signal". It uses derivative, integral, and proportional terms to modify the control output (such as motor voltage) in order to reduce error and get the desired result.

Split Range Control is a control strategy that utilizes two separate control loops each focusing on a distinct operating range (e.g., low speed & high speed). It switches between these loops based on predetermined thresholds.

By using Split Range control in motor control station we can vary the load conditions, it is suitable for wider speed ranges.

II. DESIGN OF PID CONTROLLER

PID CONTROLLER :

The PID controller calculates a control signal (output) based on the difference (error) between the desired speed (setpoint) and the actual motor speed (feedback). The control signal is then sent to the motor driver, regulating the power delivered to the motor and influencing its speed.

PID Controller Tuning :

PID control is a popular and adaptable feedback control method utilised in many different automation systems, such as motor speed control. The difference (error) between a planned setpoint and the actual system measurement (feedback) is used to calculate a control signal, or output. After that, the system's behaviour is modified with the help of this control signal to get it closer to the intended state. For This Split Range Control Ziegler Nichols Method has been used.

Ziegler-Nichols Tuning :

The Ziegler-Nichols tuning method is a heuristic approach used to determine initial parameters for a PID controller. It's based on observing the system's response to a step input and using specific criteria to derive the proportional, integral, and derivative gains



Controller	K_p	K_i	k_d
P	$K_u/2$	-	-
PI	$K_u/2.2$	$P_u/1.2$	-
PID	$K_u/1.7$	$P_u/2$	$P_u/8$

Fig 1 . Table of Ziegler Nichols Tuning Method

PID Values From Ziegler Nichols Method :

By using the transfer function, obtain K_u values in using MATLAB software and using of formula from the table 1 to calculate the optimal values of PID controller using of ZN method

CONTROL MODES	K_p	T_i	T_D
P	3.14	-	-
PI	3.21	8.31	-
PID	4.16	4.94	1.247

$K_u = 7.08$,
 $P_u = 2\pi/w$ $P_u = 9.98$

Mathematical Model of DC Motor :

A mathematical model of a DC motor represents its electrical and mechanical behavior through a set of equations. This model allows us to predict the motor's speed, torque, and current based on the applied voltage and to analyze the system's performance under various conditions.

For first order transfer function for the process Station is defined as :

$$\frac{H(s)}{Q(s)} = \frac{R}{[\tau s + 1]}$$

For DC Motor :

The torque is proportional to current as a following.

$T = K_t i$

The back emf e , is related to the rotational velocity by the following equation:

$e = K_e \dot{\theta}(t)$

In SI units *Type equation here.* (which we will use), K_t (armature constant) is equal to K_e (motor constant).

From the figure above we can write the following equations based on Newton's law combined with Kirchhoff's law can be written as follows:

J. $\ddot{\theta}(t) + b. \dot{\theta}(t) - K_e .i(t)$

L. $\frac{di}{dt}(t) + R. i(t)=V(t) K. \dot{\theta}(t)$

Using Laplace Transforms, the above modeling equations can be expressed in terms of operator(s)

$(Js + b). \theta (s) = K. I(s)$

$(Ls + R).I(s) = V(s) - K. \theta (s)$

From equation (5):



$$I(s) = \frac{(Js+b)\theta(s)}{K}$$

Substitute equation (7) into equation (6) to get:

$$\frac{(Ls+R)(Js+b)\theta(s)}{K} = V(s) - K \theta(s)$$

From equation (8):

$$\frac{\theta(s)}{V(s)} = \frac{K}{(Ls+R)(Js+b)+K}$$

Parameters	Values
R	5.2 Ω
L	1.1 mH
J	0.01 kg.m
b	0.02 N.m.sec/rad.s ⁻¹

The First Order Transfer Function Of DC Motor :

$$G(s) = 32.9 s / \tau s + 1$$

Where K = 32.9

III. SYSTEM DESIGN

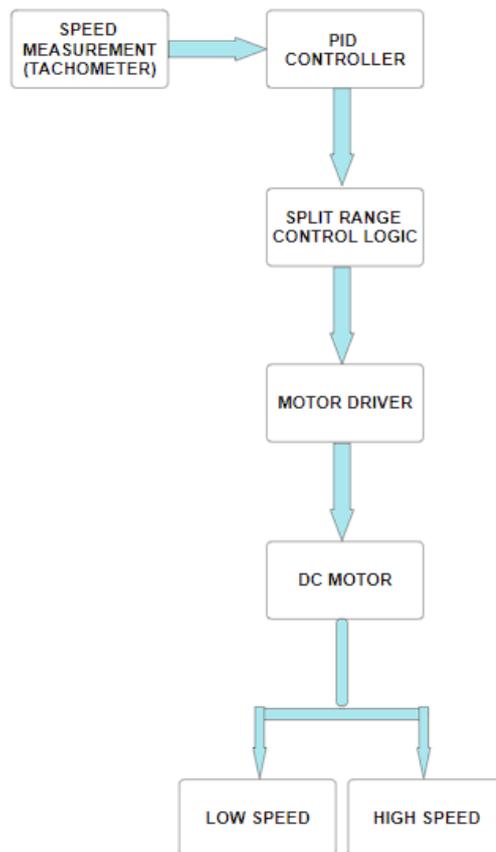


Fig 2. Block Diagram of Simulation Model

Tachometer :

In control engineering, a tachometer is an essential tool for determining the speed at which machinery parts rotate. It delivers real-time speed data necessary for performance monitoring and optimization by detecting pulses produced by rotating parts. In industrial settings, tachometers are essential for the safe and effective operation of engines, motors, and other machinery.

PID Controller :

The proportional, integral, and derivative control actions are combined by the PID controller to produce the intended system response. Based on the current error, the proportional term makes a quick correction; over time, the integral term reduces steady-state error; and the derivative term predicts future error patterns, improving stability and responsiveness.

Split Range Control :

Split range control is a technique used in process control systems to manage a variable that runs across a large range by combining numerous controllers with various setpoints. Split range control can be used in DC motor control to efficiently manage motor speed over a wide range of operating situations.

Improved Performance at Low Speeds :

At low speeds, precision control and minimising control signal fluctuations are essential. Split-range control enables tuning specifically for these requirements. This can be accomplished by employing a PID control method with a lower proportional gain (K_p) for smoother control and a greater integral gain (K_i) for increased accuracy at low speeds.

Enhanced Response at High Speeds :

At high speeds, faster response and stability become increasingly crucial. Split-range control allows you to tune the PID algorithm specifically for this region. A larger K_p can be utilised for faster response, possibly in conjunction with a lower K_i to prevent excessive overshoot when nearing the desired speed.

Motor Driver :

In order to efficiently drive motors, control systems require a motor driver, which converts control inputs into power outputs. In order to precisely control motor speed and torque, it is essential for controlling voltage, current, and direction. H-bridge and brushed or brushless DC motor drivers are two examples of the several types of motor drivers available; each is made for a particular kind of motor and its control requirements.

IV. METHODOLOGY

Simulation of controller model in Matlab:

- Develop the controller model using Simulink, integrate it with the system being controlled.
- Configure simulation settings and scenarios, analyze results to evaluate controller performance.

Process parameters analyzing:

- Through the utilization of MATLAB, we acquire and analyze the process parameters of our simulation model.
- Through this process, we can calculate the performance of the controller and identify areas for improvement to achieve a more stable controller model.
- **Monitoring and Maintenance:** Monitor the performance of your deployed system and address any issues or anomalies that arise. Periodically update your models and algorithms with new data and improvements to maintain their effectiveness over time. Continuously gather feedback from users and stakeholders to refine and enhance the system's functionality and usability.

LabVIEW Implementation:

Program Design:

Front Panel:

- Setting desired speed (numeric control).
- Displaying actual speed (indicator) - data from myRIO .
- Starting/stopping control loop (simulation or real-time control).
- Optional: Indicators for active speed range (low/high).

Block Diagram:

- **Desired Speed Input:** Reads the desired speed value from the front panel.
- **Split-Range Logic:** Compares the simulated/actual speed (depending on project stage) with a threshold value to determine the active speed range (low/high) using a comparison function (e.g., ">").
- **Control Algorithm Selection:** A case structure directs the program flow to the appropriate subVI based on the speed range.
- **Control Algorithm SubVIs:** Separate subVIs implement the PID control algorithm with:
 - Low-speed optimized tuning parameters (lower Kp for smoother control, higher Ki for better accuracy).
 - High-speed optimized tuning parameters (higher Kp for faster response, potentially lower Ki to avoid overshoot).
- **Output Display (if not using real hardware):** Displays the calculated control signal for visualization during simulation.

Transitioning to Hardware:

The program logic can be adapted for real-time hardware interaction with a motor and driver using myRIO.

- **myRIO Integration:** The myRIO interfaces with the motor driver and speed sensor.
- **Data Acquisition:** LabVIEW functions acquire actual speed data from the sensor connected to myRIO (e.g., analog input for tachometer output or counter for encoder pulses).
- **Real-Time Control:** The split-range control logic executes on the myRIO, selecting the appropriate control algorithm (low or high speed) based on the actual speed feedback.
- **Output Control:** The calculated control signal is sent from myRIO's analog output or PWM channels to the motor driver, regulating the power delivered to the motor and achieving the desired speed

V. RESULTS

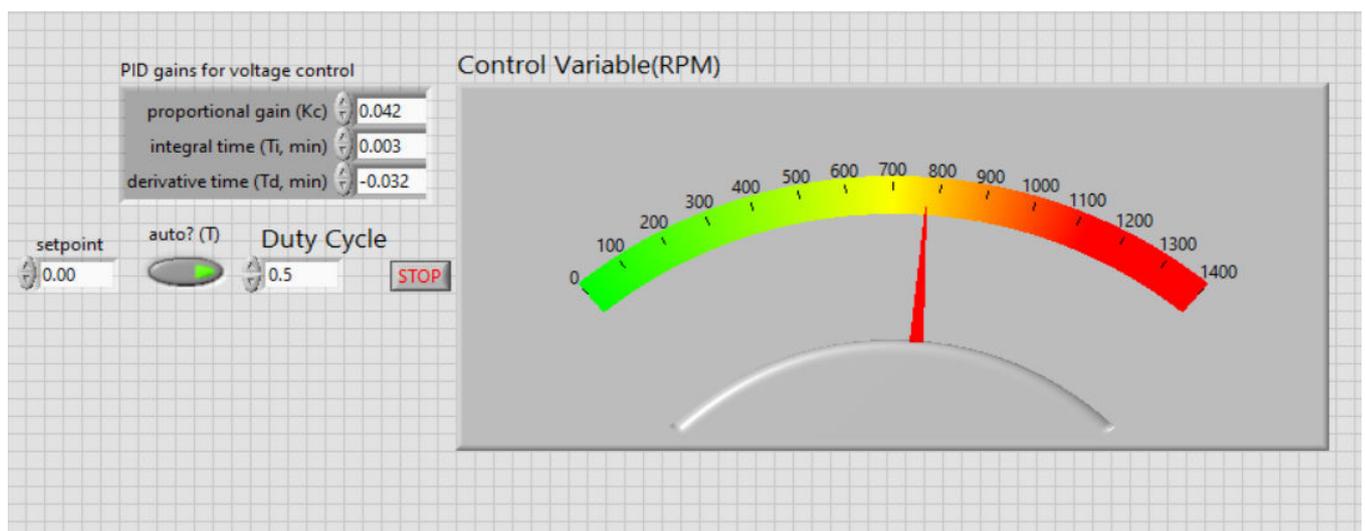


Fig 3. Front Panel of Labview Program

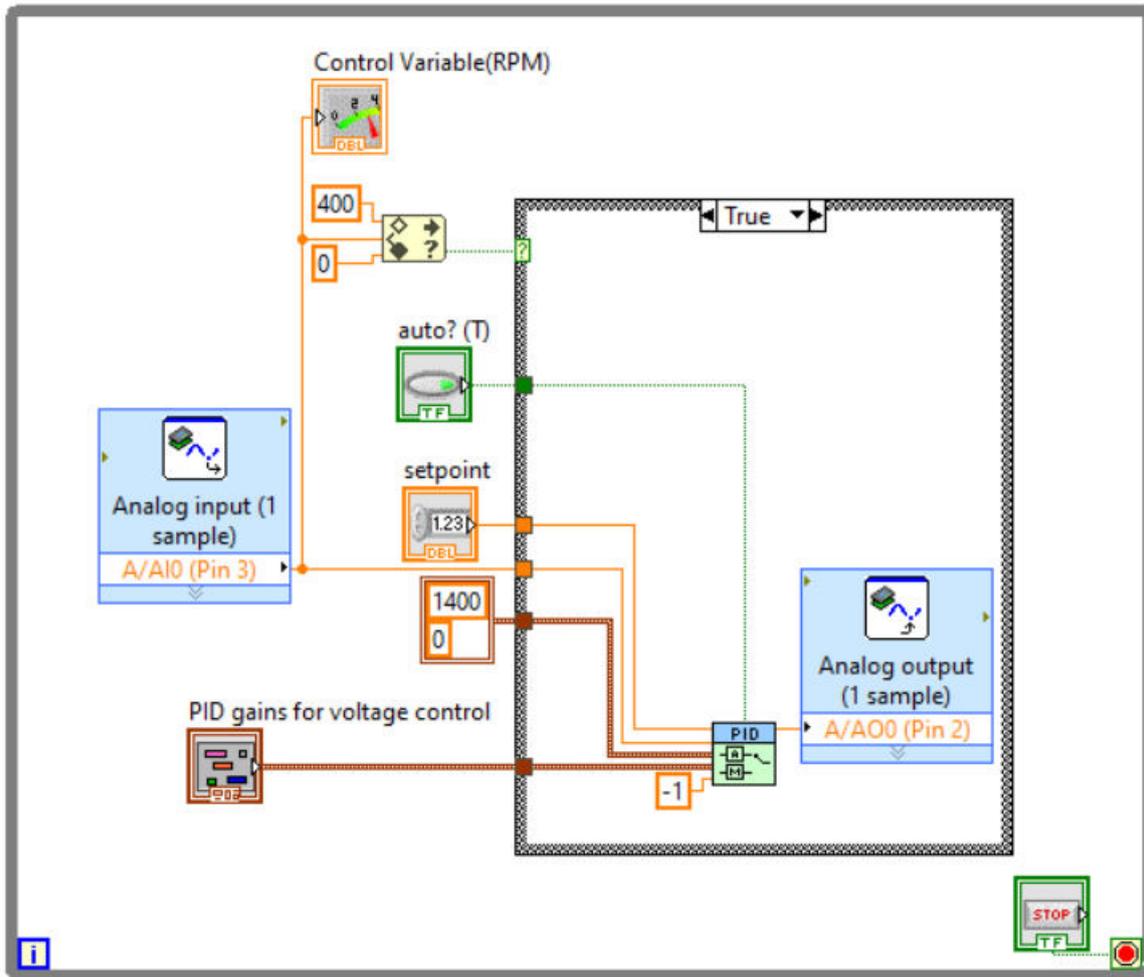


Fig 4 . Block Diagram of labview Program

VI. CONCLUSION

- With LabVIEW and myRIO, split-range control provides an adaptable method of regulating the speed of a DC motor. Below is an overview of the main conclusions and possible next steps.
- Increased Control Accuracy: You may have more precise control over the behaviour of the motor in each operating range by using different PID control VIs for the low- and high-speed zones.
- Enhanced Performance: By enabling optimised control techniques in various speed ranges, split-range control may be able to increase system performance as a whole.

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