Control of Twin Rotor MIMO System Using 1-Degree-of-Freedom PID, 2-Degree-of-Freedom PID and Fractional order PID Controller

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***Abstract*—The aim of this work is to design a speed controller of a DC motor by tuning PID controller. To get an output with minimum errors, we selected PID parameters using bio-inspired optimization technique of Genetic Algorithm. The second order system is used here for speed control. In this work bio-inspired optimization technique in controllers and their advantages over conventional methods is discussed using MATLAB/Simulink. DC motor is interfaced with Arduino via Motor driver circuitry. Discrete-Time Reduced-Order GPIO (we used GPIO PWM pin of Arduino) with Genetic algorithm calculates parameter of PID controller and according to those parameters Arduino controls DC motor. This proposed optimization methods could also be applied for higher order system to provide better system performance with minimum errors.**

Keywords— *GPIO, MPC, Speed regulation, Genetic Algorithm*

I. INTRODUCTION

DC motors are comprehensively used in various mechanical applications, like servo control and traction tasks [1] [3], because of their superiority in reasonability, force, and the customary relative straight forwardness in the preparing of legitimate analysis control schemes. However, an abrupt transient issue like assortments in the voltage, current, and jaunty speed of the motor shaft may occur while starting DC motors [2]. Additionally, the standard method for applying PWM (Pulse Width Modulation) [1] [2] hails similar disadvantage as the dynamic lead of motor armature voltage presents similar undesired issues. Such drawbacks can be tended to by using DC/DC power converters. These converters [5] [6] guaranteed the smooth start of a DC motor by applying the vital voltage according to the mentioned task. In DC/DC Buck converter, its essential takes care of segments decrease the riotous shape realized by the hard trading of the PWM [2]. Thus, in order to deal with the speed of the DC/DC Buck converter-DC motor structure [8] [9], another Discrete-Time Reduced-Order General purpose input-output (GPIO) is proposed. To improve proposed estimation we are using Genetic Algorithm.

II. LITERATURE SURVEY

An electrical DC drive is a blend of controller, converter and DC engine. Yang et al [1] utilized chopper as a converter. The output speed is compared with the reference speed and the error signal is generated for speed controller. Controller output fluctuates if there is any difference in the reference speed and the input speed.

V. M. H. Guzman et al [2] presented speed control of a brushed DC-motor when excited utilizing a DC to DC Buck power converter. Proposed controller is asymptotically steady as long as the DC power gracefully can give the required voltages at the converter inductor and capacitor. The proposed method is the least complex controller proposed in the writing with solid verification for control issue. In addition to this, the necessary number of calculations is little and they are basic.

S. Khubalkar et al [3] proposed advanced Fractional Order Proportional Integral Derivative (FO-PID) controller for speed control of buck converter for controlling speed for DC motor. Ideal shaft zero calculation technique in discrete structure is proposed for acknowledgment of advanced fractional order controller. The stand-alone controller is executed on initial stage utilizing Digital signal processor TMS320F28027. The five tuning boundaries of controller improve the presentation of control conspire. For tuning of the controller boundaries, dynamic molecule swarm streamlining procedure is utilized.

G. Rigatos et al [4] proposed a strategy for nonlinear control of the dynamical system that is shaped by a DC–DC converter and a DC motor, utilizing differential flatness hypothesis. It is demonstrated that the aforementioned system is differentially level which implies that all its state vector components and its control information sources can be communicated as differential function of primary state variables which are characterized to be the framework's flat outputs.

T. K. Nizami et al [5], proposed control scheme which appeared to gives a general output execution with upgraded power for wide varieties in load force and set-point changes, contrasted with existing regular methodologies dependent on adaptive backstepping. The hypothetical recommendations are confirmed on an exploratory model utilizing dSPACE, Control board DS1103 interfaces with an imbuilt TM320F240 Digital Signal Processor demonstrating its appropriateness to continuous electrical system. The proficiency of the proposed technique is measured utilizing execution gauges and is assessed against the customary Adaptive backstepping control (ABSC) approach.

S. Malek [6] introduced a novel, nonlinear control plot for the duty ratio contribution of the boost converter fed dc engine. The proposed control procedure broadly analysed and tentatively tested. The proposed plan however nonlinear, brings about a basic plan, guarantees that the duty ratio achieves esteems not only in the allowed run, but accomplished exact speed regulation even in instances of high unknown load disturbances. The DC-DC help converter is one of the most straightforward force electronic gadgets that have not been at this point abused in a wide scope of modern applications because of control plan troubles brought about by its model innate exceptional structure. Such a mechanical application is the DC engine speed guideline that is concentrated in the current work. Especially, in this article, a novel, non-straight control schemes for the obligation proportion contribution of the converter is proposed, which is broadly broke down and tentatively tried.

G. C. Konstantopoulos and A. T. Alexandridis [7] proposed structure an exceptionally straightforward plan, guarantees that the duty ratio takes esteems solely in the allowed range [0,1), accomplishes exact speed guideline even in instances of high load disturbances, and doesn't rely upon system parameters and states. At the same time, the design is detailed in a way that gives a closed-loop passive system, which, as demonstrated in the article, fulfils every one of these presumptions and properties that make conceivable the application of another progressed non-direct strategy that strongly connects passivity with stability.

R. S. Ortigoza et al [8] introduced a DC/DC power converter based control, to illuminate the motor shaft related with the bidirectional DC/DC Buck power converter -DC motor system. Specifically, the exact tracking error dynamics passive output feedback (ETEDPOF) strategy is utilized. The required nominal trajectories for the synthesis of the ETEDPOF-based control are characterized by methods for the system differential flatness property.

R. S. Ortigoza et al [9], proposed the new modelling DC/DC Boost power converter-inverter-DC motor that permits bidirectional rotation of the engine shaft. Toward this path, the system numerical model is created thinking about its distinctive activity modes. Thereafter, the model approval is performed by means of utilizing Matlab-Simulink.

V. H. G. Rodriguez et al [10] explained the direction following control for the DC/DC Boost converter-inverter-DC engine. In the control structure, the exact tracking error dynamics passive output feedback (ETEDPOF) system is utilized. In this way, a control that doesn't require electromechanical sensors for its execution is yield. The age of the reference directions, required by the control dependent on the ETEDPOF, is accomplished by means of differential evenness.

A low cost technique of controlling the speed of the DC motor is adopted by Pratap S Vikhe et al in [11]. DC motor is interfaced with PID Controller in LabVIEW via ATmega 8A Microcontroller. Speed of motor is calculated using infrared sensor, whose output is given as feedback to PID. The feedback is used for calculating and compensating the error produced.

B. S. Shukla et al [12] developed A BLDC motor controller model in the Matlab Simulink. The speed of motor is varied with different values E.g. 1000; 2000 RPM and comparison were carried for BLDC motor with open loop technique, PID controller, PID controller with ANN. Also the performance index based on overshoot, rise and settling time were calculated and compared. The simulation results shows that combination of PID and ANN provides improved performance response compare to traditional PID controller for nonlinear dynamic environment.

P. S. Vikhe et al [13] examined the performance comparison of PID controller. Results obtained for PID controller parameter tuning ABC optimization approach is found to be best. In this approach rise and settling time required is less. Since, for higher order and complicated systems traditional controllers are not suitable and recommended.

III. PROPOSED SYSTEM

The DC-DC buck converter is utilized as the starter of the changeless magnet dc engine to direct rakish speed in this paper. It is commonly realized that the speed control calculations of dc engines are less expensive and less difficult than those of air conditioning engines. In the interim, the speed of the dc engine can be directed over a huge range, both underneath or more appraised speed can be effortlessly accomplished.

The most testing control issue is that it is important to keep up as precisely as conceivable of the speed even within the sight of force aggravations presented on the pole of the dc engine. So as to tackle this issue, we have to have some information on the force unsettling influences. In any case, because of the challenges of direct estimation, for instance, the expense of the force sensor is over the top expensive, clamors incited by estimation will carry some terrible impacts to the shut circle framework, etc. Estimation has become a mainstream way to deal with measure the estimation of the force unsettling influence following up on the pole of the dc engine. Diverse exploration works have demonstrated its legitimacy.

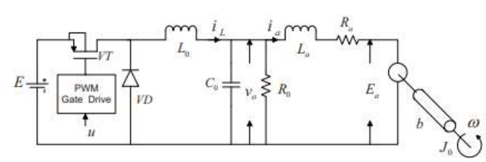

Fig.1.Circuit of DC-DC Buck Power Converter-DC Motor

Consider a dc-dc buck power converter going about as a smooth starter of perpetual magnet dc brush engine in Fig. 1. The framework has two segments: a conventional PWM-based DC-DC buck converter and a perpetual magnet dc brush engine with its armature circuit. The buck converter including a dc input voltage source E, a PWM entryway drive controlled switch V T , a diode V D, a channel inductor L0, a channel capacitor C0 and a heap resistor R0. The changeless magnet dc engine including an armature inductance La, an armature (or rotor) winding opposition Ra, an actuated electromotive power Ea. The dynamic model is given as

$$L_0\frac{di_{L_0}}{dt}=-v_0+\mu E, \qquad L_0\frac{di_{L_0}}{dt}=-v_0+\mu E,$$

$$C_0\frac{dv_0}{dt}=i_{L_0}-\frac{v_0}{R_0}-i_a, \qquad C_0\frac{dv_0}{dt}=i_{L_0}-\frac{v_0}{R_0}-i_a,$$

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$$L_a\frac{di_a}{dt}=v_0-R_a i_a-k_e\omega L_a\frac{di_a}{dt}=v_0-R_a i_a-k_e\omega \tag{1}$$

$$Speed\ Regulation=\frac{(Nnl-Nfl)}{Nfl}x\ 100\%$$

where iL is the inductor current of the buck converter, vo is the converter yield voltage, ia is the dc engine armature circuit current, ω is the rakish speed of the engine shaft, ke is the counter electromotive power steady, km is the engine force consistent, J0 is the snapshot of idleness of the rotor, b is the gooey rubbing coefficient of the engine, τL is the heap force. The obligation proportion u(t) ∈ [0, 1] speaks to the control signal. In addition, the reference rakish speed is characterized as ω∗(t). It is wanted to have the yield precise speed ω(t) asymptotically track the given reference direction ω∗(t), paying little heed with the impacts of the obscure, however limited burden force τL(t). Block diagram of proposed system is shown in fig 2.

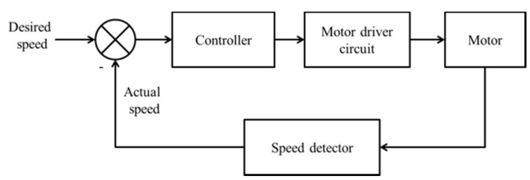

Fig.2. Proposed system

In this paper, speed of DC motor with 30RPM is controlled using hardware (Arduino Uno, MDC and IR sensor) and software (Arduino IDE and Python). Here genetic Algorithm is used to control speed. As shown in figure 2, speed is fed to controller, controller commands motor to drive on particular speed. Output from controller is insufficient of driving motor hence we have used motor driver circuit. Detail explanation is given in following section. IR sensor and GA algorithm constitutes speed detector and speed estimator circuit respectively.

IV. CONCLUSION

A practically silly discrete-time strong prescient speed guideline calculation for a nonexclusive DC-DC buck power converter-driven DC engine. A discrete-time decreased request GPIO has been proposed to assess unmeasur-capable virtual states and lumped unsettling influences and vulnerabilities. With the assistance of GPIO and GA, the speed later on forecast skyline has been anticipated to encourage MPC structure. The information requirement on the job proportion has been forced on the retreating skyline enhancement process, which at long last gives the vigorous prescient speed guideline law.

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