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Modelling and Control of Hybrid Stepper Motor using LabVIEW

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Abstract: In recent years motors have been playing key role in many applications viz, industrial, transport, military etc. The stepper motor has varied applications from low level to high torque applications. The main disadvantage of the stepper motor is to control it for its Step angle and its ripples. In our paper, we have modeled and developed a prototype which is simulated using MATLAB and the motor is triggered and controlled using LabVIEW and Arduino. The MATLAB platform helps to develop the controlled parameter for LabVIEW, which in turn provide controlled, non-harmonic output.

Keywords: Stepper Motor, MATLAB, LabVIEW, Ardunio

I. INTRODUCTION

Despite strong competition from servo systems, hybrid stepper motors remain the preferred solution for many applications as they can provide accurate position and speed control in an open-loop system. However, they provide a challenge to the motor designer in two respects. Firstly, they are a truly 3-d device, the main flux taking both radial and axial paths, and secondly, they are designed to operate under highly saturated conditions in order to achieve a competitive torque per unit volume [1]. A simple FOC without DQ transformation is developed for the position tracking of PMSMs [5]. An approach for applying EKF to a drive-in order to estimate a hybrid stepper motor's position when the drive is connected to the motor by long cables is developed [6]. A stepper motor of required torque is excited with digital input pulse, and it rotates through a particular angle. In addition to this, open loop control of motor further makes it effortless to control its movement. However, closed control becomes essential when acceleration with variable loads is involved [1]. Stepper motor can accept digital signal directly, without having D/A converter, so that computer control of stepper motor is very convenient.

At present , the acceleration and deceleration process is using linear law to control .In this method, pulse frequency changes have a constant acceleration, but the torque of stepper motor with the increase in pulse frequency decreased, So the linear law speed control curve is not the ideal rising and falling speed control curve [2].Because of high precision of positioning ,no cumulative error and low cost of the driver ,stepper motor are widely used in some automation system .In addition to the development of modern industry ,there are more and more requirements of precision and high speed performance of using the stepper motor as driver system. The control mode of stepper motor is thus gradually developed into closed loop control and adopts high efficient controller to get better performance as comparing to open loop control [3].

Stepper motors are also known as step motors, are used in industrial robots, computer numerical control machines,3D printing machines, instruments used in laser and optics, varies medical robots and space robots.

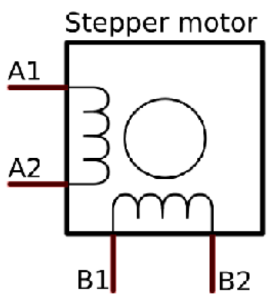

Figure (1.1) Cross section of hybrid stepper motor

The advantages of using stepping motors in open-loop positioning control systems don't exclude certain limits of frequency at motor acceleration and deceleration. The improvement of stepping motor dynamic performances is achieved by its control based on variable frequency upon a given law.

A. Motor specifications

Table 1 specifications of hybrid stepper motor

DESCRIPITION	RATINGS
Step angle (degree)	1.8
Rated current (A)	1.7
Phase resitance (ohm)	1.2
Phase Inductance (mH)	1.8
Holding Torque	28
Detente Torque	1.6
Motor weight	220

II. MATHEMATICAL MODELLING

A Mathematical model is a description of a system using mathematical concepts. A model may help to explain a system in a better way to investigate the effect of different components and to make predictions about behavior. Dynamic models are typically represented as differential equations or difference equations.

A. Voltage Equation

The voltage equation of the phase k is,
$U_K = R_K I_K + d\varphi_{K/dt,}$
K = 1,2,3…
φ_K – total flux that flow through phase K
$\varphi_K = \sum^{M}_{J=1} L_{Kj} I_j$
L_{Kj} – static self inducing of phase k
$U_K = R_K I_K + \sum^{m}_{j=1} L_{Kj} di_j/dt + dl_{kj}/d\theta \; d\theta/dt \; i_j$

B. Torque equation
The torque equation of motor is given by,
$J \, d^2\theta/dt^2 + B \, d\theta/dt + T_r = T_e$
J - total moment of inertia
B – coeffeicient of viscous friction
T_r - Load torque
T_e - Electromagnetic Torque
\

III. WORKING PRINCIPLE

A. System Identification with Matlab Tool.

In this paper, the motor equations of torque, voltage are given to the matlab simulation model of hybrid stepper motor. These equations are modeled using simulation. The input values of motor parameter are fed to the simulation model which gives the transfer function of proposed model using system identification tool. The obtained transfer function is fed to the PID tuning which turns the transfer function for PID values. After tuning the controlled response of PID values are obtained. The controlled PID values are given to the LabVIEW, the controlled output is obtained.

Without using MATLAB Simulink controller, the simulation output of LabVIEW produces some perturbations and damping. By using modern simulation method, the motor parameters can be controlled in LabVIEW through obtained transfer function. Whereas in conventional method the derivation of motor parameter is complex. In MATLAB using the system identification tool the transfer unction is obtained. The input values of motor parameter are fed to the simulation model and they are obtained to the system identification tool which gives the transfer function of the proposed model.

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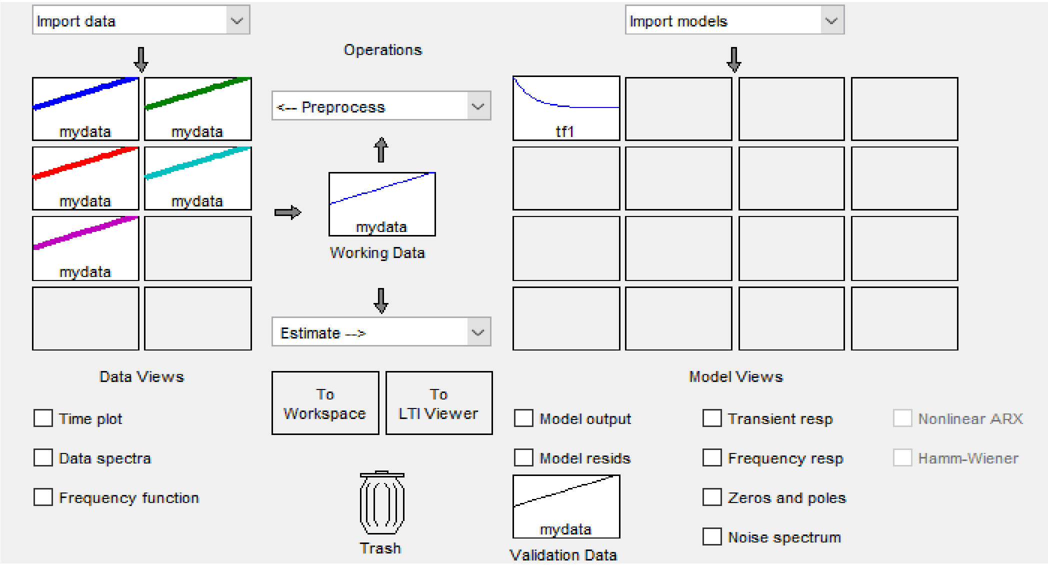

Figure (1.2) System identification tool

B. PID Tuning -Controller Design

The obtained transfer function from the system identification tool box is fed to the PID tuning tool, which turns the transfer function for PID values. Initially the PID response is obtained for undamped system.

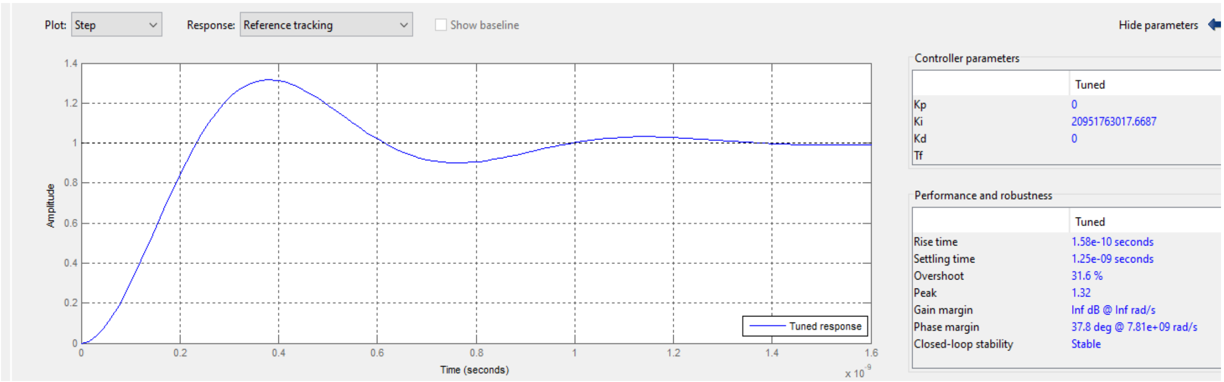

Figure (1.3) Response with natural tuning

C. PID Tuning -Controlled Design

In the above, the output response of the motor has some damping. So, we are going for further tuning. Which gives us the improved response.

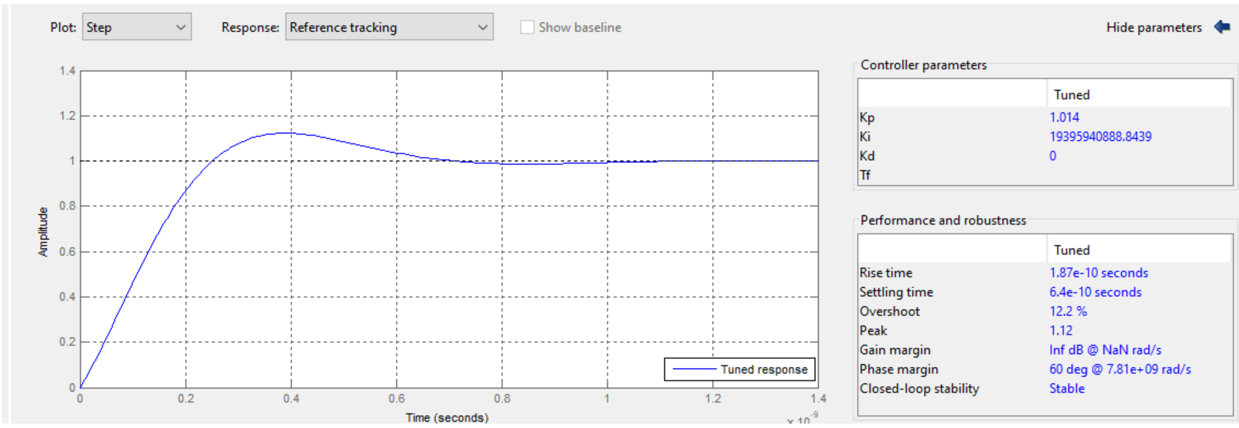

Figure (1.4) PID tuned response

After further tuning the PID values are obtained for controlled response.

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IV. MATLAB OUTPUT

In matlab the output has been get through system identification tool. the figure (1.5) shows the without controller in matlab simulink.

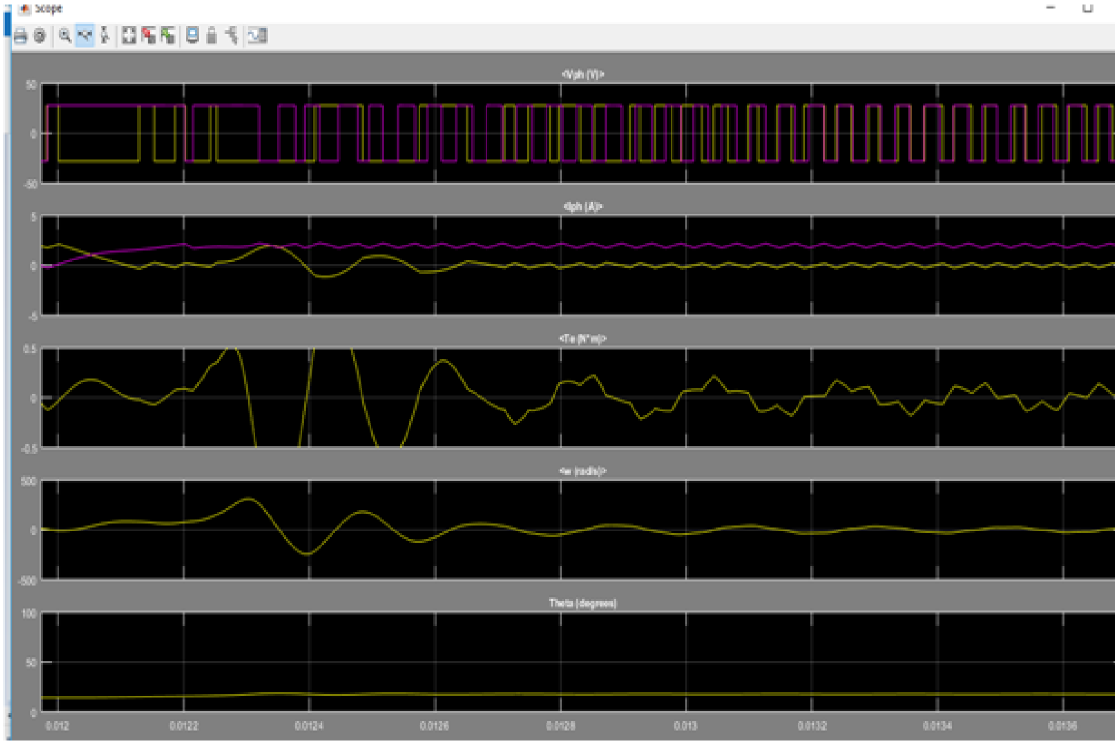

Figure (1.5) MATLAB Simulink Output Without Controller

Later tuning, the output has been through system identification tool. The figure (1.6) shows the with controller in matlab simulink.

Figure (1.6) Matlab Simulink Output With Controller

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V. HARDWARE AND SIMULATION

The Hybrid stepper motor is taken for the proposed paper. The input 12volt supply is given to the motor and Arduino is interfaced with LabVIEW and the digital sequenced pulses for each phase of the motor is given through the motor driver.

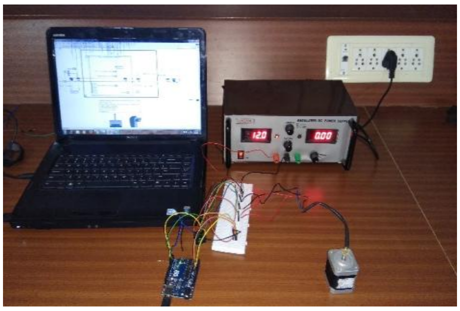

Figure (1.7) Hardware Setup Model

The pluses can be changed in the contol panel and motor output can be controlled using in labview.

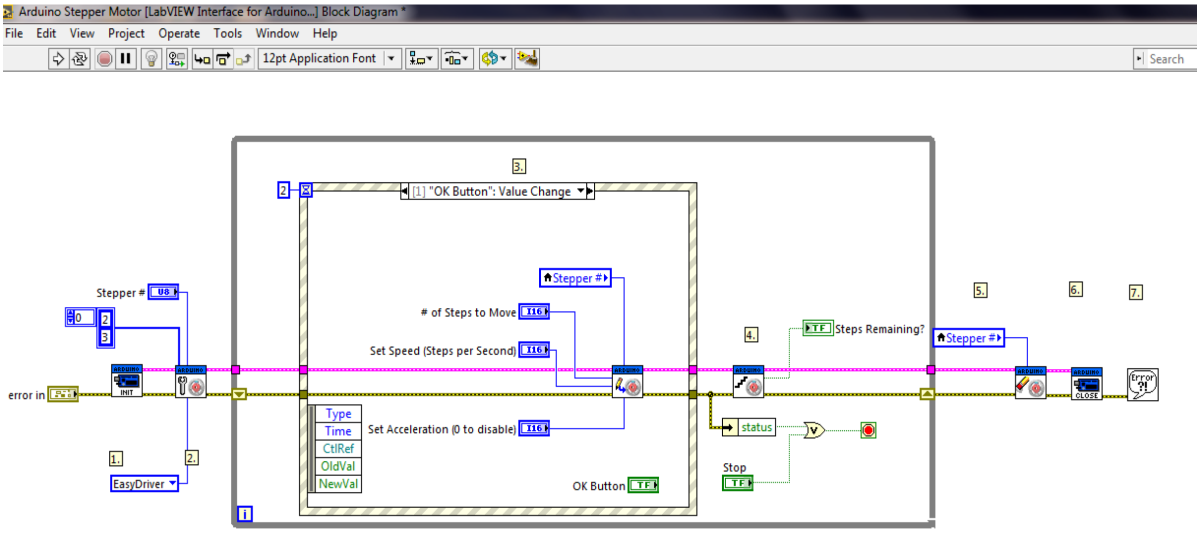

Figure (1.8) Control Panel of Stepper Motor in LabVIEW

A. Model without controller.

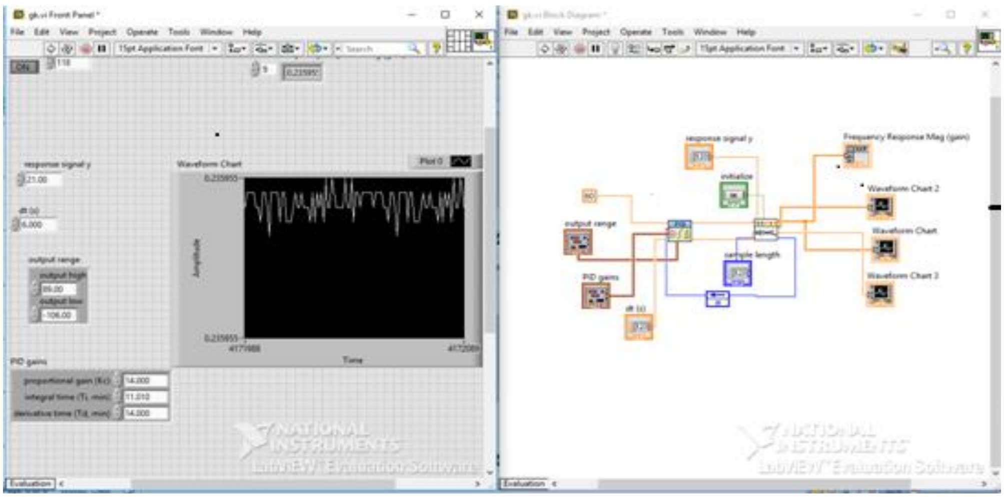

Figure (1.9) LabVIEW Simulation Output Without Controller

In LabVIEW the simulation output is obtained with harmonics in without controller.

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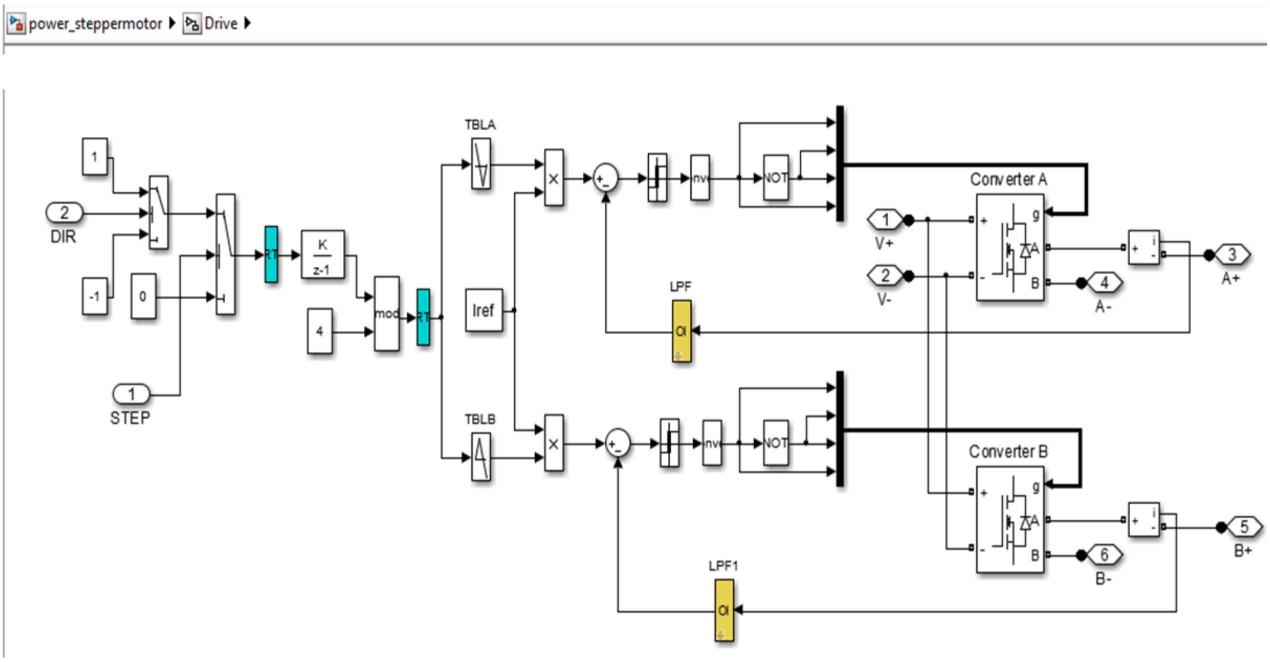
B. Bridge Circuit Model



Figure(1.10) Bridge circuit model

C. LABVIEW Model with Controller

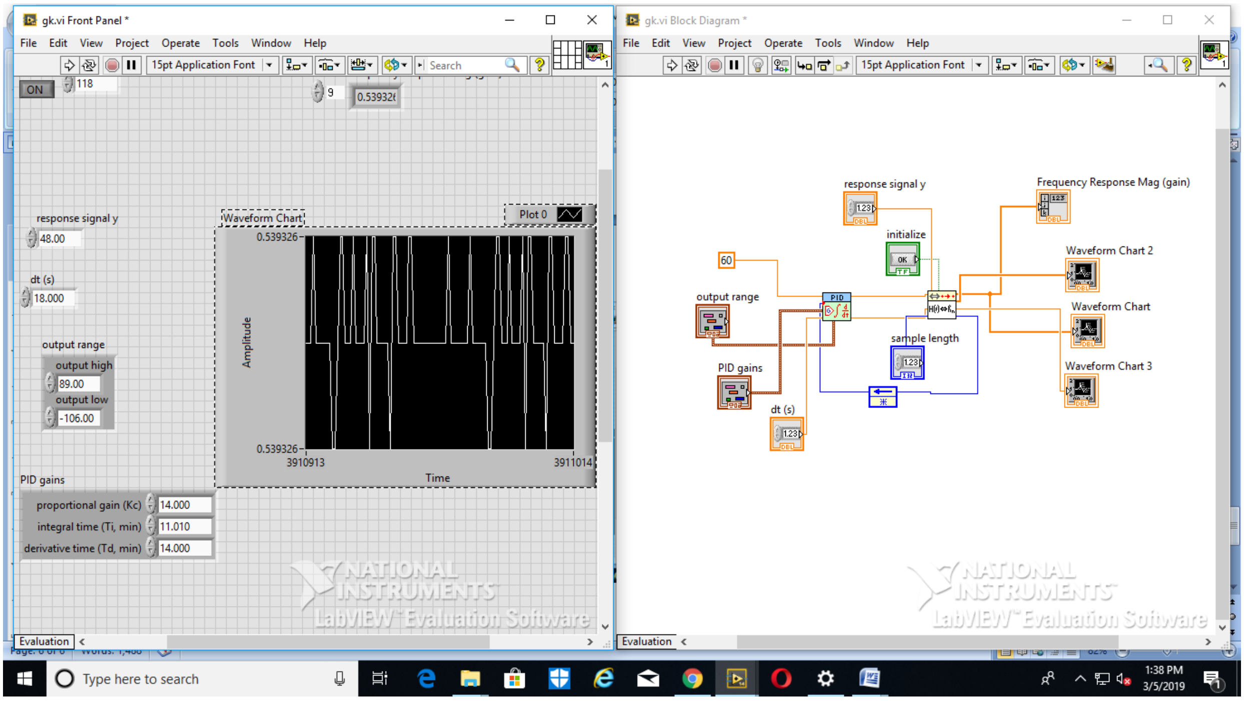


Figure (2.0) LabVIEW Simulink Output with Controller

In labview the simulation output is obtained in with controller. Here the ripples are reduced.

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VI. CONCLUSION

In this paper the proposed Hybrid stepper motor is successfully modelled, and the output of the motor is controlled with the designed controller. Initially the parameters of the motor are taken into the Matlab platform, through which the system and controller are designed. The LabVIEW platform interfaced Arduino acts as a hardware tool for controlling the motor. The controller designed through Matlab is used in LabVIEW for controlled response.

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