DATA DRIVEN PID CONTROL SYSTEM FOR DC MOTOR

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Abstract- **Aim of the project is to implement the data driven control system to control the speed of a dc motor using a PID controller. In this paper, we have used component based modeling similar to the real dc motor by using a simscape electronics system to obtain the input voltage and output speed of the dc motor and system identification toolbox for obtaining the model of the object. The transfer function is derived by performing the system identification process in time domain data. Using the acquired transfer function, the PID controller is tuned using the Matlab software. Routh stability criterion, root locus, time domain analysis and frequency domain analysis of the system are done using Matlab and the results are presented in the paper. In the end, the simulation results of the speed control of the dc motor are presented.**

***Keywords*— Data driven control system, System identification, DC motor, pid controller, Simscape electronics system.**

I. INTRODUCTION

DC Motors has a wide range of applications in the industry. They are used in home appliances, robot manipulators, toys, agricultural devices and so on because of their dynamic characteristics and high efficiency. However, the speed of the dc motors need to be controlled. This is due to the fact that the motor's load torque varies due to external factors such as temperature, humidity and changes over time and thus in order to keep the motor running at a constant speed, the speed needs to be controlled. In order to design the controller, it is necessary to first design the model. To solve this problem, data driven control must be used. Data driven control methods allow tuning a controller without the need of an identified model of the system. It is a designed controller when no plant model is available. In this case, component based modeling similar to a real DC motor is used using simscape electronic systems.

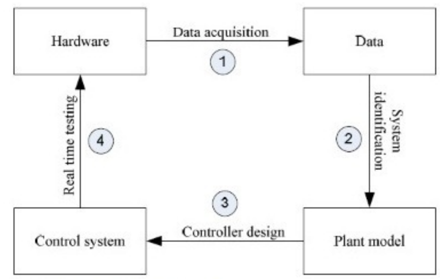
System Identification technique is used to solve the objective of designing mathematical models that is based on the perceived system data. The system identification toolbox is useful for representing dynamic systems and ensures some linear and nonlinear black-box model structures. In this paper, nonlinear black-box model structures in the system identification toolbox have been used for representing the continuous-time transfer function of the DC motor. After the transfer function of the system is estimated, the PID controller parameters kp, ki and kd are auto tuned using the pid tuner to achieve the stability of the system. PID controller design has the following special features: simple mathematical modeling, good reliability, high reliability, stabilization. Therefore, a PID controller is used for the controller design.

II. CONTROL OBJECTIVE

Control the speed of the DC motor by using the PID controller and estimated transfer function from the data driven model.

III. DATA DRIVEN CONTROL

Nowadays, many industrial processes and robotic systems have become more complex. Although the plant model of the systems might be available, the complexity makes it difficult to design the controller. In such cases, data driven modeling can be used. In this paper, we consider the data driven control system of DC motor by using system identification process and implement the data driven control flow work as shown:

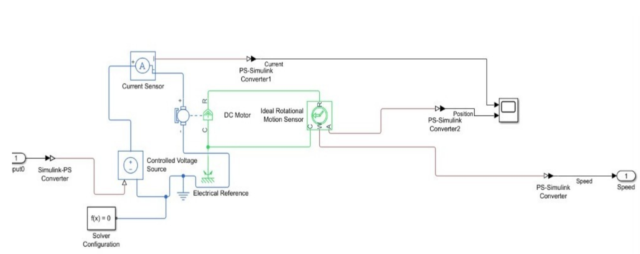


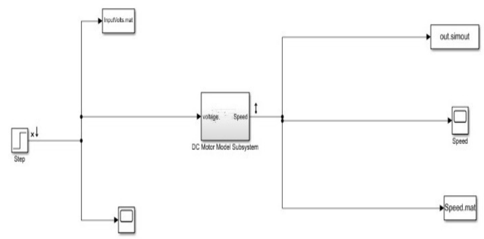
Data Driven Control Workflow

In this paper, the DC motor is a software part, from which input voltage and output speed can be measured. The measured data is used to operate the system identification process. And then we get the transfer function of the plant model from the system identification process. It is also important to choose a controller design for controlling the plant model. After the modeling, real time testing of the dc motor can be done.

IV. DC MOTORMODEL USING SIMSCAPE SYSTEM

In this paper, a physical block diagram of the simscape extension is used to build the DC motor model. The main advantage of the simscape model is the ability to modify the model quickly without having the equations of the system.





DC Motor Subsystem

V. SYSTEM IDENTIFICATION PROCESS

The System Identification Toolbox provides Matlab functions, Simulink blocks and interactive tools for creating dynamic model systems. In this process, input and output data is required in the time domain to identify the continuous transfer function.

5	6	7	8	9	10	11	12	13	14
.9683e-06	3.4529e-05	6.1090e-05	8.7651e-05	3.5326e-04	6.1887e-04	8.8448e-04	0.0035	0.0062	0.0089
.5200e-05	6.5924e-05	1.1665e-04	1.6736e-04	6.7430e-04	0.0012	0.0017	0.0067	0.0117	0.0167

Data acquired for speed(output)

	6	7	8	9	10	11	12	13	1
6	3.4529e-05	6.1090e-05	8.7651e-05	3.5326e-04	6.1887e-04	8.8448e-04	0.0035	0.0062	(
1	1	1	1	1	1	1	1	1	

Data acquired for voltage(input)

After doing the identification process, we get the transfer function with the following parameterization:

1. Fit to estimation— [97.93;89.89]% (stability enforced)
2. FPE— 0.0009793
3. MSE— 0.4767

```
Status:
Estimated using TFEST on time domain data "Data1".
Fit to estimation data: [97.93;89.89]% (stability enforced)
FPE: 0.0009793, MSE: 0.4767
```

Transfer Function of the system is estimated as:
ω(s)/Y(s) = (-0.04965s+0.008474)/(s^2+0.122s+0.008696)

$$y2: \quad \frac{-0.04965\ s + 0.008474}{s^2 + 0.122\ s + 0.008696}$$

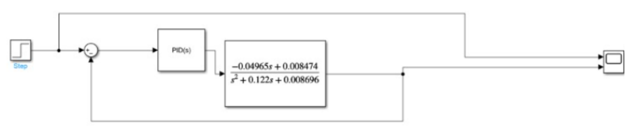
VI. CONTROLLER DESIGN

The Proportional-integral-differential (PID) controller is the most effective type of regulator which provides high accuracy. The output of the PID controller is calculated using the formula:

$$u(t) = K_p e(t) + K_i \int_0^t e(\tau) d\tau + K_d \frac{de(t)}{dt}$$

The control signal is a sum of three components: Kp, Ki and Kd. Kp depends on the error and is responsible for the response to the instantaneous control error. Ki contains the accumulated control error, which is an additional source of output power and allows to achieve the maximum speed

of reaching the setpoint without overshoot. Kd depends on the rate of change of the parameter, which causes the regulator to react to a sharp change in the measured parameter, which can be solving an external disturbing effect.
In this paper, a PID controller is used for the proposed plant model. In order to correctly regulate the plant model, it is necessary to tune the coefficients of the PID controller. The auto tuning method is used to get the desired response of the DC motor.
The tuned values are coming as follows:
Kp=0.825
Ki = 0.0423
Kd =2.156



VII. STABILITY, TIME DOMAIN, ROOT LOCUS AND FREQUENCY RESPONSE ANALYSIS

Routh Criterion:

```
/                       5012902702030571  \
|         1,            ----------------- |
|                       576460752303423488 |
|                                          |
|         61                               |
|         ---,                  0           |
|         500                              |
|                                          |
|  5012902702030571                        |
| ------------------,           0          |
\ 576460752303423488                       /

 No sign changes and hence system in stable
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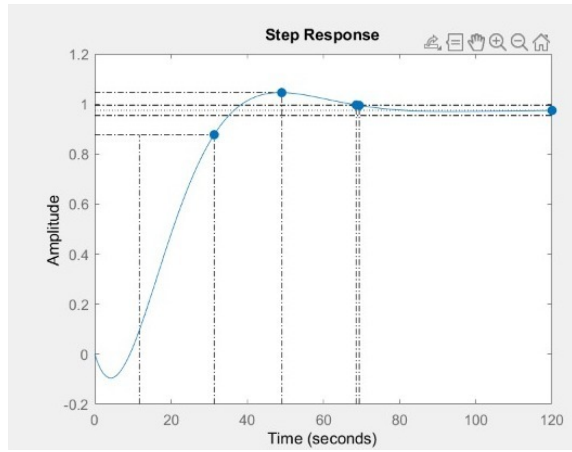
The system is stable.

Time Domain Analysis:

Time Response of transfer function on the step input is as shown:



Rise time– 19.6 sec
Transient Time– 68.6 sec
Overshoot– 7.26% at time 49.1 sec
Peak amplitude– 1.05

Time Response Analysis with different values of Kp

Kp	Rise Time	Max Overshoot	Peak amplitude
0.825	-0.0088	1.2644	0.1070
5	-6.4488	1.1134	0.2300
20	26.631	2.719	0.9747

Time Response Analysis with different values of Ki

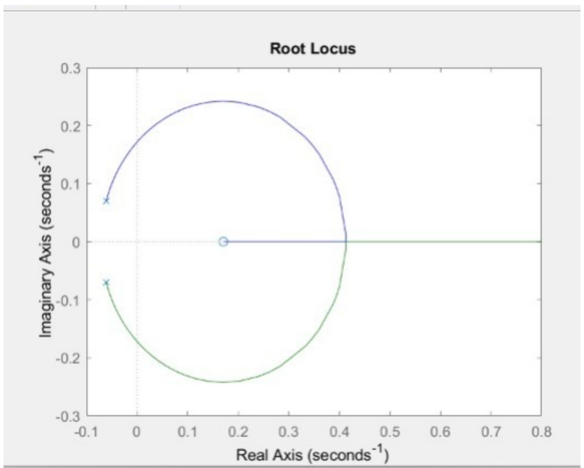
Ki	Rise Time	Max Overshoot	Peak amplitude
0.0423	-0.0088	1.2644	0.1070
5	0.0204	0	0.2413
20	0.1223	0	0.9860

Time Response Analysis with different values of Kd

Kd	Rise Time	Max Overshoot	Peak amplitude
2.156	-0.0088	1.2644	0.1070
5	0.0014	1.2644	0.2482
20	5.424	3.575	0.9930

Root Locus:

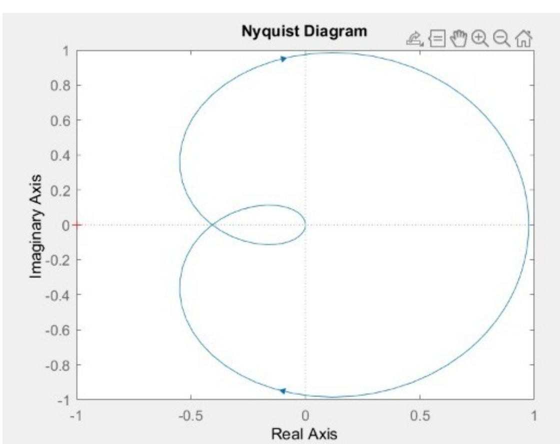
Root locus of the system transfer function is as follows:



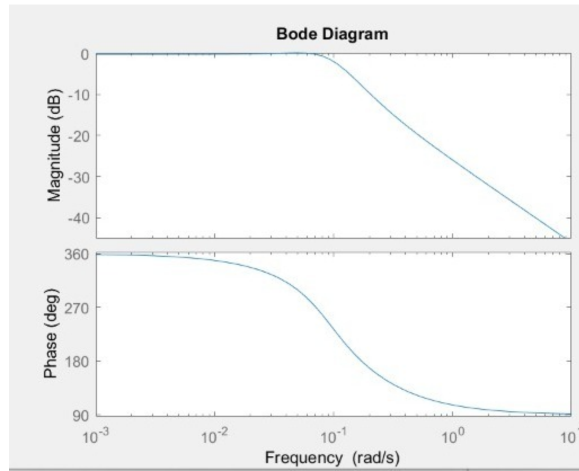
The poles are denoted by cross(x) and the zeroes are denoted by circles(o)

Frequency response Analysis

Nyquist plot



Bode plot



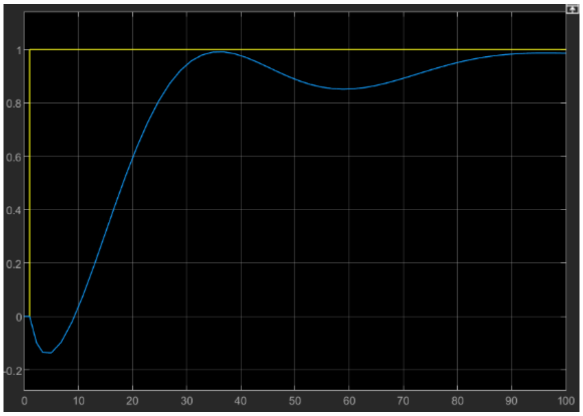
VIII. ACKNOWLEDGEMENT

We would like to thank Dr.Debanjan Das for his continuous support and guidance. We would also like to thank everyone who helped us in our project directly or indirectly.

IX. CONCLUSION AND FUTURE SCOPE

In this paper, data driven control system of a DC motor is implemented by using system identification process. Speed of the DC motor is controlled using the PID controller.

The speed response of the DC motor using PID controller is given below.



Yellow line- expected speed, Blue line- actual speed

The produced model can be a realistic dynamic model of a dc motor. Data driven can further be done on a hardware model to acquire data from it. The performance of the proposed control system is the effectiveness and acceptable response of the DC motor and it’s useful for real time testing of the DC motor.

X. REFERENCES

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