MATLAB/SIMULINK MODELLING OF DC MOTOR

PROJECT REPORT

By

DILIP.R

dilipdilip1656@gmail.com
Mahendra Engineering college
BE-EEE ..final year

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ABSTRACT

Dc motor acts as an energy conversion actuator that coverts electrical energy (source)into mechanical energy (to load). these motors are extensively applied for robotic manipulations, cutting tools, electric tractions, etc.. the torque -speed characteristics of motor are most compatible with most mechanical loads.

A permanent magnet DC motor can be thought of as an electrical system that consists of the rotor winding (ideal inductor and ideal resistor) and an electromotive force element. Back emf represents how the motor acts as generator/voltage source that works against the input voltage

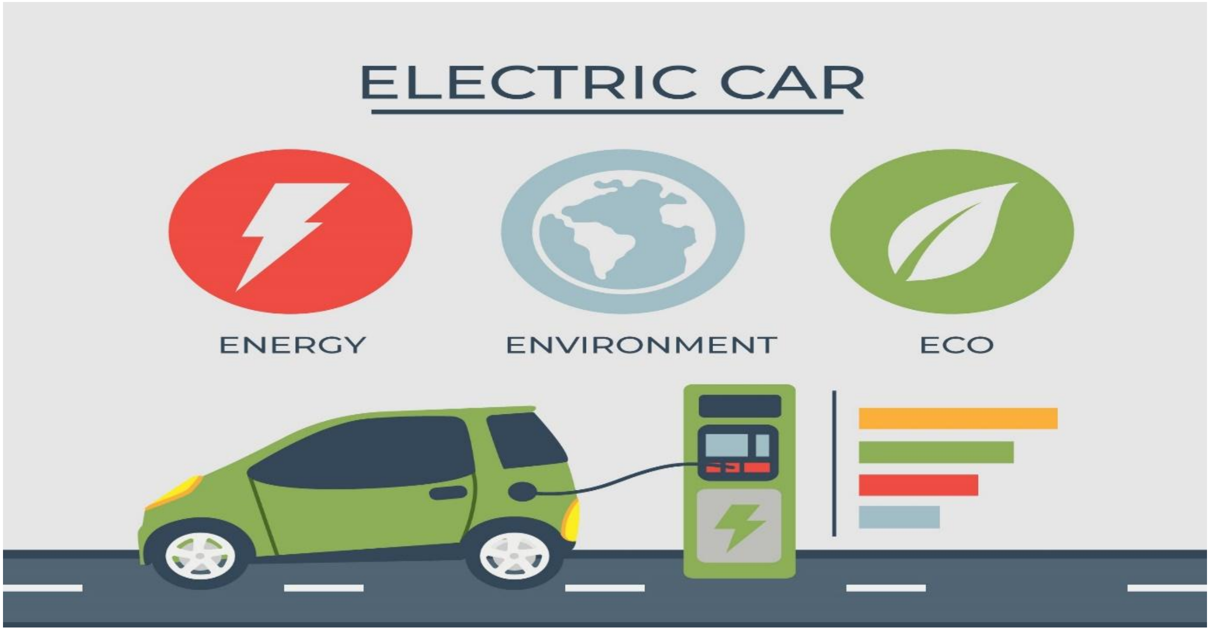
Computer modelling and simulation tools have been extensively used to support and enhance electric machinery courses. MATLAB with its toolboxes such as Simulink and SimPowerSystems is one of the most popular software packages used by educators to enhance teaching the transient and steady-state characteristics of electric machines

In the present work transfer function and modelling of a motor is performed by using Generalized equations in MATLAB and Simulink.

INTRODUCTION TO ELECTRICAL VEHICLE

Electric vehicles (EVs) are revolutionizing the automotive industry by offering a sustainable and environmentally friendly alternative to traditional internal combustion engines (ICE) vehicles. Unlike conventional vehicles that rely on fossil fuels, EVs are powered by electricity, stored in rechargeable batteries, and use electric motors for propulsion. The adoption of EVs has gained significant momentum in recent years due to several factors. Firstly, concerns over climate change and the need to reduce greenhouse gas emissions have driven the demand for cleaner transportation options. EVs produce zero tailpipe emissions, resulting in lower carbon footprints compared to gasoline or diesel-powered vehicles. This makes EVs a key solution for achieving sustainable and greener transportation. Secondly, advancements in battery technology have significantly improved the range and performance of EVs. Lithium-ion batteries, commonly used in EVs, have become more efficient, providing longer driving ranges and quicker charging times. This has alleviated a range of anxiety concerns and increased the practicality and appeal of EVs for everyday use

Furthermore, government incentives, subsidies, and regulations aimed at promoting clean transportation have also played a crucial role in the growth of the EV market. Many countries and regions around the world have implemented policies to encourage the adoption of EVs, such as tax credits, rebates, and investments in charging infrastructure. These measures have made EVs more affordable and accessible to a wider range of consumers. In addition to their environmental benefits, EVs offer other advantages. Electric motors provide instant torque, delivering swift acceleration and a smooth driving experience. Moreover, EVs have lower operating costs compared to conventional vehicles, as electricity is generally cheaper than gasoline or diesel fuel, and the maintenance requirements are typically less complex. Despite the progress made in the EV industry, challenges remain. The limited availability of charging infrastructure, longer charging times compared to refuelling with gasoline, and the higher upfront costs of EVs are some factors that continue to impact widespread adoption. However, ongoing technological advancements and the commitment of governments, automakers, and other stakeholders are expected to address these challenges and further accelerate the transition towards electric mobility. In conclusion, electric vehicles represent a transformative solution for sustainable transportation, addressing concerns about climate change and air pollution. With improving battery technology, expanding charging infrastructure, and supportive policies, EVs are becoming increasingly viable and appealing options for consumers worldwide. The electrification of the automotive industry is set to shape the future of transportation, creating cleaner, greener, and more efficient mobility systems



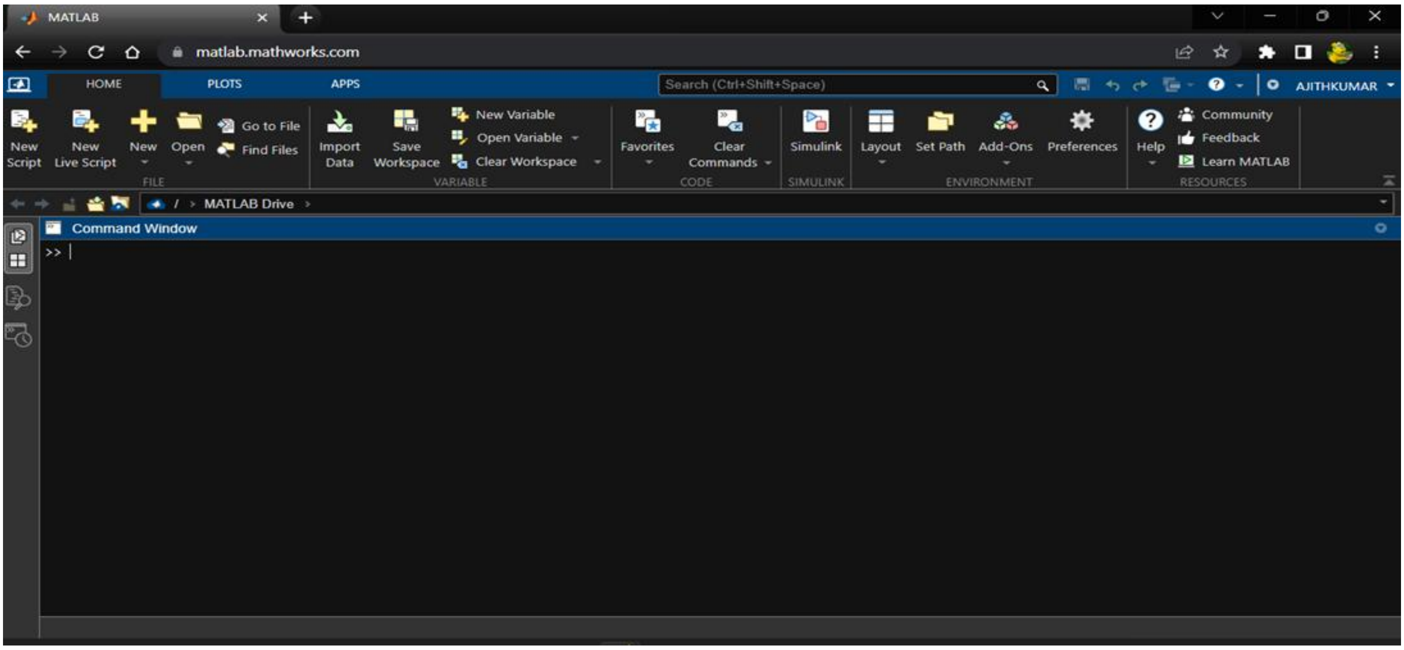
INTRODUCTION TO SIMULINK

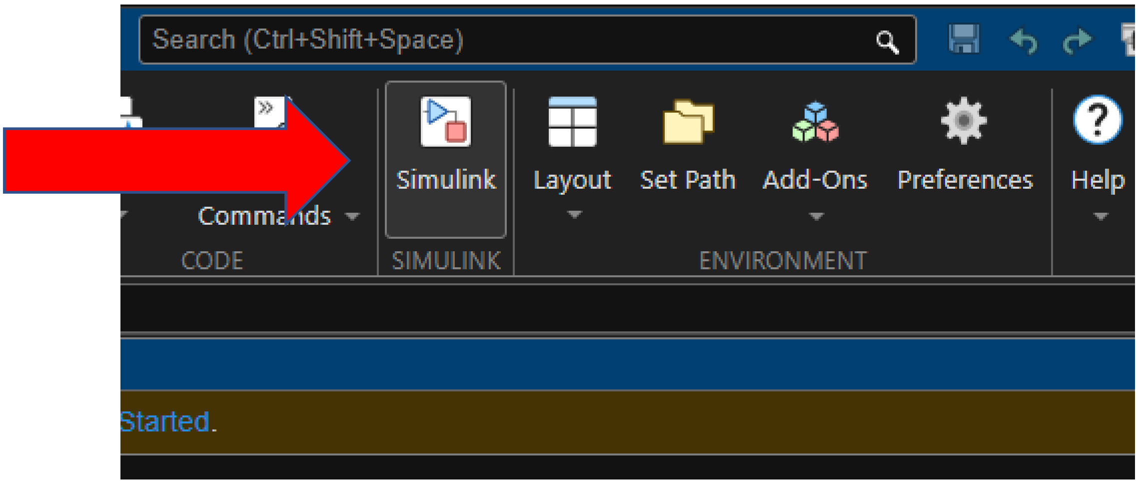
3.1 Model Components

The Simulink model comprises several components, including the electric motor model, vehicle dynamics model, and distance calculation module. The electric motor model represents the torque-speed characteristics of the motor, converting the input torque into rotational motion. The vehicle dynamics model considers factors such as mass, aerodynamic drag, rolling resistance, and gravitational force to predict the vehicle's acceleration. The distance calculation module integrates the acceleration to estimate the distance travelled by the vehicle.

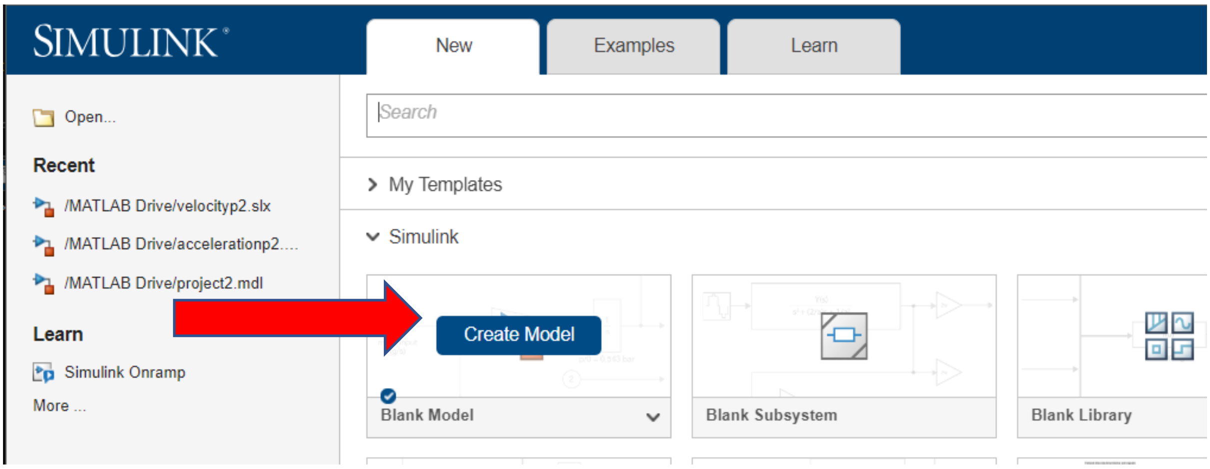
3.2 Simulation Setup

The Simulink model is configured with appropriate parameters, including motor specifications, vehicle mass, aerodynamic coefficients, and road conditions. The torque input to the motor is defined based on user-defined profiles or real-world data. The simulation time and solver settings are determined to ensure accurate and efficient simulation results.

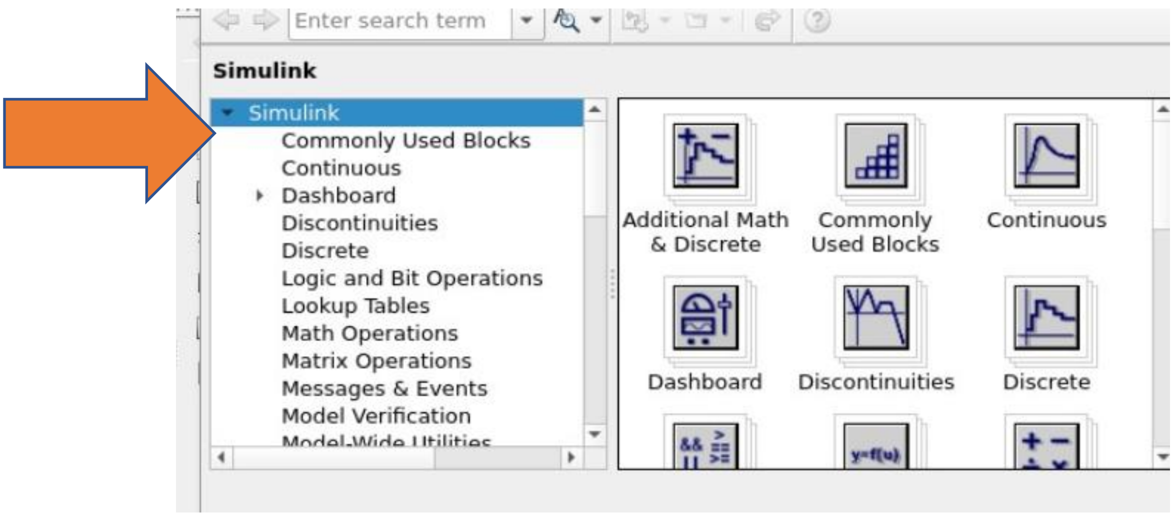


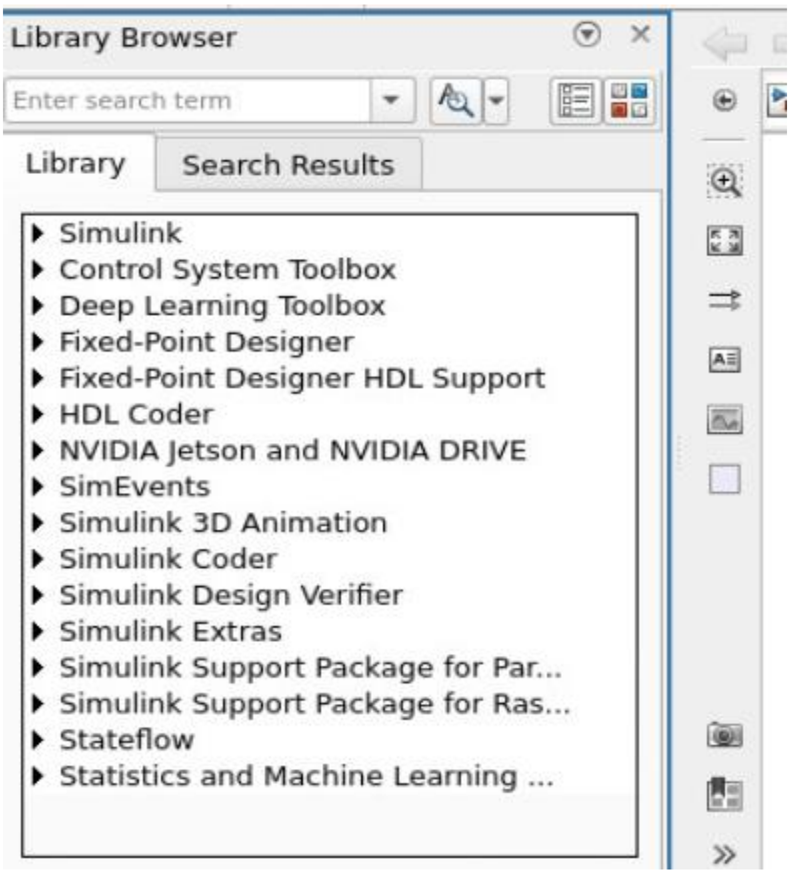


- **Then click on Simulink and create a new model .**



- In the Simulink have a number of library





3.3. Results and Analysis

The Simulink model generates simulation results for the velocity and distance travelled by the electric vehicle. The output is compared with real-world data obtained from performance tests conducted on an actual electric vehicle. The comparison demonstrates the accuracy and reliability of the model in predicting the vehicle's behaviour based on the motor torque input. Various scenarios can be simulated to analyse the effects of different torque inputs on velocity and distance. This analysis provides valuable insights into the performance and energy consumption of the electric vehicle under different driving conditions.

3.4 Model Validation and Sensitivity Analysis

The Simulink model is validated by comparing the simulated results with real-world data. T he accuracy of the model is assessed by evaluating the deviation between the simulated and actual velocity and distance measurements. Sensitivity analysis can also be conducted to assess the impact of varying parameters, such as vehicle mass, aerodynamic drag coefficient, or road conditions, on the vehicle's motion characteristics.

MATHEMATICAL EQUATION FOR DC MOTOR

- Design calculations**:**

Design Specification …………

SYMBOL	DEFINE	VALUE
➢ J	Moment of inertia of the motor	0..1 kg*m^2
➢ B	Motor viscous friction constant	0.1 N*m*s
➢ KE	Electromotive force constant	0.01 V/rad/s
➢ KT	Motor constant torque	0.01N*m/Amp
➢ R	Electric resistance	1 Ω
➢ L	Electric inductance	0.5 H

SYSTEM EQUATION

- In general ,the torque generated by a dc motor is proportional to the armature current and the strength of magnetic field ,In this example we will assume that the magnetic field is kept at constant ..Hence therefore ,that the motor torque is proportional to only the armature current (i) by a constant factor [Kt]

$$T = Kt*i$$

- The back emf ,e is proportional to the angular velocity of the shaft by a constant factor Ke

$$e=Ke*\theta$$

- In SI Unit ,the motor torque and back emf constants are equal ,that is Kt=Ke;

- Therefore ,we will use K to represent both themotor torque constant and the back emf constant.

- By governing equations based on newtons 2nd law and kirchhoff's voltage law

$$J\ddot{\theta} + b\dot{\theta} = Ki$$

$$L\frac{\partial i}{\partial t} + Ri = V - K\dot{\theta}$$

- Applying the Laplace transform, the above modelling equations can be expressed in terms of the Laplace variable s

$$s(Js + b)\theta(s) = KI(s)$$

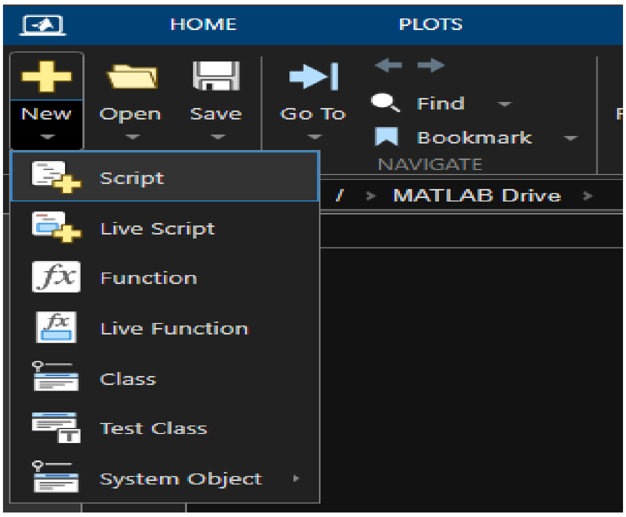
$$(Ls + R)I(s) = V(s) - s\theta(s)$$

- We arrive at the following open-loop transfer function by eliminating I(s) between the two above equations, where the rotational speed is considered the output and the armature voltage is considered the input.

$$T(s) = \frac{w(s)}{V(s)} = \frac{K}{(Js+b)(Ls+R)+K^2} \quad [\frac{rad/sec}{V}]$$

MATLAB CODE FOR DC MOTOR SPEED USING MATLAB

❖ First of all open a MATLAB script new page



➢ Then by using given specification create an variable to store those value in script mode which should be in meaning full variable name

➢ Let command an each using "% " Symbol which is useful for user To read an code easily.

```
J = 0.01;

b = 0.1;

K = 0.01;

R = 1;

L = 0.5;
```

Editor - C:\Users\91949\Documents\MATLAB\openloopsystem.m *

openloopsystem.m *

```
J=0.01;%momentof inertia of rotor
b=0.1;%motor viscous friction constant
K=0.01;%constant (K=Ke=kt)
R=1;%resistance
L=0.5;%lnductance
```

- Create a transfer function using a tf('s')

- Then create a variable to store a output power of motor in P-MOTOR

```
%transferfunction
s=tf('s');
P_MOTOR=K/((J*s+b)*(L*s+R)+K^2);
linearSystemAnalyzer('step',P_MOTOR,0:0.1:5)
```

- We then need to identify the inputs and outputs of the model we wish to extract. First right-click on the signal representing the Voltage input in the Simulink model. Then choose Linear Analysis Points > Open-loop Input from the resulting menu. Similarly, right-click on the signal representing the Speed output and select Linear Analysis Points > Openloop Output from the resulting menu. The input and output signals should now be identified on your model by arrow symbols as shown in the figure below.
- By creating a linearSytemAnalyzer (‘ function’, variable_name, range)

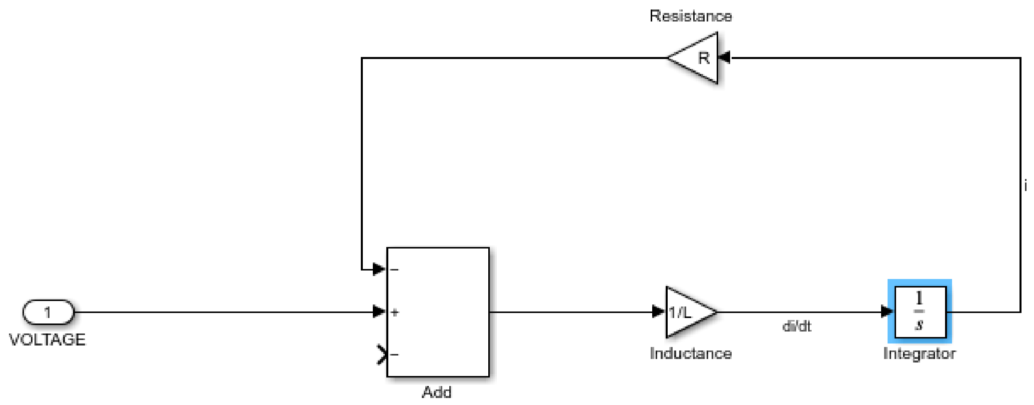
Editor - C:\Users\91949\Documents\MATLAB\openloopsystem.m *

openloopsystem.m *

```
J=0.01;%momentof inertia of rotor
b=0.1;%motor viscous friction constant
K=0.01;%constant (K=Ke=kt)
R=1;%resistance
L=0.5;%lnductance
%transferfunction
s=tf('s');
P_MOTOR=K/((J*s+b)*(L*s+R)+K^2);
linearSystemAnalyzer('step',P_MOTOR,0:0.1:5)
```

MODEL DC MOTOR INPUT VOLTAGE AND OUTPUT SPEED USING SIMULINK

- Create a new model in Simulink
- Then create a model for a di/dt by an add block , gain, integrator
- Then make a variable name as like a specification I in the bock
- Set an voltage as a input



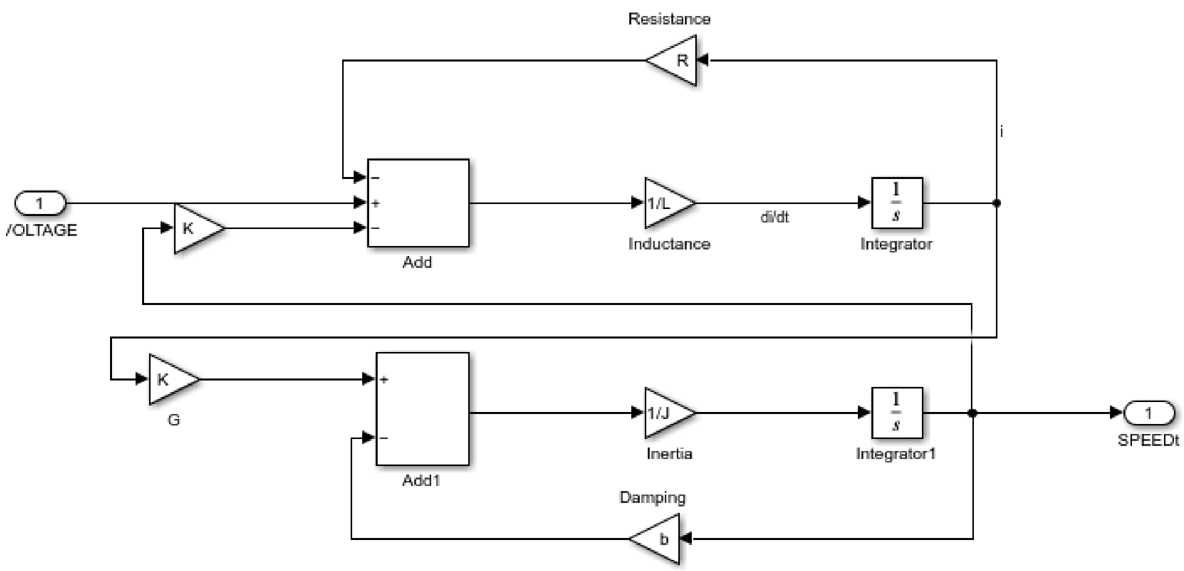
- A linear model of the system can be extracted from the Simulink model into the MATLAB workspace. This can be accomplished employing the MATLAB command or from directly within Simulink as we will do here. We will specifically use the base Simulink model developed from first principles shown below.

- The open-loop step response can also be generated directly within Simulink, without extracting any models to the MATLAB workspace. In order to simulate the step response, the details of the simulation must first be set. This can be accomplished by selecting Model Configuration Parameters .

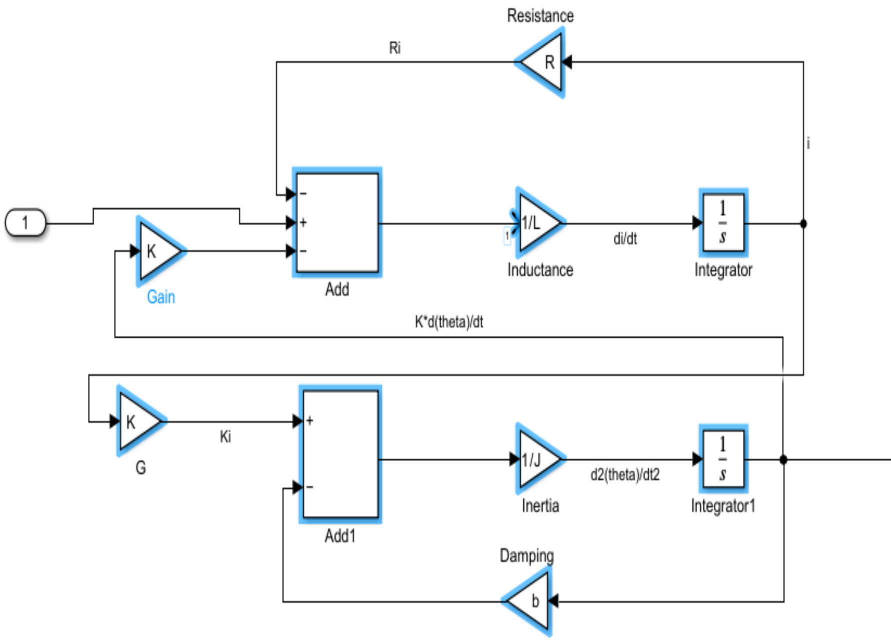
- Next we need to add an input signal and a means for displaying the output of our simulation. This is done by doing the following

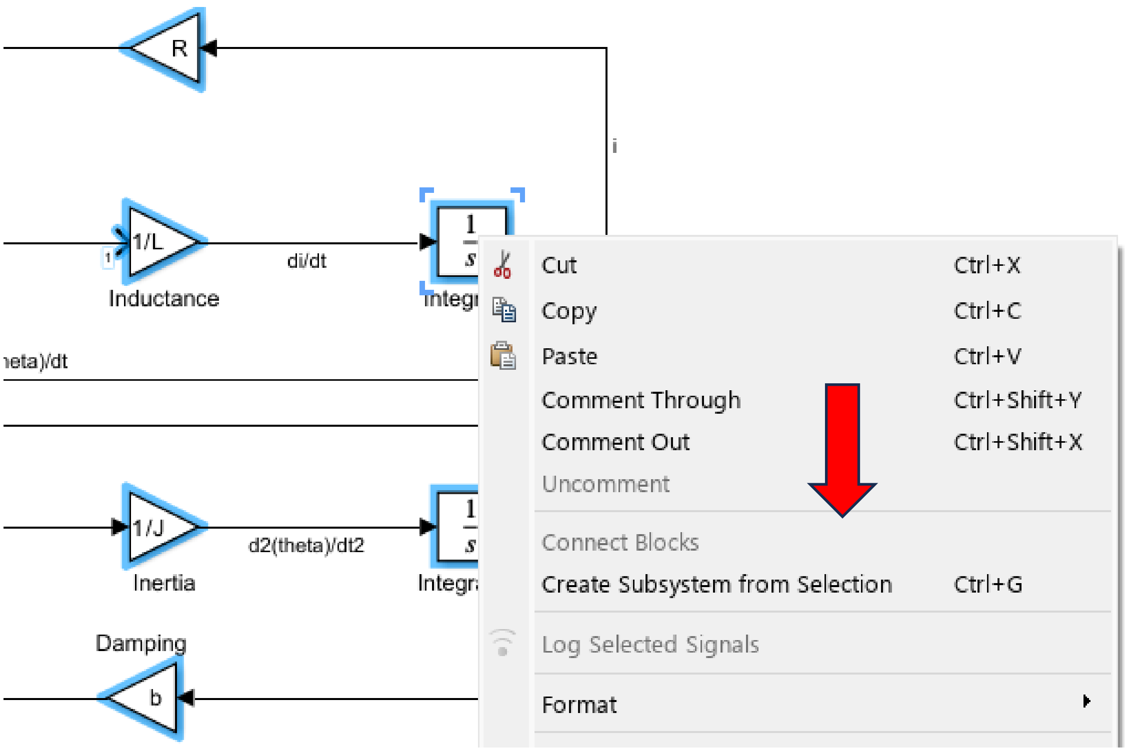
  - ✓ Remove the In1 and Out1 blocks
  - ✓ Insert a Step block from the Simulink/Sources library and connect it with a line to the Voltage input of the motor subsystem.
  - ✓ To view the Speed output, insert a Scope from the Simulink/Sinks library and connect it to the Speed output of the motor subsystem.
  - ✓ To provide an appropriate unit step input at t=0, double-click the Step block and set the Step time to "0". The final model should appear as shown in the following figure

DC motor speed simulink modeling

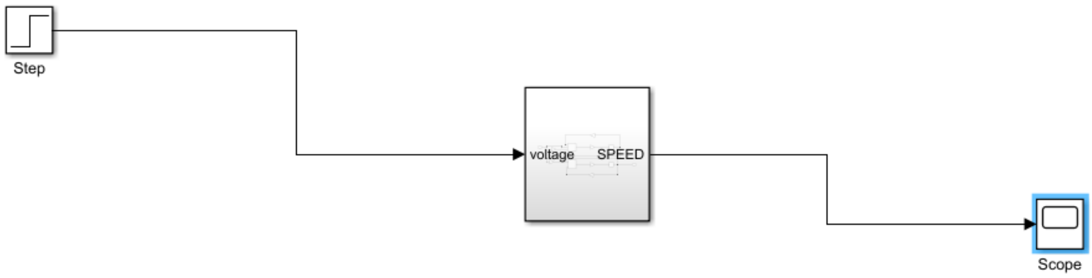


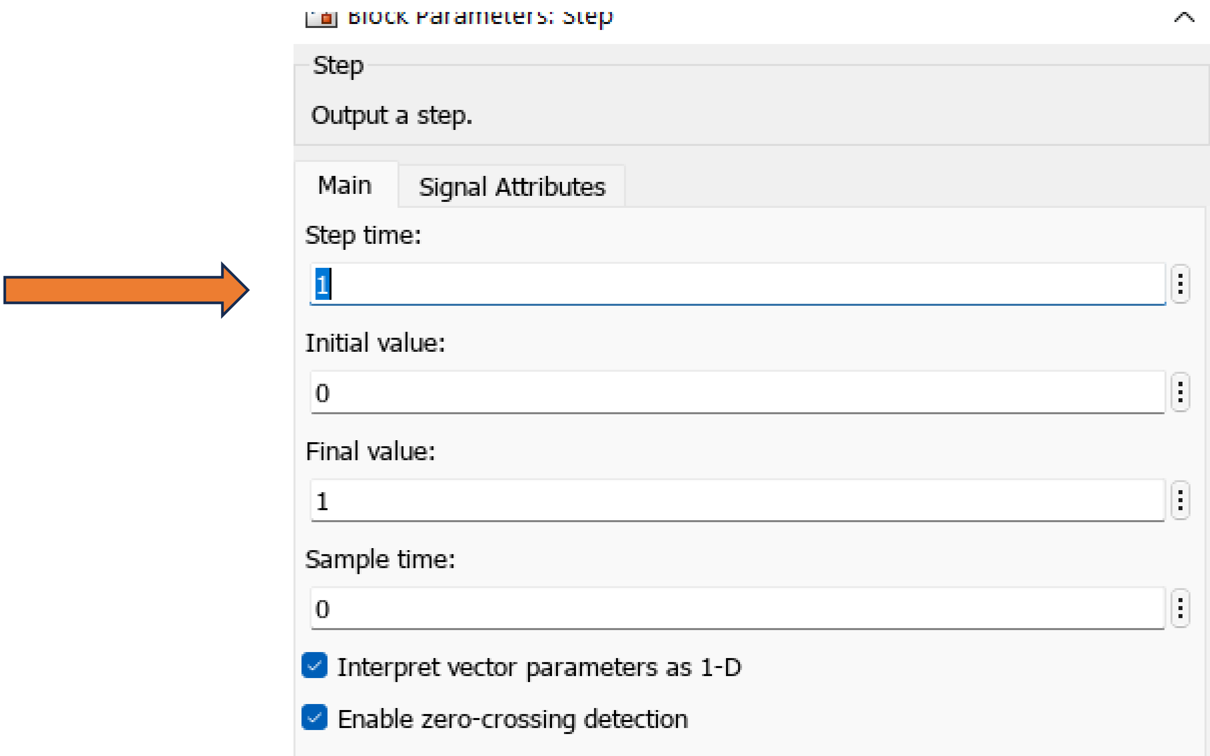
➢ By selecting all block make into subsystem
By clicking a create a subsystem from selection





➢ Its an model we created from selection then by varying an step input we can visual see the output change in scope





➢ It’s an all data model specified list

System - DC_MOTORPROJECT

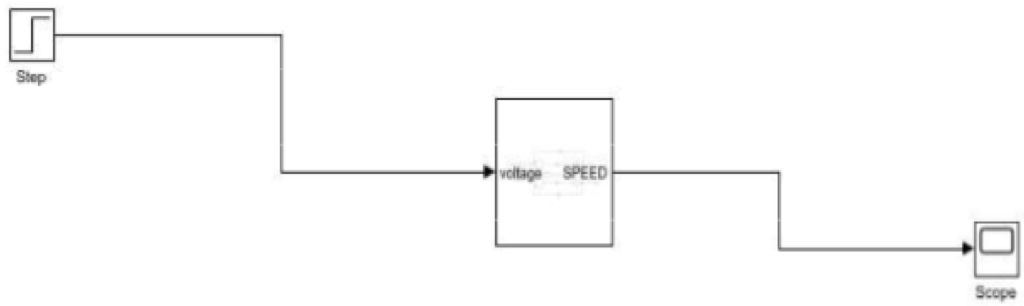


Table 1. Step Block Properties

Name	Time	Before	After	Out Data Type Str	Sample Time	Zero Cross
Step	1	0	1	double	0	on

Appendix

Table 2. Block Type Count

BlockType	Count	Block Names
SubSystem	1	Subsystem
Step	1	Step
Scope	1	Scope

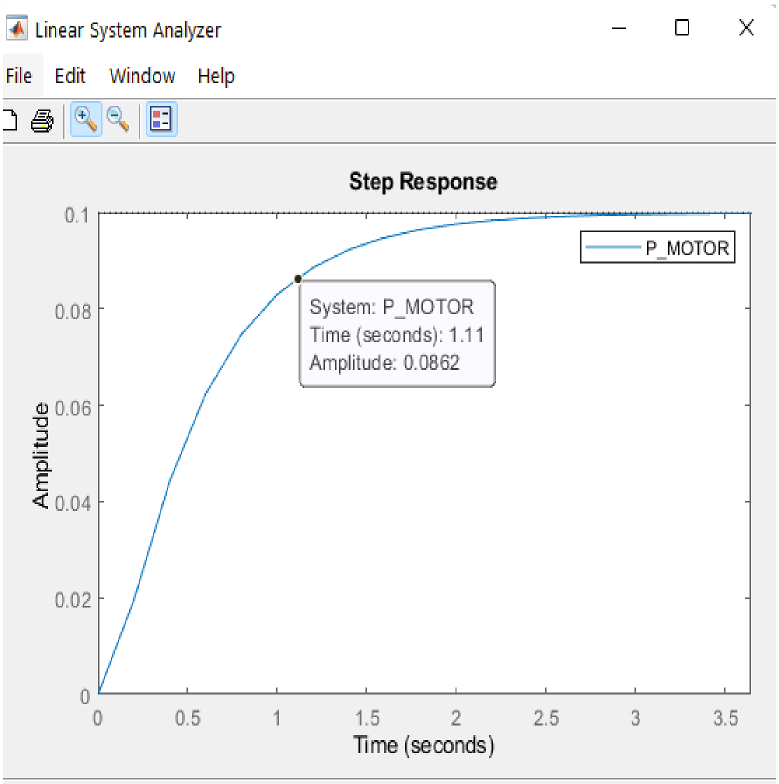
Table 3. Model Variables

Variable Name	Parent Blocks	Calling character vector	Value
J	Subsystem	J	0.0100
K	Subsystem	K	0.0100
L	Subsystem	L	0.5000
R	Subsystem	R	1
b	Subsystem	b	0.1000

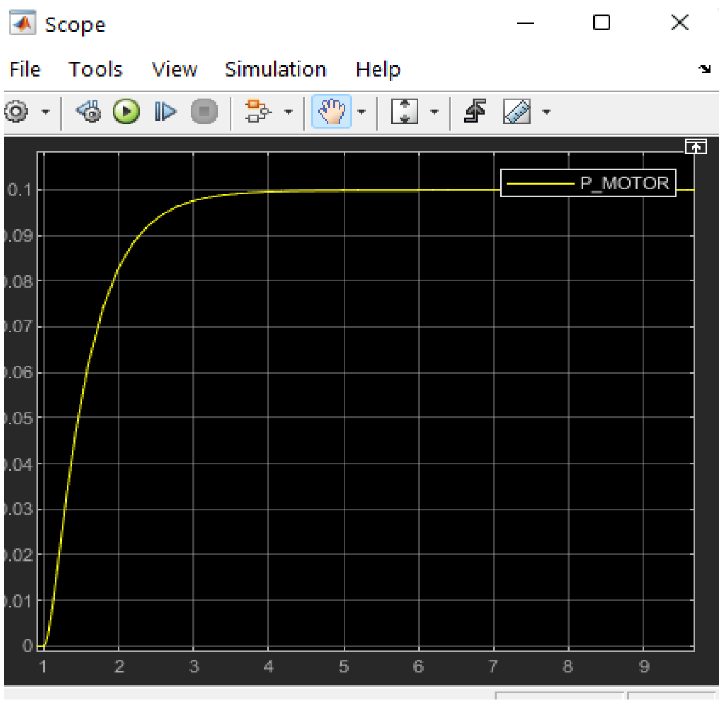
RESULT

The Simulink model successfully calculated the output power of the dc motor based on the step volatge input. The results obtained from the simulation provided valuable insights into the vehicle's motion torque – speed characteristics ..

Result of openloop system by lienarsystem analyzer



It's an result of an Simulink model output based on step input voltage



CONCLUSION

In armature controlled separately excited DC motor, rotational speed is proportional to armature voltage. However, due to load disturbances, mechanical wear and tear and other environmental factors DC motor response varies with time. Simulation model of DC motor speed control method and open-loop control system for DC motor drives have been developed using MATLAB/Simulink.

The report demonstrates the significance and effectiveness of MATLAB/Simulink modelling in the analysis and control of DC motors. Through the developed model, it is evident that MATLAB/Simulink provides a powerful platform for accurately representing the dynamic behavior of DC motors.

In summary, the MATLAB/Simulink modelling of DC motors proves to be a valuable and comprehensive approach. Its accuracy, flexibility, and efficiency make it an indispensable tool for researchers, engineers, and educators involved in the analysis, design, and control of DC motor systems.