Journal of Multidisciplinary Innovations and Perspectives (JMIP)
Maiden Edition
www.fedpodjournal.com
Volume 1; Issue 2; February 2025; Page No. 85-91.

ANALYSIS OF SEPARATELY EXCITED DC MOTOR USING MATLAB/SIMULINK

***Yekini Olawale Saheed**
Department of Electrical/Electronics Engineering, Allover Central Polytechnic, Ota Ogun State
*Olayek8@gmail.com

Abstract
High starting and decelerating torque are provided by DC motors in applications that call for rapid stops or reversals. DC motors are well suited for speed control over a large range, which is easily accomplished. In this study, an independently stimulated DC motor is started using three distinct techniques: (i) Increasing the voltage gradually while decreasing it until it reaches a constant value (controlled voltage) (ii) Using a direct starter (iii) Using a step resistance starter to begin. The impact of machine characteristics like rotational speed (ω), armature current (Ia), and torque (Te) on the three (3) approaches will also be examined in this study MATLAB Simulink.

Keywords: Electromechanical, Armature, Torque, Simulink, Machine, Starter

Introduction

Direct current (DC) motor is an electrical device that transforms electrical energy into mechanical energy. Direct current serves as the electrical energy input for a DC motor, converting it into mechanical energy. DC motors are use in applications such as electric traction, positioning a radar and handling robots motors due to its flexibility and instantaneous speed. (Talavaru *et.al.,*2014). DC motors can also be used for speed control and load characteristics due to its accuracy and efficiency. Speed management characteristics of a DC motor is of great importance in areas where correct signal representation and speed accuracy and are needed for steady speed of a motor (Khan *et.al.,* 2016). Generally speaking, speed control techniques are less complicated and costly than AC drive techniques (Guru & Hiziroglu, 1988). DC motors continue to be important components of contemporary industrial drives. Separately excited DC motors are generally utilized in variable speed drives. Due to its commutators, DC motors are not most suitable for high- speed applications than AC motors (Yasser et.al,

High performance motor drive development is crucial for industrial and other applications. One of the characteristics of a high performance motor drive system is the ability to have a good dynamic speed command tracking and load regulating responsiveness. Due to the simplicity, ease of use, high reliability, flexibility, and affordable price of DC drives. It is used for speed and position control. DC motors have far better speed and torque characteristics than AC motors. DC motors provide excellent control of speed for acceleration and deceleration (Umesh & Rakesh, 2013). The armature resistance and impedance are low in DC motors, the armature current rises sharply with a slight increase in terminal voltage, potentially damaging the power converter device. (Sheeshant & Anupam, 2017).

In Separately excited DC motor, separate supply is provided for excitation of both field coil and armature coil. Figure 1 shows the separately excited dc motor. As the motor speed increases, the back EMF increases and the difference (V – E) go on decreasing. This results in a gradual decrease of armature current until the motor attains its stable speed and the corresponding back EMF. The back EMF helps the armature resistance in limiting the current through the armature.

Cite this article as:
Yekini, A.S. (2025). Analysis of Separately Excited DC Motor Using MATLAB/Simulink. *Journal of Multidisciplinary Innovations and Perspectives (JMIP), 1*(2) 85-91.

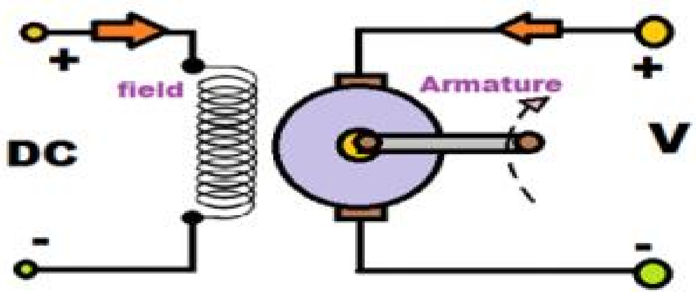

*Figure 1: Separately Excited DC motor (*Guoqiang & Xianguang, 2014)

Review of Related works

The authors designed a DC motor which speed is controlled by Proportional integral and derivative (PID) controller. The PID controller derivative (KP, KI, and KD) gains are modified in accordance with fuzzy logic. The result was simulated using MATLAB. The simulated result shows that the self-tuned PID controller performs better than traditional controllers PID. The result also showed that Fuzzy PID Controller provides DC motor with good speed tracking with reduced rise and settling time, minimum steady state error and low overshoot (Umesh & Rakesh, 2013).

The Pulse Width Modulation (PWM) technique was used in this work to regulate the speed of a DC motor. The pulse was generated using AT89S52 microcontroller. The motor is composed of two H-Bridges driven by an L293D IC. An optocoupler and a 555 IC were used to measure the speed of DC motor. Circuits and motors are powered by rectifier circuits. This study demonstrates that small DC motors can be effectively controlled with precision and accuracy without the need for expensive parts or complex circuitry (Khan. *et al.,* 2016).

The authors used a DC drive control system to run the DC motor so as to obtain the performance of the series DC motor below base speed and the performance of the separately excited DC motor above base speed and to change speed direction in a regenerative braking mode at any motor speed. The model of the DC motor and saturation was reviewed in this work. A steady state and transient analysis of the motor was performed below and above base speed. (Yasser *et.al.,* 2008)

This research work focused on the control of a separately excited DC motor using analogue PI controller and adaptive back stepping control mechanism. Results were simulated using MATLAB Simulink software. Result showed that adaptive back stepping control provides better overall system performance compared to conventional PI (Talavaru *et.al.,* 2014).

This research presented a fuzzy self-organizing algorithm for speed control of separately excited dc motors. The algorithm is experimented by controlling the speed of separately excited dc motor (Tipsuwanporn *et. al.,* 2007).

Methodology

Procedure

1. Start the Simulink
2. Open the Blank Model
3. In the "Library Browser" search for the following blocks and drag them into your model window: (a) "DC Machine" (b) "DC Voltage Source" – use the one from "powerlib" library,
4. The DC Voltage Source is set to 240 V and replicate in the model window. Two of the voltage sources is needed; one to feed the field winding and the other one to feed the armature winding
5. "Gain" – "Simulink/MathOperations" library set to 0.23
6. "Demux" – "Simulink/Commonly Used Blocks" library set output to 4
7. "Scope" - "Simulink/Commonly Used Blocks" and replicate it twice in the model window. 3 of the scopes are needed; to display speed of rotation, armature current and torque

Cite this article as:
Yekini, A.S. (2025). Analysis of Separately Excited DC Motor Using MATLAB/Simulink. *Journal of Multidisciplinary Innovations and Perspectives (JMIP), 1*(2) 85-91.

8. "XY Graph" – configure the range of this plot to: X-min = 0; X-max = 150; Y-min = 0 and Y-max = 500; Leave Sample time at -1.
9. "powergui" – leave it on default settings as before
10. Connect and label your "equipment" as indicated in the figure below. Additional element in the figure, third "Demux" output is "Terminator".
11. Run your model and inspect the results by double clicking on the scope blocks as shown in figure 2.
12. Three scopes have been used to observe three important variables in our experiment – speed of rotation, **w**, armature current **Ia** and torque **Te**. In that case "Show Legend" option in the scope display window should also be enabled in order to indicate the meaning of each trace in the plot. Try to find out how to do this
13. To simulate this setup, we need to remove the DC Voltage Source from the model and add the following blocks to it. (a) "Controlled Voltage Source" from "powerlib" library (b) "Ramp" block from "Simulink/Sources" library – set the "Slope" of this block to 70 in the parameter dialogue (c) "Saturation" block from "Simulink/Commonly Used Blocks" set – set the "Upper limit" to 240 and "Lower limit" to 0 for this block
14. The connected experimental setup is shown in figure 3.
15. Alternative method to start our DC motor without danger of damaging the equipment or blowing fuses in the lab is to use a so called step resistance starter.
16. To construct a three-step resistance starter you will need the following equipment in your model window:

- 3 Resistors - find the "Series RLC Branch" block, set the "Branch type" to "R" and replicate it twice in the model window. Specify the following resistances for each block, i.e. resistor: 3.66 Ω, 1.64 Ω, 0.737Ω
- 3 Switches to switch each individual resistor on or off in your starter – find the "Breaker" element, replicate it and keep its default settings
- 3 "Step" blocks from "Simulink/Sources" set; those blocks should provide timing for switches; "Step time" for those blocks should be set to 2.3 s, 4.6 s and 6.9 s.

17. Setup is completed as shown in figure 4 by adding another 240 V DC Voltage Source to our model. This source needs to be connected to armature winding via constructed step resistance starter. Reconfigure the XY Graph element to observe the change of speed of rotation w (rad/s) versus torque Te (Nm) as indicated in the figure below. Run the experiment and observe the results.

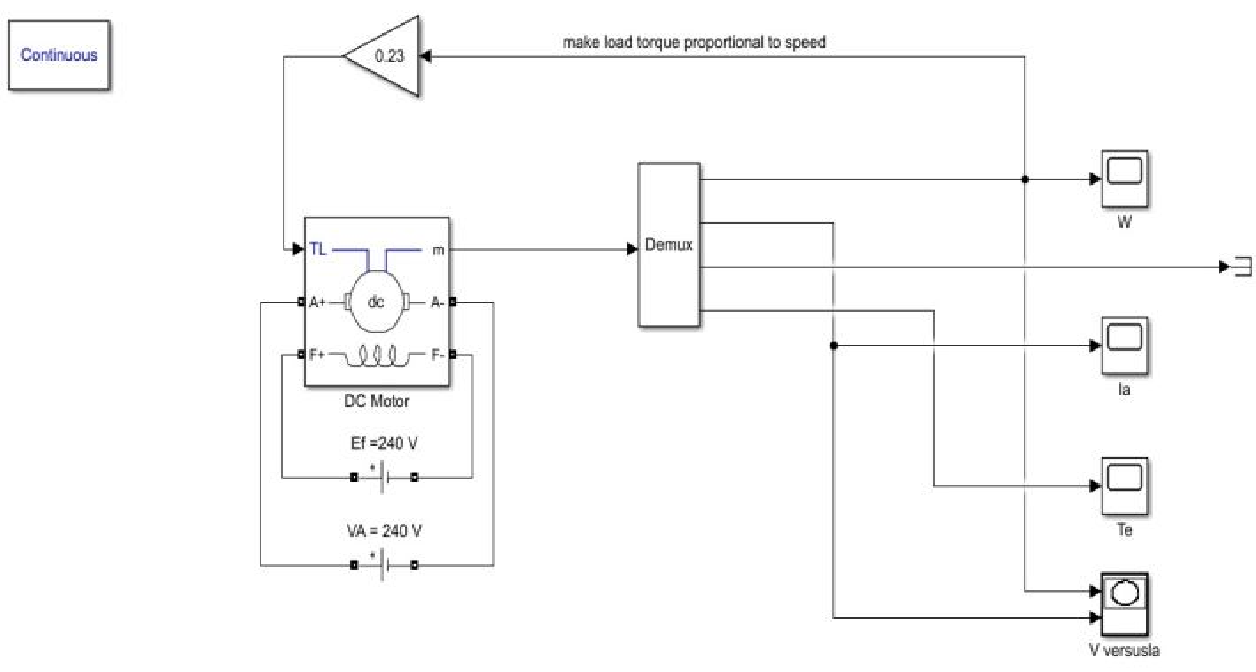

Figure 2: Circuit diagram of DC motor direct starter

Cite this article as:
Yekini, A.S. (2025). Analysis of Separately Excited DC Motor Using MATLAB/Simulink. *Journal of Multidisciplinary Innovations and Perspectives (JMIP), 1*(2) 85-91.

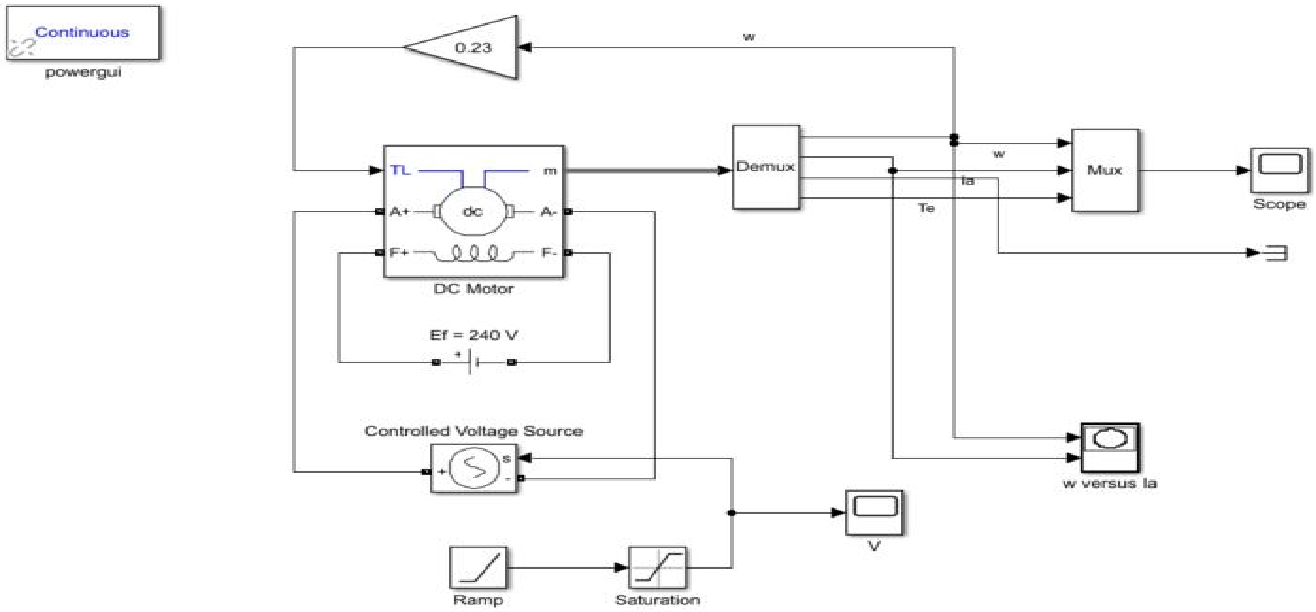

Figure 3: Circuit diagram of DC motor controlled voltage

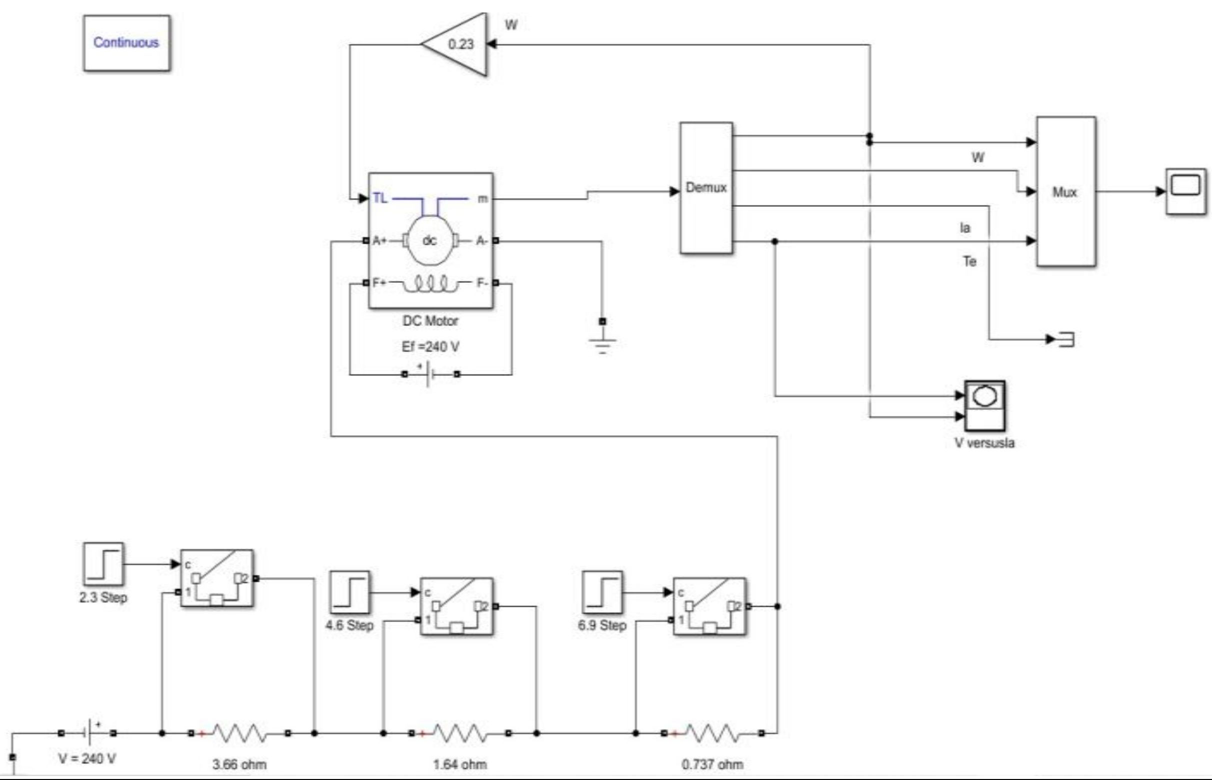

Figure 4: Circuit diagram of DC motor resistor controlled

Cite this article as:
Yekini, A.S. (2025). Analysis of Separately Excited DC Motor Using MATLAB/Simulink. *Journal of Multidisciplinary Innovations and Perspectives (JMIP), 1*(2) 85-91.

Result

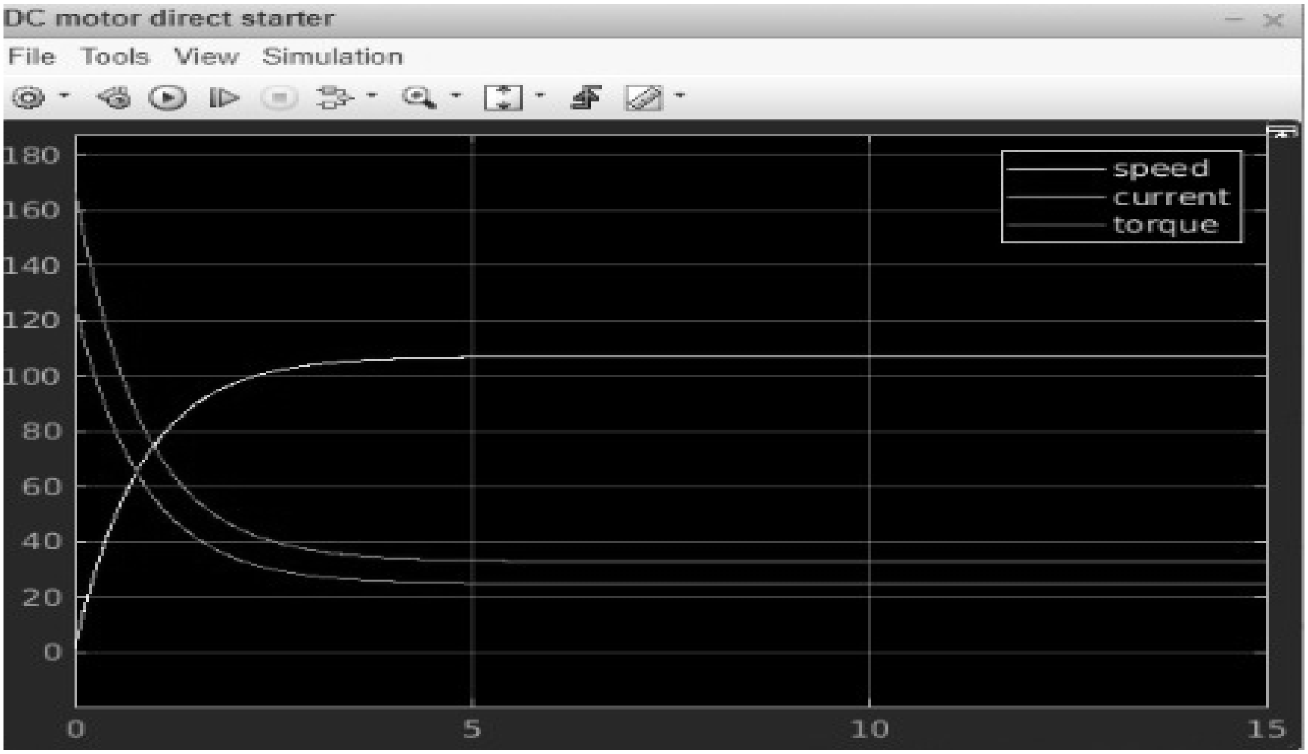

Figure 5: Simulation result using DC motor direct starter

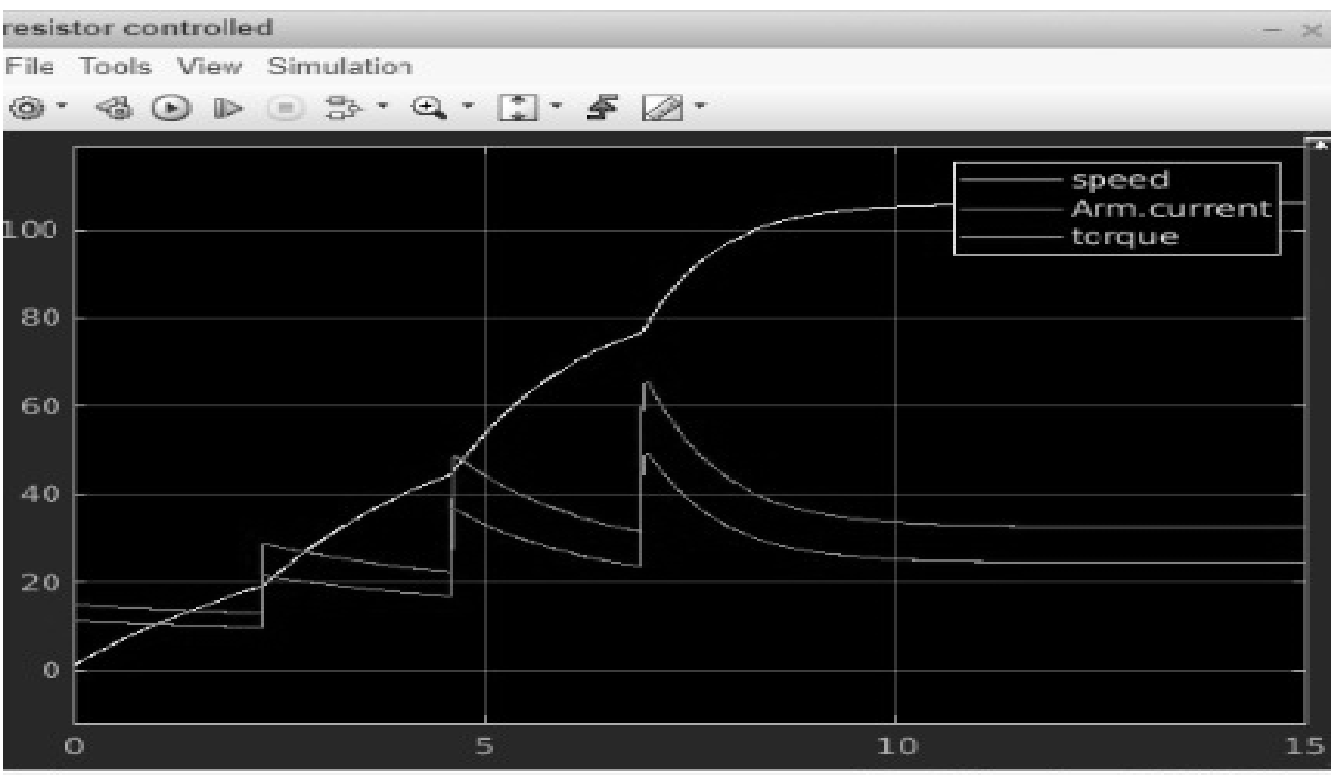

Figure 6 : Simulation result using resistor controlled

Cite this article as:
Yekini, A.S. (2025). Analysis of Separately Excited DC Motor Using MATLAB/Simulink. *Journal of Multidisciplinary Innovations and Perspectives (JMIP), 1*(2) 85-91.

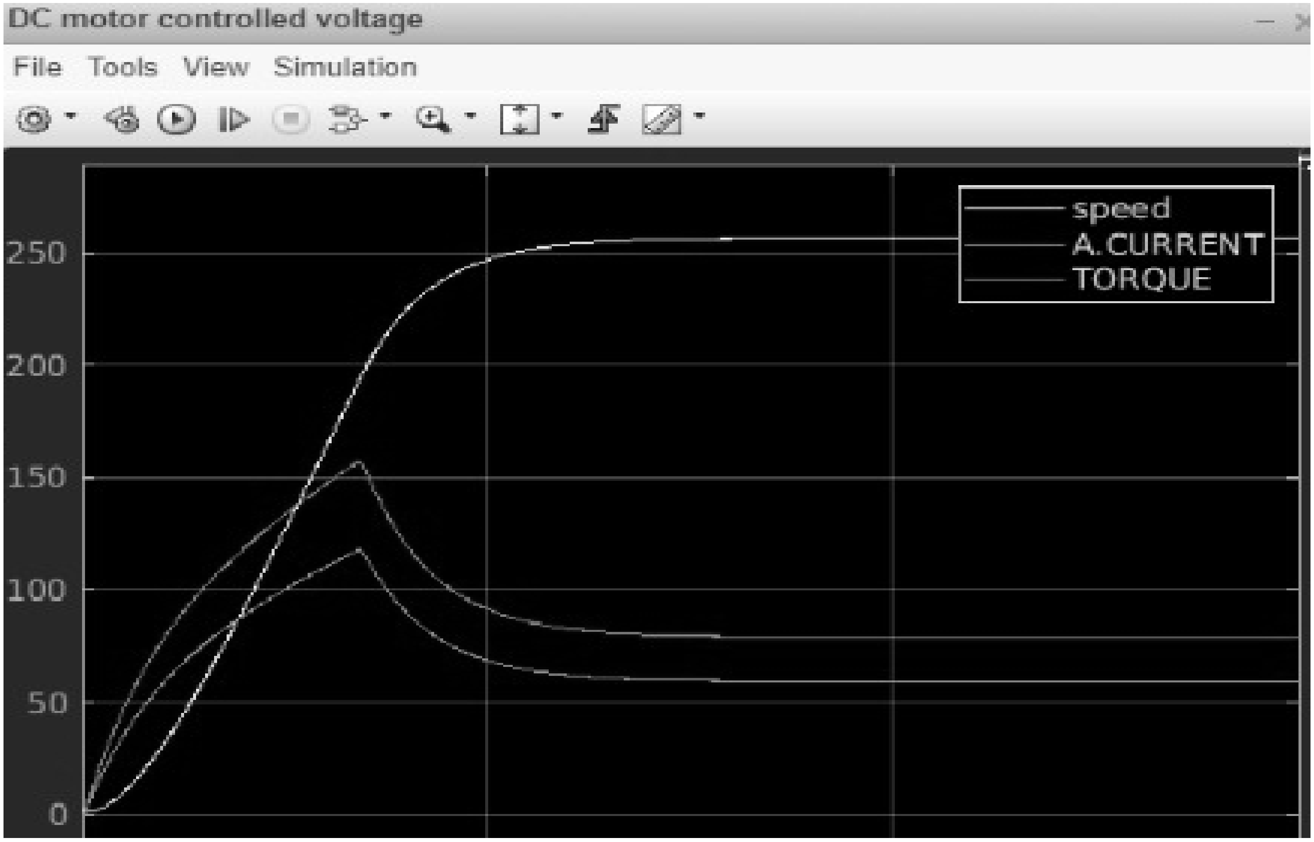

Figure 7: Simulation result using DC motor controlled voltage

Findings

The result of the simulation as shown in figure 5 shows that speed of rotation (w) of the motor increases sharply before getting to saturation point. Back emf is generated and the armature current (I_a) falls which in turn reduce the torque (T_e). Since torque (T_e) is directly proportion to armature current (I_a).As observed in figure 7, during the starting phase, the torque (T_e) and speed (w) takes more time to reach the peak value as compared to the armature current (I_a). Also, the time to reach the peak value at each value decreases. In figure 6; as the motor is start at reduced voltage, then gradually increase the voltage to its constant value, the speed (w) slowly increases rapidy and take longer time to get saturation point. armature current ((I_a) and torque (T_e) increases slowly and goes into saturation very shortly.

Discussion

Starting of dc separately excited DC motor using direct starter; at the instant of startup, the armature does not rotate, therefore the counter EMF EA is zero because no flux is induced in the armature winding. This current is subject to the armature to produce as mechanical shock and would blow fuse and disconnect itself from supply.

Starting using resistance starter; initially when the rotor is at a rest the full resistances of the starter appears in series with armature winding is within safe limit. When the separately excited DC motor starts rotating back emf produce which takes care of the armature current by reducing the net voltage in armature winding. Hence the starter is no more required. Therefore, the starting resistances are cut off in steps with a specific delay time and finally no resistance of starter remains in the circuit and the rated voltage appears across the armature winding It is evident from the experiment that using a direct starter to start a DC separately excited will damage the armature winding, brushes and burn fuse because of the large current that flows through the armature winding during starting. It is advisable to use either a DC motor controlled voltage or resistor controlled.

Cite this article as:
Yekini, A.S. (2025). Analysis of Separately Excited DC Motor Using MATLAB/Simulink. *Journal of Multidisciplinary Innovations and Perspectives (JMIP), 1*(2) 85-91.

References

Guoqiang .C & Xianguang .S(2014). Simulation used in education for a separately excited DC motor World Transactions on Engineering and Technology Education Vol.12, No.1

Guru.B.S. and Hiziroglu .H.R (1988). Electric Machinery and Transformers. Oxford University Press, New York.

Harrouz, A., Becheri, H., Colak, I. (2018). Backstepping control of a separately excited DC motor. Electr Eng **100**, 1393–1403 . https://doi.org/10.1007/s00202-017-0592-5

Khan M.R , Mohd. K., Pushpendra .K (2016.). Speed Control of DC Motor by using PWM". International Journal of Advanced Research in Computer and Communication Engineering Vol. 5, Issue 4 ISSN (Online) 2278-1021 ISSN (Print) 2319 5940

Sheeshant. A & Anupam M.(2017). Inner Current Loop Speed Control for Closed Loop Separately Excited DC Motor. IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 4 Issue 8 ISSN (Online) 2348 – 7968

Talavaru P, Nagaraj N, Kishore K.R.V (2014).Microcontroller based closed loop speed and position control of DC motor. Int J Eng Adv Technol (IJEAT) ISSN 3(5):2249–8958

Tipsuwanporn, V., Numsomran, A., Klinsmitth N., & Gulphanich, S. (2007). Separately excited DC motor drive with fuzzy self-organizing. 2007 International Conference on Control, Automation and Systems. doi:10.1109/iccas.2007.4406541

Umesh K.B. & Rakesh N. (2013). Speed Control of DC Motor Using Fuzzy PID Controller Advance in Electronic and Electric Engineering. ISSN 2231-1297, Volume 3, Number 9 , pp. 1209-1220 © Research India Publications http://www.ripublication.com/aeee.html

Yasser G. D, Hamdy A. A, Amany M. E (2008) .High starting performance separately excited DC motor. Department of Electrical and Control Engineering Arab Academy for Science and Technology Miami, Alexandria, Egypt