Research Article

Science Set Journal of Economics Research

Efficiency Improvement of Electric Vehicle by Using Dual Speed Transmission

Richa Pandey, Abhimanyu Kumar*

Department of Mechanical Engineering, BIT Mesra, Ranchi, Jharkhand-835215, India

***Corresponding author:** Abhimanyu Kumar, Department of Mechanical Engineering, BIT Mesra, Ranchi, Jharkhand-835215, India

Submitted: 17 June 2024 **Accepted:** 21 June 2024 **Published:** 30 June 2024

Citation: *Richa Pandey, Abhimanyu Kumar (2024) Efficiency Improvement of Electric Vehicle by Using Dual Speed Transmission. Sci Set J of Economics Res 3(3), 01-05.*

Abstract

The future of transportation leads significantly towards sustainability and efficiency, which are optimized by the development of electric vehicles. This project explores the development of a dual-speed transmission model for EVs using MATLAB simulation to assess the potential gains in efficiency and overall vehicle performance by using the MIDC drive cycle. System requirements, including the desired gear ratios, drive cycle, vehicle mass, motor torque, etc., to achieve specific efficiency and performance goals. MATLAB Simulink is used to create a simulation model that includes a dynamic EV powertrain with a dual-speed transmission subsystem. The project will compare the implications of integrating a single-speed transmission system with a more complex dual-speed transmission system, examining their impacts on the vehicle's range.

Keywords: Single Speed Transmission, Dual Speed Transmission, Range, Matlab Simulink, Drive Cycle

Introduction

Electric vehicles (EVs) represent a promising solution for sustainable transportation, offering reduced emissions and operational costs compared to conventional vehicles. Range anxiety is one of the major concerns for the electric vehicle industry. To further optimize the performance of EVs, this project investigates the integration of a dual-speed transmission system. By leveraging MATLAB Simulink for simulation and analysis, the aim is to enhance both efficiency and range, key factors influencing the adoption of electric mobility. Through the exploration of dual-speed transmission technology.

Efficiency improvement in electric vehicles (EVs) is a major concern, as it directly impacts range, energy consumption, and the overall performance of vehicles. One innovative approach to enhancing EV efficiency is the integration of a dual-speed transmission system. Dual-speed transmissions optimize and improve performance under varying driving conditions. This technology allows for more efficient use of the electric motor's power, resulting in reduced energy consumption and increased range. In this project, we explore the electric vehicle design in MATLAB Simulink and simulation for single-speed transmission and dual-clutch speed transmission.

Through modeling, analysis, and optimization, we aim to demonstrate how this technology can contribute to the advancement of sustainable and energy-efficient transportation solutions. The electric vehicle model consists of a DC motor, a lithium-ion battery, a motor controller, a vehicle body, a single- and dual-speed transmission system, and an and an MIDC drive cycle.

When the physical model is ready in Matlab Simulik, run the simulation for both single and dual speed transmission separately and check for how much range increases in dual speed transmission as compared to single speed transmission [1].

Methodologies

Drive Cycle: The drive cycle block source is taken from Matlab Simulink. In this block, the FTP-75 drive cycle by default comes, but there is an option to add or load a different drive cycle, and these (.mat,.xls,.xlsx, or.txt) file formats are supported. In this block set, the MIDC drive cycle is
added, with a maximum speed of 50 km/h in city driving conditions.

Ports:

- **Output:** RefSpd — Vehicle reference speed
- **Refspd:** Referance speed of vehicle

- **Input:** VelFed — Vehicle longitudinal speed
- **Velfed:** Feedback velocity of vehicle

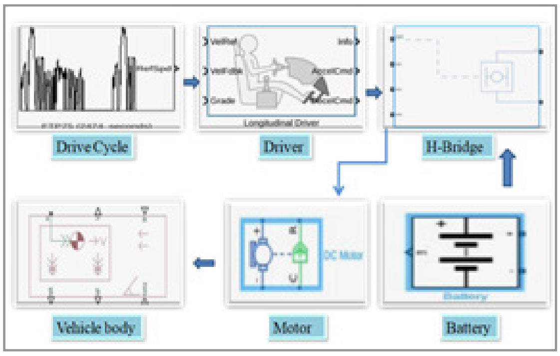

Figure 1: Methodologies of electric vehicle

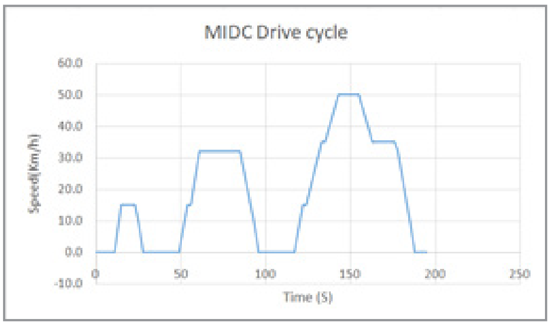

Figure 2: MIDC drive cycle

Longitudinal Driver: The longitudinal driver is an in-built block provided by the powertrain blocks. It acts as a speed controller to generate braking and acceleration commands based on reference and feedback velocities that can vary from 0 to 1.

The VelFdbk port corresponds to the feedback velocity. The actual velocity output given by the vehicle body is connected here. By comparing the actual (feedback) velocity with the reference velocity, the driver block generates acceleration and braking signals in order to minimize the error between the two concerned velocities. The grade corresponds to the grade angle. For this simulation, no inclination is considered, and hence, a constant block with a value 0 is connected [2].

Acceleration and deceleration commands are generated, respectively, and are connected to the corresponding ports of the Controlled Voltage block. Proportional-integral (PI) control is used by the block to monitor feed-forward and wind-up gains.

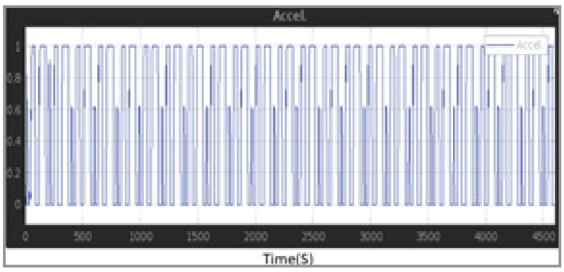

Figure 3: Acceleration commands based on reference and feedback velocities

Figure 3 shows the acceleration graph based on the longitudinal driver acceleration commands, which vary from 0 to 1.

H-Bridge: The PWM port's input signal determines the controlled voltage source. It is connected to both the H-bridge's output, which supplies the DC motor with a controlled voltage, and PWM, which regulates voltage signals [3].

Ports:

- **+:** Positive load connection port
- **-:** Negative load connection port REF: REF is the floating zero-volt reference.
- **REV:** Reverse threshold voltage
- **BRK:** Braking threshold voltage
- **PWM:** This stands for pulse width modulation, which provides the voltage pulses to H-bridge average mode, is used.

DC Motor: The DC motor is connected with single- and dual-speed transmission separately. In this case, the case, the thermal effect of the motor is not considered.

Table 1: DC motor parameter
Motor: Rated by load and speed

Maximum Speed (rpm)	10000
DC voltage (V)	320
Rated load (KW)	94

Battery: The Battery Pack subsystem consists of a battery block, a controlled source, a power GUI block, and a bus selector. The controlled current source receives a signal from the H-Bridge, which is current, and these blocks m are connected to the battery block. A bus selector is connected to Li-ion batteries, which show the SOC, voltage, and current of the battery [4].

Table 2: Battery Parameters:

Rated capacity (Ah)	92.02
Nominal voltage (V)	326

Vehicle Body: A two-axle vehicle in longitudinal motion is modeled by the Vehicle Body Block, a simulation tool that takes into account factors like body mass, aerodynamic drag, road inclination, weight distribution, and externally defined mass and inertia.

Table 3: Vehicle Parameters:

Vehicle mass (Kg)	1580
No. of wheels per axle	2
Acceleration due to gravity (g)	9.81 m/s^2
Aerodynamic drag coefficient (Cd)	0.15
Rolling resistance coefficient (μ)	0.015
Gradiability	5°
Vehicle frontal area (A)	2.8 m^2
Gear ratio	9.6, 5.2

Result and Discussion

Single-speed transmission: Matlab simulation runs in which the vehicle covers a distance of 89.65 km, initial SOC of the battery is 100, and the SOC drops from 100 to 0%.

In Figure 4, feedback velocity and reference velocity for single-speed transmission are shown. In which feedback velocity flows the reference velocity based on the MIDC drive cycle, which is shown in figure no. 2 in the MIDC drive cycle [5].

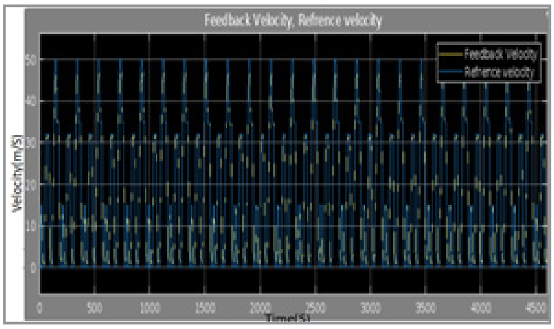

Figure 4: Feedback velocity & Reference velocity for single speed transmission

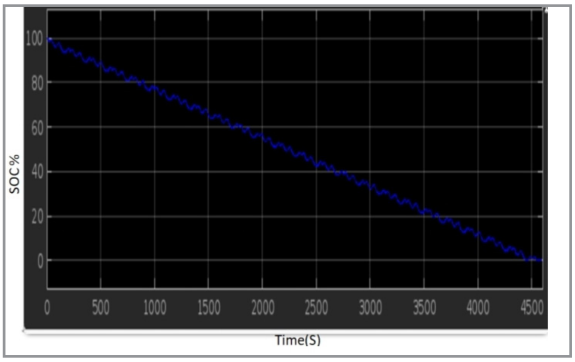

Figure 5: Discharge of battery SOC

The initial SOC of the battery is 100% and drops to 0% during the vehicle simulation run for single-speed transmission [6]. As shown in figure no. 5

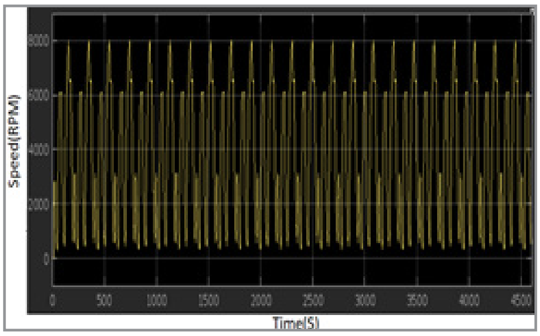

Figure 6: Motor RPM for Single speed transmission

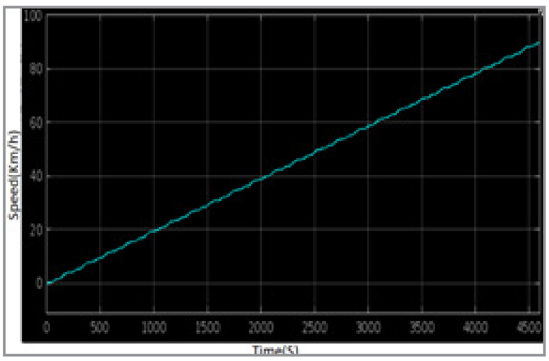

Figure 7: Distance covered for Single speed transmission

Dual speed transmission: Matlab simulation run for dual clutch speed transmission t = 1000 sec in which vehicle cover a distance of 97.05 km and initial SOC of battery is 100 and SOC drop from 100 to 0%.

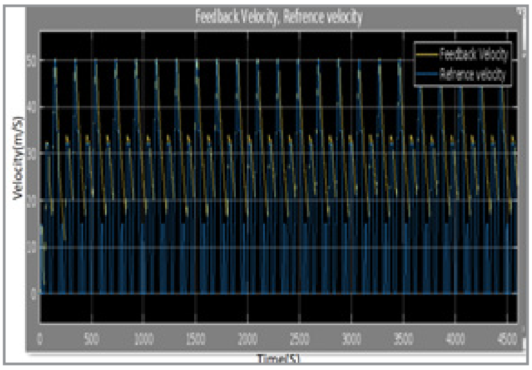

Figure 8: Feedback velocity & Reference velocity for dual speed transmission

In figure no. 8, the feedback velocity flow is based on the reference velocities based on the MIDC drive cycle, in which the maximum speed is 50 km/h.

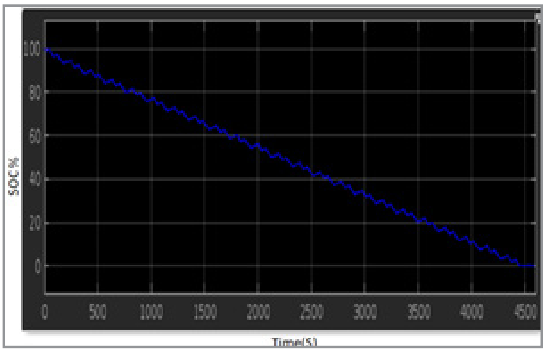

Figure 9: Discharge of battery SOC

Discharge of battery SOC during dual-speed transmission. As shown in figure 9,

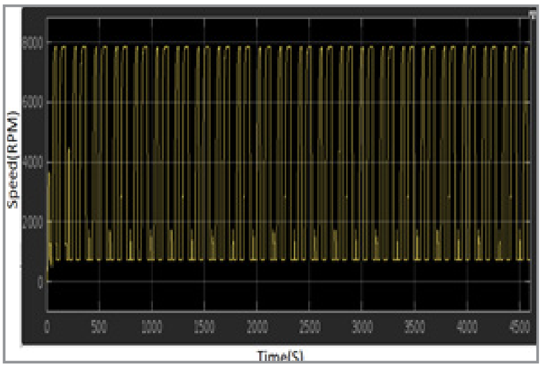

Figure 10: Motor RPM for dual speed transmission

As shown in figure 10, In a dual-speed transmission, switching between gears alters the motor's RPM and torque output [7]. The low-speed gear increases torque at lower RPM for better acceleration and climbing, while the high-speed gear sacrifices some torque for higher RPM and efficiency during cruising [8].

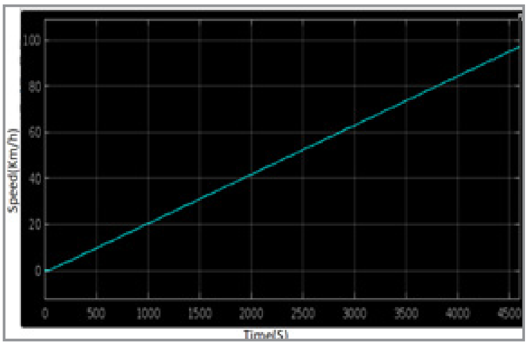

Figure 11: Distance covered for dual speed transmission

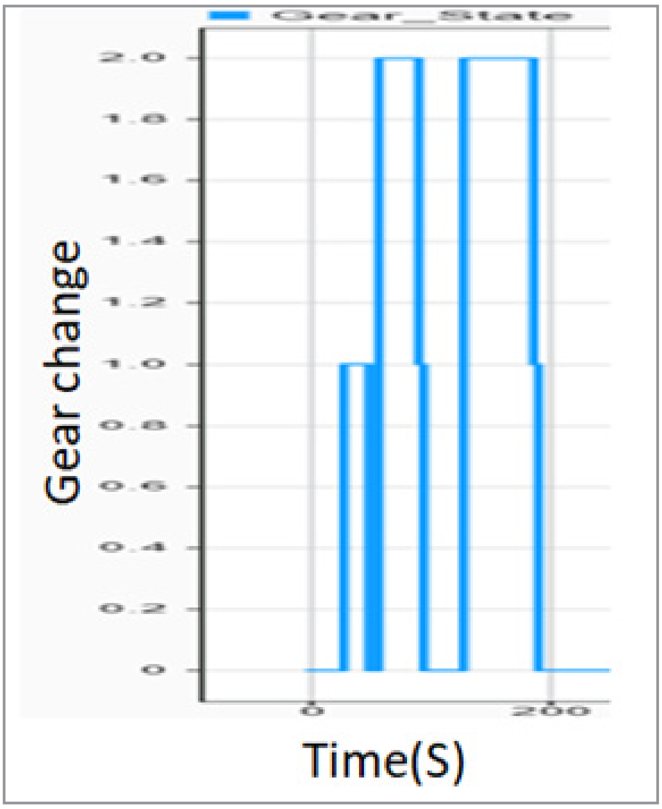

Figure 12: X-axis: Time(S) Y-axis: Gear change from 1to 2 Change of gear 1 to gear 2

Figure 12 shows the gear change from gear 1 to gear 2 for one cycle 190s [9].

A physical model of an electric vehicle made in Matlab Simulink for single-speed transmission and dual-speed transmission in the MIDC drive cycle. The results of single- and dual-speed transmission are then obtained by running Matlab Simulink [10]. The single-speed transmission covers a distance of 89.65 km, and the battery SOC drops from 100% to 0%. In the case of dual-speed transmission, cover a distance of 97.05 km and the battery SOC drop from 100% to 0%.

Table 4: Result of range improvement and SOC

MIDC drive cycle	Distance (KM)
Single speed transmission	89.65
Dual speed transmission	97.05
Range efficiency(Based on distance covered)	7.6%

As shown in Table 4, Hence, the range of the vehicle increases by 7.6% based on the distance covered by dual-speed transmission when compared with single-speed transmission. The battery SOC drop for both single-speed transmissions and dual-speed transmissions from 100 to 0%

Conclusion

In this study, we find a result of the dual-speed transmission system on the efficiency and range of electric vehicles, particularly under the MIDC drive cycle in city drive condition. When a dual-speed transmission is integrated instead of a single-speed transmission, our results show an improvement in the distance traveled [11].

In the MIDC drive cycle, the electric vehicle physical model in Matlab Simulink equipped with a dual-speed transmission achieved a distance of 97.05 kilometers. In contrast, the same vehicle with a single-speed transmission covered a distance of 89.65 kilometers .This represents a notable increase in range efficiency, with the dual-speed transmission configuration demonstrating a 7.6% improvement in distance covered [12].

Reference

1. He B, Chen Y, Wei Q, Wang C, Wei C, Li X (2023) Performance Comparison of Pure Electric Vehicles with Two-Speed Transmission and Adaptive Gear Shifting Strategy Design. Energies.
2. Chan Chin, Pant Kumar (2023) Analysis of Electric Vehicle Batteries with Emphasis on Range. International Journal of Novel Research in Engineering & Pharmaceutical Sciences 1: 20-22.
3. Kazuki Ogawa, Tatsuhito Aihara (2021) Development of two-speed dual-clutch transmission for seamless gear shifting in EVs, Transportation Engineering 6: 100097.
4. Sun GB, Chiu YJ, Zuo WY, Zhou S, Gan JC, Li Y (2021) Transmission ratio optimization of two-speed gearbox in battery electric passenger vehicles. Advances in Mechanical Engineering 13: 168781402110228.
5. Khond S, Sheikh Y, Renge Mohan (2020) Modelling and Simulation of Two Gear Electric Vehicle in MATLAB SIMULINK. HELIX 10: 31-37.
6. Jinglai Wu, Jiejunyi Liang, Jiageng Ruan, Nong Zhang, Paul Walker D (2018) Efficiency comparison of electric vehicles powertrains with dual motor and single motor input, Mechanism and Machine Theory 128: 569-585.
7. Yang Tian, Jiageng Ruan, Nong Zhang, Jinglai Wu, Paul Walker (2018) Modelling and control of a novel two-speed transmission for electric vehicles, Mechanism and Machine Theory 127: 13-32.
8. Laitinen H (2017) Improving electric vehicle energy efficiency with two-speed gearbox . Master's Thesis, Aalto University School of Engineering.
9. Mruzek Martin, Gajdáč Igor, Kucera Lubos, Gajdošík, Tomáš (2017) The Possibilities of Increasing the Electric Vehicle Range. Procedia Engineering 192: 621-625.
10. Sarrafan K, Sutanto D, Muttaqi KM, Town G (2017) Accurate range estimation for an electric vehicle including changing environmental conditions and traction system efficiency.

11. Martin Mruzek, Igor Gajdáč, Ľuboš Kučera, Dalibor Barta (2016) Analysis of Parameters Influencing Electric Vehicle Range,Procedia Engineering 134: 165-174.

12. Wu Guang, Zhang Xing, Dong Zuomin (2013) Impacts of Two-Speed Gearbox on Electric Vehicle's Fuel Economy and Performance. SAE Technical.