Grenze International Journal of Engineering and Technology, June Issue

Steering-Predictive Adaptive Regenerative Braking Control for Improved Vehicle Stability in Electric Vehicles

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***Abstract*— Electric vehicles use regenerative braking to recover part of the vehicle's kinetic energy during deceleration. In many existing control strategies, the main objective is maximizing energy recovery, while the interaction between braking and steering is often not considered. When a vehicle is braking while turning, the braking torque applied to the driven wheels can influence the available lateral tire force and may affect stability. This study investigates a steering-adaptive regenerative braking method that adjusts braking torque based on steering wheel motion. The controller monitors the steering angular rate and interprets a rapid steering input as the beginning of a turn. If the steering rate exceeds 30°/s, the regenerative braking torque is temporarily reduced to limit braking force at the rear axle. The approach is evaluated using numerical simulation of a vehicle dynamics model during an aggressive turning maneuver. The simulation results indicate a small decrease in peak rear sideslip of about 2.9% compared with a conventional constant-torque regenerative braking strategy. Yaw-rate behavior and lateral acceleration remain largely unchanged, while the recovered braking energy decreases by approximately 0.9%. These findings suggest that steering-adaptive modulation of regenerative braking can slightly improve stability during turning with only a minor reduction in energy recovery.**

***Keywords*— Electric vehicles, Regenerative braking, Vehicle stability, Steering-adaptive control, Vehicle dynamics.**

I. Introduction

The rapid growth of electric vehicles (EVs) has increased the demand for control systems that can improve both energy efficiency and driving safety. One of the key technologies used in EVs is regenerative braking, which allows a portion of the vehicle's kinetic energy to be converted into electrical energy and stored in the battery during deceleration [1], [2]. Because of this capability, many researchers have focused on developing control strategies that can maximize the amount of energy recovered while still maintaining acceptable braking performance [3], [4]. Most existing regenerative braking approaches mainly concentrate on improving energy recovery and managing longitudinal vehicle dynamics. Several adaptive and intelligent control methods have been proposed that adjust braking behavior based on factors such as battery condition, driving behavior, and traffic environment in order to improve efficiency and ride comfort [5], [6].

Grenze ID: 01.GIJET.12.2.39_25

In addition, some systems allow the braking characteristics to be customized according to driver preference, particularly in car-following situations [7]. Although these strategies are effective for energy management, they typically focus on straight-line driving and give limited attention to vehicle stability during turning maneuvers. When a vehicle is cornering, braking torque applied at the driven wheels can influence the available lateral tire forces and affect the yaw dynamics of the vehicle. As a result, braking during steering can have a direct impact on vehicle stability. Previous studies have shown that steering angle and steering rate provide useful information about driver intent and can be used to support stability control during cornering [8], [9]. Control approaches that coordinate steering inputs with differential torque or yaw moment control have demonstrated improvements in vehicle handling and maneuverability [10]. However, most of these studies focus on distributing drive torque rather than adapting regenerative braking based on steering inputs. The interaction between braking and steering is inherently complex because longitudinal braking forces and lateral cornering forces share the same tire friction limits. If braking forces are not properly managed during a turn, the vehicle may experience instability such as oversteer or understeer [11]. Some coordinated steering and braking control strategies have been explored to enhance vehicle safety, especially under fault or emergency conditions [12]. Related studies have also investigated path tracking control with four-wheel independent steering, driving and braking systems for autonomous electric vehicles [13]. Related research has examined game-theoretic optimization of regenerative braking strategies considering vehicle stability and comfort [14]. Related adaptive braking strategies based on driving style recognition and environmental conditions have also been proposed for intelligent electric vehicles [15]. Additional intelligent regenerative braking control methods using fuzzy logic and optimization techniques have been explored to improve braking performance and energy recovery [16]. Reinforcement learning-based regenerative braking control approaches have also been investigated for adaptive braking behavior in electric vehicles [17]. Other studies have focused on the optimal distribution of regenerative and friction braking forces while considering brake stability requirements [18]. Research related to energy recovery systems during braking for electric vehicles has also contributed to understanding regenerative braking effectiveness [19]. Furthermore, independent wheel torque control methods for four-wheel-drive electric vehicles have demonstrated improved differential drive assisted steering performance [20]. However, many of these approaches respond only after instability has already begun, rather than anticipating it in advance. Although significant progress has been made in regenerative braking optimization and steering-based stability control, the integration of these two aspects has received relatively limited attention. In particular, the use of steering wheel angular rate as an early indicator of a turning maneuver to adjust regenerative braking torque has not been widely explored. Furthermore, the potential influence of such steering-aware braking strategies on stability indicators such as yaw-rate error, sideslip angle, and lateral acceleration has not been extensively studied.To address this gap, this work investigates a steering-aware regenerative braking strategy for electric vehicles. The proposed approach monitors steering inputs and identifies the beginning of a turn based on the steering wheel angular rate. When the steering rate exceeds a predefined threshold, the regenerative braking torque is temporarily reduced in order to limit braking force at the driven wheels. The concept is evaluated through numerical simulations using a vehicle dynamics model under turning maneuvers. The simulation results provide insight into the interaction between regenerative braking and steering dynamics, showing a modest reduction in rear sideslip while maintaining similar yaw behavior with only a small reduction in recovered braking energy.

II. Related Work

In recent years, there has been a great deal of research to make the braking systems of electric vehicles smarter, safer, and more efficient. Most of the research that currently exists is related to regenerative braking control, stability control through steering, and braking methods that are cognizant of the driver. In Regenerative braking, as a major method for improving the efficiency of an electric vehicle, has gained widespread acceptance in the capture of the vehicle's kinetic energy during braking. Various approaches based on PID, Sliding mode control, fuzzy logic, and MPC have been proposed to optimize the regenerative braking chance to ensure an acceptable level of braking dynamics [1–4]. Research indicates the effectiveness of motor-level regenerative braking control in improving efficiency and robustness in the face of different braking situations [3], [4]. Recently, adaptive regenerative braking controllers have appeared. These controllers consider battery status, driving behavior, and system limitations to improve ride comfort and energy consumption [5], [6]. Even though such controllers work well in optimizing the amount of captured energy during braking, their focus usually is limited to straight braking rather than braking from turns. The issue of stability during turns is not given much attention. Corners of a vehicle have been a focus of research regarding stability, with approaches being developed using steering control [7], [8]. Based on observations of the steering angle of the vehicle and the rate at which the steering is being turned, researchers are able to predict the intent of the driver, which is used in yaw moment control [9], [10]. Wheel-sharing control approaches, which distribute either drive torque or yaw moments among the wheels of a vehicle, have demonstrated improved handling and vehicle stability, with the largest improvements being found among electric vehicles with independent drives [11], [12]. Many review articles emphasize that joint braking and steering are a difficult maneuver because of a strong coupling between forces in the longitudinal and lateral tire directions [13], [14]. In this case, coupling can cause a tendency to understeer or oversteer with a single incorrect maneuver. Despite its effectiveness in issues of stability through steering or control of drive torque, regenerative braking usually does not take into account steering activities [15]. As cars become increasingly smarter and more software-defined, driver-aware braking systems are drawing more notice. People are researching ways of personalizing regenerative braking to tailor how a vehicle slows down to each driver's taste with the aim of improving comfort and increasing the ease of acceptance of the drivers [16], [17]. Simultaneously, intelligent regenerative braking is being developed for car-following and adaptive cruise control, where the braking behavior becomes tuned by adaptive algorithms and real-time parameter updates [18], [19]. But most of those work just on longitudinal control-how smoothly you decelerate and how well you maintain distance. They don't account for steering dynamics or stability when the car corners, and that gap matters because steering–braking interactions can be crucial. Some works in coordinated braking and steering under fault conditions have shown gains in safety and stability, underlining this interaction [20]. Still, the field tends to be reactive, addressing abnormal situations rather than proactively boosting stability during normal driving. Based on the above observations, regenerative braking optimization and steering-based stability controller have been observed to address these domains independently. The community engaged in regenerative braking research focuses more on optimizing the efficiency of the braking system, addressing longitudinal dynamics, rather than steering-based dynamics, where the controller focuses more on the yaw dynamics of the vehicle. There is very limited work associated with integrating the steering dynamics of the vehicle within regenerative braking systems. Specifically, the opportunity associated with the early indication of the driver's intent through the angular rate of the steering wheel, coupled with the corresponding adjustment of the regenerative brake torque near the beginning of the turn, remains untapped for stability enhancement. However, the stability gains associated with these systems have received very limited attention, focusing more on metrics such as yaw rate error, sideslip angle, and lateral acceleration.

III. METHODOLOGY

The following section describes a system architecture for the steering and adaptive braking regeneration concept and formulates the control problem that we address.

A. System Architecture

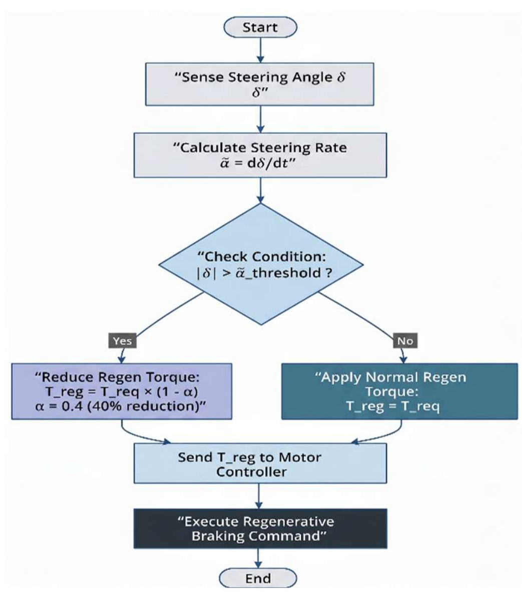

Fig. 1. Flowchart of the proposed steering-adaptive regenerative braking control logic based on steering angular rate

The proposed system tackles the steering-aware regenerative braking system as a supervisory control system, as shown in Fig. 1. In real-time, the system optimizes the regenerative braking force according to the real-time steering input. The aim is to improve the stability of the vehicle during cornering without compromise in the energy regeneration efficiency.

The sensing layer receives the steering angle through the steering angle sensor of the vehicle. From this, it calculates the angular rate of the steering, indicating what the driver intends to do next. The decision layer considers the dynamics of steering and determines when to start with the turning mode based on steering rates beyond certain thresholds.

Based on this analysis, the control layer determines when it is time to reduce regenerative braking torque so as to maintain stability for the vehicle. The actuation layer then provides the adjusted regenerative braking torque command for processing through the electric motor controller for braking. The regeneration control torque is largely for momentary reduction of regeneration braking when changing into a turn, with full regeneration braking permitted for energy saving when driving in a straight direction.

B. Problem Formulation

The conflict being addressed in this work focuses on the balance between the stability of the vehicle and the regenerative braking torque that takes place during the process of steering and regenerative braking. A braking torque that is too high can have a destabilizing effect on the vehicle's yaw, but a braking torque that is too low can decrease the regenerative braking effect.

Given:

Steering angle $\delta(t)$

Vehicle speed $v(t)$ $E_{recovery}$

Maximum available regenerative braking torque $T_{max}(v)$

The goal is to determine an adaptive regenerative braking torque $T_{reg}(t)$such that the following objectives are satisfied: Vehicle stability during turning is enhanced, expressed as minimizing yaw rate deviation during cornering:

$$\min\int \mid r\text{actual}(t) - r\text{desired}(t) \mid dt \qquad (1)$$

where r represents the vehicle yaw rate.

Energy recovery remains acceptable, ensuring that the recovered braking energy satisfies:

$$\text{Erecovery} = \int T_{reg}(t)\ .\ \omega_{wheel}(t)dt \geq E_{min} \qquad (2)$$

where $\omega_{wheel}$is the wheel angular velocity.

$$T_{reg}(t) = \begin{cases} T_{req}(t)(1-\alpha), & |\dot{\delta}(t)| > \dot{\delta}_{th} \\ T_{req}(t), & \text{otherwise} \end{cases} \qquad (3)$$

Control action is predictive rather than reactive, such that regenerative braking torque is adapted based on steering rate rather than yaw rate error, enabling early intervention before instability develops

C. Control Strategy Overview

For dealing with the above problem, a threshold control strategy is employed in which the steering angular rate is considered as the major predictive signal for turn detection. If the absolute value of the steering rate exceeds a certain threshold, the controller indicates the initiation of turn and cuts down the regenerative braking torque. The control logic is defined as:

IF $\mid \dot{\delta} \mid > \dot{\delta}_{threshold}$ AND regenerative braking active

THEN $T_{reg} \leftarrow T_{reg} \times (1-\alpha)$

ELSE $T_{reg} \leftarrow$ normal regenerative braking torque

where, $\dot{\delta}_{threshold} = 30°/s$ is the steering-rate threshold used to detect turn entry,$\alpha = 0.4$ represents a 40% reduction in regenerative braking torque during turning,$T_{max} = 250$Nm is the maximum available regenerative torque at the given vehicle speed.

By using steering rate as a trigger, the proposed strategy converts the stability–energy trade-off into a real-time, steering-based decision process, enabling proactive stability enhancement instead of corrective action after instability occurs.

D. Vehicle Dynamics Model for Stability Analysis

The stability effects of steering-adaptive braking are analyzed using a linear bicycle model with coupled longitudinal-lateral dynamics. The model captures essential vehicle behavior during combined braking and steering maneuvers.
Lateral and yaw dynamics:

$$m(\dot{v} + ur) = F_{yf} + F_{yr} \quad (4)$$

$$I_z\dot{r} = aF_{yf} - bF_{yr} + \Delta M_z \quad (5)$$

where:

$m = 1500$ kg: vehicle mass
$I_z = 2500$ kg·m²: yaw moment of inertia
v: lateral velocity, u: longitudinal velocity
r: yaw rate
$a = 1.2$ m, $b = 1.5$ m: distances from CG to front/rear axles
ΔM_z: yaw moment disturbance from braking asymmetry
Tire forces with linear approximation:

$$F_{yf} = C_{\alpha f}\alpha_f, \alpha_f = \delta - \frac{v + ar}{u} \quad (6)$$

$$F_{yr} = C_{\alpha r}\alpha_r, \alpha_r = -\frac{v - br}{u} \quad (7)$$

where $C_{\alpha f} = 80{,}000$ N/rad, $C_{\alpha r} = 100{,}000$ N/rad are cornering stiffness coefficients.
Braking-stability-coupling:
The regenerative braking torque T_{reg} creates longitudinal force:

$$F_x = \frac{T_{reg}}{R_{wheel}} \quad (8)$$

which reduces available lateral force through the friction ellipse constraint:

$$F_{y,avail} = \sqrt{(\mu F_z)^2 - F_x^2} \quad (9)$$

This coupling explains why braking during turns compromises stability, justifying torque reduction

E. Assumptions and Scope

The steering torque sensor records correctly smoothed measures. While driving normally (in any mode besides an emergency maneuver). Tire–road friction The simple model assumes that the road surface provides enough tire–road friction, i.e. it is not in a severe low-adhesion state (like on ice or snow).Regenerative braking is only enabled when the battery state-of-charge allows it. The control approach focuses on turn entry, not steady-state cornering. Therefore, this work does not focus on heavy braking and extreme turning maneuvers. Emergency braking is out of the scope, that is emergency deceleration with ABS operating. The vehicle dynamics model is based on parameters for a medium-size electric vehicle provided in Table I.

F. Simulation Model Description

The simulation of the proposed steering adaptive regenerative braking strategy has been implemented using MATLAB numerical simulation (R2025b). In the simulation, the simulation environment processes the signals from steering input to braking torque output.The steering input generator computes the actual values of the steering wheel angle (δ) and the steering angular rate (δ) to simulate various driving maneuvers, including straight driving and turning. These values are used as inputs to the control algorithm, which implements the proposed strategy. Based on the value of the steering rate, the controller adjusts the regenerative braking torque in real-time to improve the stability of the vehicle during turning

G. Vehicle and Control Parameters

The simulation parameters are set to reflect a general mid-size electric vehicle in an urban driving environment. The key vehicle and control parameters used in the simulation are presented in Table I. The steering-adaptive control strategy proportionally decreases the control regenerative braking torque in response to the steering angular rate during turn entry and the applied regenerative braking torque is given by

$$T_{\text{reg}}(t) = \begin{cases} T_{\text{req}}(t)\,(1-\alpha), & |\,\dot{\delta}(t)\,| > \dot{\delta}_{\text{th}} \\ T_{\text{req}}(t), & |\,\dot{\delta}(t)\,| \leq \dot{\delta}_{\text{th}} \\ 0, & \text{otherwise} \end{cases} \quad (10)$$

subject to the constraint

$$T_{\text{reg}}(t) \leq T_{\text{max}}. \quad (11)$$

Here, $T_{\text{req}}(t)$denotes the instantaneous requested regenerative braking torque, $T_{\text{max}} = 250$ Nmrepresents the maximum regenerative torque capability of the motor, $\dot{\delta}_{\text{th}} = 30\ ^\circ/\text{s}$is the steering-rate threshold, and $\alpha = 0.4$ is the torque reduction factor. In the simulation, full regenerative braking demand ($T_{\text{req}}(t) = T_{\text{max}}$) is assumed continuously to represent a conservative worst-case stability scenario. In practical applications, the controller would scale the actual requested braking torque using the same control rule

TABLE I: VEHICLE PARAMETERS AND CONTROL SETTINGS

Parameter	Symbol	Value
Vehicle mass	m	1500 kg
Yaw moment of inertia	I_Z	2500 kg·m²
Front cornering stiffness	$C_{\alpha f}$	80,000 N/rad
Rear cornering stiffness	$C_{\alpha r}$	100,000 N/rad
Wheelbase	L	2.7 m
Distance from CG to front axle	a	1.2 m
Distance from CG to rear axle	b	1.5 m
Wheel radius	R_{wheel}	0.32 m
Tire–road friction coefficient	μ	0.85
Maximum regenerative torque	T_{max}	250 Nm
Steering rate threshold	$\dot{\delta}_{th}$	30 °/s
Torque reduction factor	α	0.4
Nominal vehicle speed	v	60 km/h
Integration time step	Δt	0.1 s

H. Test Scenarios

A 30-second steering maneuver is used to evaluate and test the proposed steering-adaptive regenerative braking strategy. The simulation covers straight driving, turn-in, steady state cornering, and turn departure. The car moves with no steering for 0-5 s and then for 16-30 s when it is driving straight with zero steering input.Turn-in is performed between 5-8 s, and during this time, the steering angle is raised from 0° to 60° at a constant steering rate of 60°/s. During this phase, the steering angle is maintained at a constant value of 60° for 8-13 s, and it is a steady turn. Turn departure is performed between 13-16 s, and during this time, the steering angle is reduced back to 0° at a rate of -60°/s.

I. Performance Metrics

The performance of the proposed steering adaptive regenerative braking control strategy will be assessed through simulation tools using the braking behavior indicators. Thus, the major consideration will be the extent to which the controller is able to respond to steering inputs through adaptive regenerative braking torque. The regeneration braking torque is the major performance indicator. This is part of the strategy that enables the direct monitoring of the braking torque, which will be minimized inside the turn and normalized back to full regenerative braking while driving in a straight line. Moreover, the overall energy recovery dynamics are investigated based on a regeneration torque analysis during the driving maneuver. Thus, stability-based torque reduction does not negatively impact energy recuperation in a negative way. Finally, the responsiveness of the control algorithm will be evaluated in terms of the speed and smoothness of the adjustment of the braking torque when the steering rate passes beyond the preset threshold value. For evaluation purposes, the proposed strategy is compared with a conventional regenerative braking approach that applies constant braking torque irrespective of steering input

IV. RESULTS AND DISCUSSION

This section presents the results obtained from the MATLAB simulation of the proposed steering-adaptive regenerative braking strategy. The performance of the proposed method is compared with a conventional regenerative braking strategy in which the braking torque is kept constant and does not depend on any steering input.

A. Steering Input and Controller Response

The input to the steering system used in the simulation is shown in Fig. 2. Initially, the vehicle travels in a straight line with zero steering input. After 3 seconds from the start of the simulation, the steering wheel starts to turn as the vehicle begins to turn. The turning continues until the steering wheel reaches 90 degrees. After this turning maneuver, the steering wheel slowly starts to turn in the opposite direction to zero degrees as the vehicle comes back to a straight-line path.

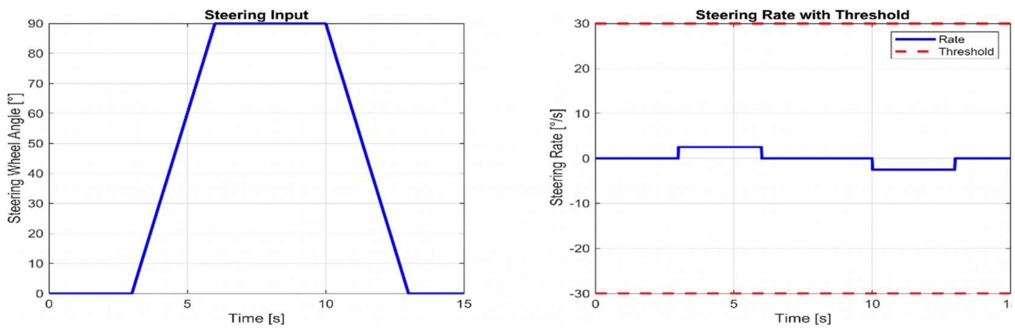

Fig. 2(a): Steering wheel angle profile during the simulated driving maneuver. Fig. 2(b): Steering angular rate corresponding to the steering input, showing threshold crossing during turn entry and exit.

Fig. 2(a) shows the steering angular rate corresponding to this maneuver. Initially, the steering wheel is stationary in a straight-line path. After 3 seconds from the start of the simulation, the steering wheel starts to turn as the vehicle begins to turn. The dashed lines in Fig. 2(b) represent the threshold for the steering rate. Whenever this threshold is surpassed, it is clear that a turning maneuver has begun. The control strategy then temporarily decreases the regenerative braking torque to reduce the braking force in the driven wheels.

B. Vehicle Stability Behavior

The vehicle stability behavior is shown in Fig 3. In Fig 3a, the vehicle's yaw rate response of the conventional braking strategy is compared with the vehicle's yaw rate response of the proposed adaptive braking strategy with respect to the desired vehicle's yaw rate. As shown, the vehicle's yaw rate response of the proposed adaptive braking strategy generally follows the desired vehicle's yaw rate. Therefore, the proposed adaptive braking strategy does not have any adverse effect on the vehicle's yaw motion.Fig 3b shows the vehicle's rear axle sideslip angle response of the conventional braking strategy and the proposed adaptive braking strategy. As shown, the vehicle's rear axle sideslip angle response of the proposed adaptive braking strategy is slightly lower compared to the conventional braking strategy. Therefore, the proposed adaptive braking strategy is able to utilize the tire grip more efficiently. Fig 3c shows the vehicle's yaw rate error response of the conventional braking strategy and the proposed adaptive braking strategy. As shown, the vehicle's yaw rate error response of the proposed adaptive braking strategy is close to the conventional braking strategy. Therefore, the proposed adaptive braking strategy is able to track the vehicle's yaw motion efficiently.

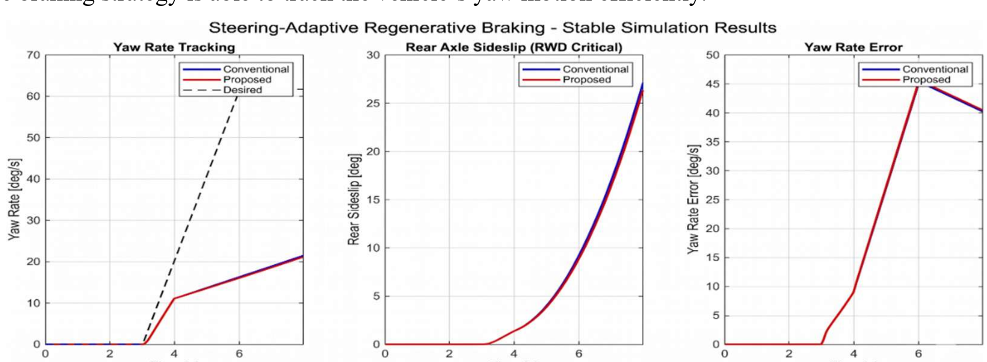

Fig. 3: Vehicle stability metrics during the turning maneuver: (a) yaw rate tracking compared with the desired reference, (b) rear axle sideslip angle, and (c) yaw rate error for conventional and steering-adaptive regenerative braking strategies

C. Quantitative Performance Comparison

Table II summarizes the quantitative comparison between the conventional regenerative braking strategy and the proposed steering-adaptive approach.

TABLE II: QUANTITATIVE PERFORMANCE COMPARISON

Metric	Conventional	Proposed	Change
Integrated yaw error (deg·s)	144.42	145.18	−0.5%
Peak rear sideslip angle (deg)	27.24	26.45	2.9%
Peak lateral acceleration (m/s²)	3.87	3.88	−0.1%
Total energy recovery (kJ)	110.8	109.7	−0.9%

From the results, it is evident that the proposed steering adaptive regenerative braking strategy decreases the peak rear sideslip angle by 2.9%, from 27.24° to 26.45°. This indicates that there is an improvement in lateral stability during the turn. The integrated yaw rate error does not vary, only increasing by 0.5%. The peak lateral acceleration does not vary between the two strategies. In addition, in terms of regenerative braking, the proposed strategy decreases the recovered energy by 0.9%, from 110.8 kJ to 109.7 kJ. The degradation in regenerative braking torque when steering is related to the coupling effect of longitudinal braking forces and lateral tire forces. During cornering, braking torque is applied to the driven wheels, and as a result, a part of the available tire grip is used for braking instead of steering. Using the suggested method, the tires are able to maintain greater grip for lateral movements, reducing the chances of oversteer when entering the turn.The braking torque is not completely lost, though, as the regenerative braking torque is available in full when the vehicle is in a straight path. As such, the loss in total regenerative braking energy is minimal. Using the suggested method, the total available regenerative braking energy is decreased by approximately 0.9% in the simulated case, resulting in an improvement in vehicle stability. The suggested method is also realistic, as it requires minimal hardware changes. The suggested method relies on the available steering information, which is available in most contemporary vehicles. As such, the suggested method is computationally efficient. The current study assumes that the vehicle speed is constant and that regenerative braking is always available. Future research may consider varying vehicle speeds and the ability to adapt to changing road friction.

V. CONCLUSION

This paper presents a steering adaptive regenerative braking strategy that is intended to improve vehicle stability while cornering. In this strategy, the steering angular rate is used to recognize cornering maneuvers, and the regenerative braking torque is reduced at the driven wheels. Simulation results showed that the vehicle stability is improved with a small decrease in the rear sideslip while maintaining similar yaw rate behavior. There is a small loss of braking energy, approximately 0.9%, which is a good indication that steering adaptive regenerative braking is beneficial to vehicle stability with minimal effects on energy efficiency.

REFERENCES

[1] Y. Xing, C. Lv, Y. Liu, Y. Zhao, D. Cao and S. Kawahara, "Hybrid-Learning-Based Driver Steering Intention Prediction Using Neuromuscular Dynamics," in *IEEE Transactions on Industrial Electronics*, vol. 69, no. 2, pp. 1750-1761, Feb. 2022, doi: 10.1109/TIE.2021.3059537.

[2] M. and S. P. S., "Novel Regenerative Braking Controllers for Electric Vehicle Driven by BLDC Motor," 2021 Fourth International Conference on Electrical, Computer and Communication Technologies (ICECCT), Erode, India, 2021, pp. 1-6, doi: 10.1109/ICECCT52121.2021.9616660.

[3] Yin, Z., Ma, X., Su, R., Huang, Z., & Zhang, C. (2023). Regenerative Braking of Electric Vehicles Based on Fuzzy Control Strategy. *Processes*, *11*(10), 2985. https://doi.org/10.3390/pr11102985

[4] Huang, B., Yu, W., Wu, Z., Yang, A., & Wei, J. (2025). System Integration to Intelligent Control: State of the Art and Future Trends of Electric Vehicle Regenerative Braking Systems. *Energies*, *18*(19), 5109. https://doi.org/10.3390/en18195109

[5] V. Khemka, A. P. Sagar and V. L. Srinivas, "Fuzzy Logic Control for Regenerative Braking Energy Management in a Battery-Supercapacitor based Electric Vehicle," 2024 9th International Youth Conference on Energy (IYCE), Colmar, France, 2024, pp. 1-6, doi: 10.1109/IYCE60333.2024.10634906.

[6] S. Oak, D. Lee, G. Sim, S. Kim and G. Park, "Real-Time Personalized Car-Following Control With Online Parameter Adaptation for Intelligent Regenerative Braking Systems," in IEEE Access, vol. 13, pp. 168055-168066, 2025, doi: 10.1109/ACCESS.2025.3611825.

[7] Q. Li, J. Zhang, L. Li, X. Wang, B. Zhang and X. Ping, "Coordination Control of Maneuverability and Stability for Four-Wheel-Independent-Drive EV Considering Tire Sideslip," in IEEE Transactions on Transportation Electrification, vol. 8, no. 3, pp. 3111-3126, Sept. 2022, doi: 10.1109/TTE.2022.3159843.
[8] J. Choi et al., "Coordinated Steering Angle and Yaw Moment Distribution to Increase Vehicle Regenerative Energy in Autonomous Driving," 2022 IEEE 25th International Conference on Intelligent Transportation Systems (ITSC), Macau, China, 2022, pp. 3083-3088, doi: 10.1109/ITSC55140.2022.9921910.
[9] R. Levickas and V. Žuraulis, "Stability Issues of Rear–Wheel–Drive Electric Vehicle During Regenerative Braking," in Applied Sciences, vol. 15, no. 20, p. 10926, 2025, doi: 10.3390/app152010926.
[10] J. Guo, W. Li, J. Wang, Y. Luo and K. Li, "Safe and Energy-Efficient Car-Following Control Strategy for Intelligent Electric Vehicles Considering Regenerative Braking," in IEEE Transactions on Intelligent Transportation Systems, vol. 23, no. 7, pp. 7070-7081, July 2022, doi: 10.1109/TITS.2021.3066611.
[11] P. Hang, B. Lou, and C. Lv, "Nonlinear Predictive Motion Control for Autonomous Mobile Robots Considering Active Fault-Tolerant Control and Regenerative Braking," in Sensors, vol. 22, no. 10, p. 3939, 2022, doi: 10.3390/s22103939.
[12] Y. Ha, S. Jeon, J. Park, S. Choi and S. Woo, "Coordinated Control Approach for Brake Actuator Failures: A Fault-Tolerant Strategy Using Braking Systems and Steering," in IEEE Access, vol. 13, pp. 108005-108024, 2025, doi: 10.1109/ACCESS.2025.3581926.
[13] Y. Jeong and S. Yim, "Path Tracking Control With Four-Wheel Independent Steering, Driving and Braking Systems for Autonomous Electric Vehicles," in IEEE Access, vol. 10, pp. 74733-74746, 2022, doi: 10.1109/ACCESS.2022.3190955.
[14] Li, Chunyu & Zhang, Lu & Lian, Shiqiang & Liu, Menglong. (2024). Research on regenerative braking control of electric vehicles based on game theory optimization. Science Progress. 107. 368504241247404. 10.1177/00368504241247404.
[15] M. Ziadia, S. Kelouwani, A. Amamou, and K. Agbossou, "Weather-Adaptive Regenerative Braking Strategy Based on Driving Style Recognition for Intelligent Electric Vehicles," in Sensors, vol. 25, no. 4, p. 1175, 2025, doi: 10.3390/s25041175.
[16] Zuo J, Chai Q, Zuo J and Li G (2025) Control strategy of electric vehicle regenerative braking integrating fuzzy control and PSO. Front. Mech. Eng. 11:1697447. doi: 10.3389/fmech.2025.1697447
[17] Z. Peng and Z. He, "Optimization of Regenerative Braking Control Strategy for Dual-Motor Electric Vehicles Based on Deep Reinforcement Learning," in IEEE Transactions on Intelligent Transportation Systems, 2025, doi: 10.1109/TITS.2025.3553875.
[18] M. Tang and X. Zhang, "Optimal Regenerative Braking Control Strategy for Electric Vehicles Based on Braking Intention Recognition and Load Estimation," in *IEEE Transactions on Vehicular Technology*, vol. 73, no. 3, pp. 3378-3392, March 2024, doi: 10.1109/TVT.2023.3327298.
[19] Z. Zheng, Z. Shi, Y. Luo, and J. Kang, "A Study of Energy Recovery System during Braking for Electric Vehicle," 2016,doi: 10.2991/icaset-16.2016.2.
[20] J. Wang, Q. Wang, L. Jin, and C. Song, "Independent wheel torque control of 4WD electric vehicle for differential drive assisted steering," in Mechatronics, vol. 21, no. 1, pp. 63–76, 2011, doi: 10.1016/j.mechatronics.2010.08.005.