# Time Delay Control of a 4WS Vehicle-A Comparison of Single and Dual Steering Control Strategies

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**ABSTRACT**

A dual steering control, where steering angle of both rear and front wheels are controlled independently, and single rear steering control of a 4WS vehicle is studied. In this regard, a Time Delay Controller (here after called TDC) is proposed. The TDC performance is compared with the LQR optimal control method. Control schemes are based on the yaw and lateral velocity reference model following. A 3DOF linear vehicle model comprising yaw, lateral and roll motions is used to design the control laws. The time delay controller is a model reference tracker that estimates disturbances such as side wind, road irregularities and actual model nonlinearities, and considers them into the linear controller model.

Simulations based on steady state cornering and lane change maneuvers are presented. To establish the sufficient level of model complexity, a 3-DOF nonlinear simulation model comprising yaw, lateral and roll motions with CALSPAN tire coefficients is used. Results indicate that time delay controller is a robust and stable control strategy for the 4WS vehicles, which is not influenced effectively under disturbances like side wind. This controller acts better than optimal regulators like LQR in single steering control and improve the vehicle response by making the system approach the reference model. TDC easily acts on actual systems with great reliability. But the most important factor in its behavior is tuning the delay factor L for good stability and acceptable handling response. This factor should be tuned from experimental data and more theoretical and experimental researches are needed to make this method more practical and useful.

**Key Words:**
3DOF Handling Model, CALSPAN Tire, Time Delay Control, Vehicle Dynamics, Model Reference Tracking Control