Enhanced Improvement Of Vehicle Dynamic Behaviour By Applying Torque Vectoring 
Viewed From The Vehicle Dynamic And Powertrains Perspective

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Introduction and objective.
Study is conducted on a fully electric vehicle equipped with individual electric motors applied on the rear axle. When applying Torque Vectoring (TV) an extra yaw-moment will be applied on the vehicle which will help to steer and control the vehicle during under- and oversteer situations. This study will function as a fundament for the construction of a Torque Vectoring CarLab (test vehicle) and the modification to the Tyre Estimator® to cope with TV.

Approach and Results.
To study the vehicle behaviour when applying TV, a vehicle model is designed in MATLAB® SimMechanics®. To apply TV, an Direct Yaw Moment (DYM) controller is created.

This controller strives to minimise the deviation between the vehicles yaw-rate \(\dot{\gamma}\) and the calculated target yaw-rate:

\[
\dot{\gamma}_{\text{target}} = \frac{g \cdot V_f \cdot \delta_f}{\eta \cdot V_x^2 + g \cdot L}
\]

Aiming to keep the vehicle stable in all situations, a Traction (TR) controller is created and a Drive Force Limitation (DFL) controller is recommended.

Conclusions and Recommendations.
The Induction motor is considered particularly well suited when applying Torque Vectoring. This because it is very robust and it can adjust its magnetic field strength extending the control capabilities.

Simulation results show that the main improvement of applying Torque Vectoring is that the steer characteristic of the vehicle moves toward a linear steer characteristic.
Also by applying a shift in longitudinal tyre forces, the inner rear wheel will have more margin to transfer lateral tyre forces.

To ensure that the Tyre Estimator®, a program developed by TNO to generate axle characteristics, can cope with TV, additions have to be made. The motor torque need to be measured so the extra yaw-moment due to TV can be calculated. Additionally the vehicle models inside the Tyre Estimator® need to be modified to apply this extra yaw-moment on the z-axis (perpendicular to the road) of the vehicle model.

A strong conclusion about the difference in consumption with and without TV, cannot be drawn because it strongly dependents on the operating points of the electric motor. Simulation results showed that the energy consumption may increase or decrease by as much as 1%.

Example of the used energy with and without Torque Vectoring.