Direct yaw moment controller Design

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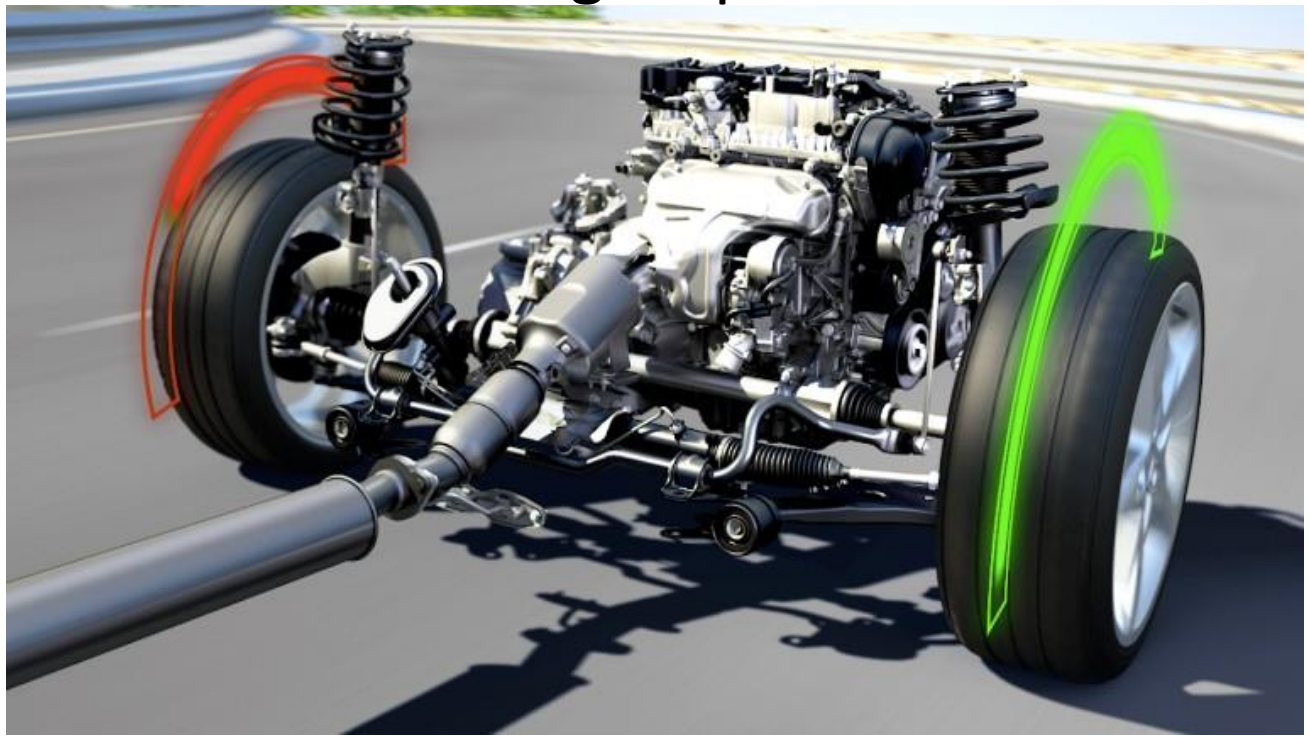
Torque vectoring and cornering response

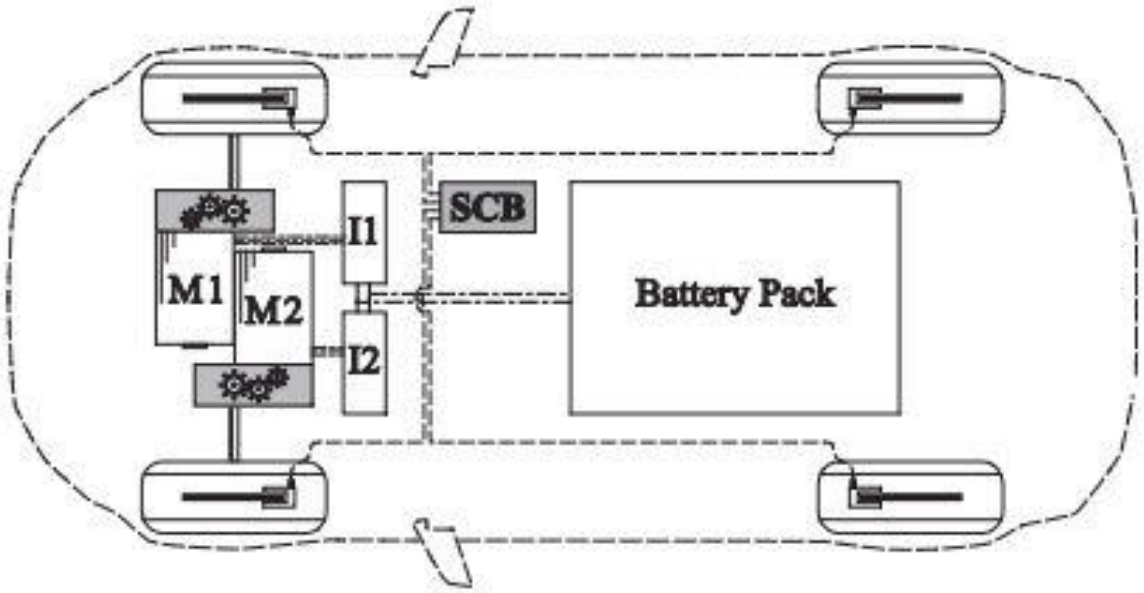
- A direct yaw moment control the generation of a yaw moment through an asymmetric wheel torque distribution helps in improving transient cornering response



Active differentials, friction brakes, electric drivetrains…

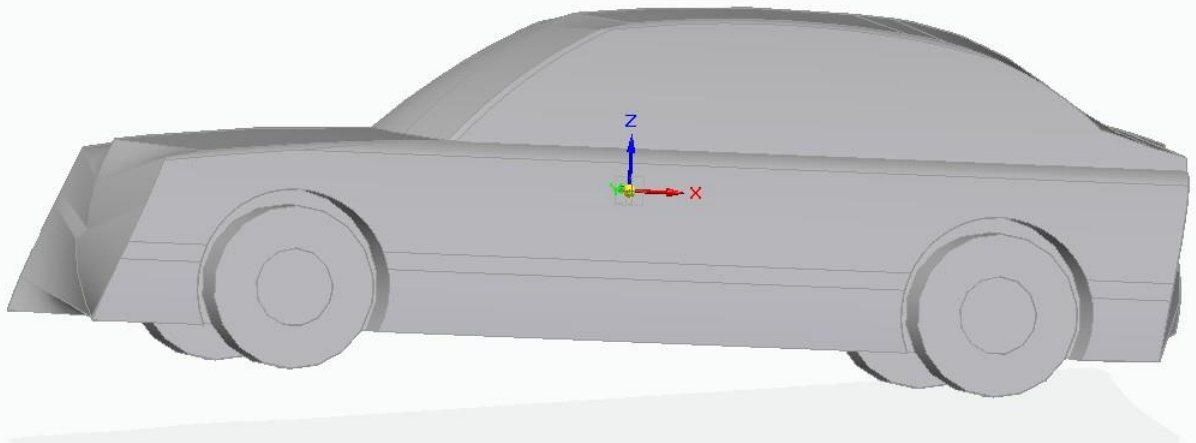
- Torque vectoring can be achieved through active differentials, or friction brakes which via yaw moment generation.
- With the advent of electric vehicles,
  - one (main) motor generates the axle torque demand (requested by the driver),
  - second motor produces the required wheel torque difference to achieve the torque-vectoring functionality. *This solution has the advantage that the peak yaw moment to be generated by each driven axle is independent from the axle torque demand.*

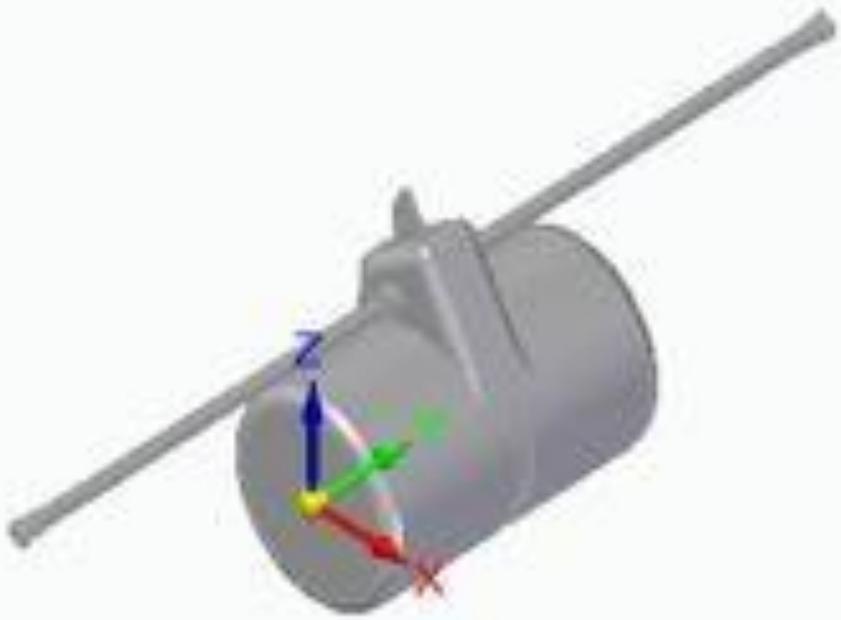
Drive train layout



Each wheel is independent and is powered via electric motor connected via half axles.
This allows for independent control and supply of wheel torque demand

CAD MODEL

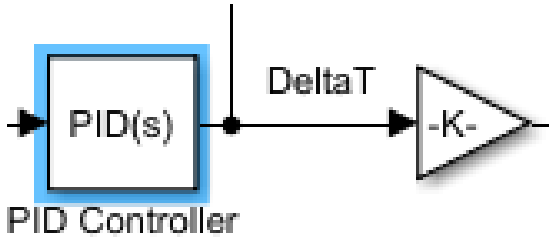




Proposed control strategy

- The most basic method is to distribute the left and right torque, proportional to the amount of steering input.

$$\Delta T = f(\delta)$$



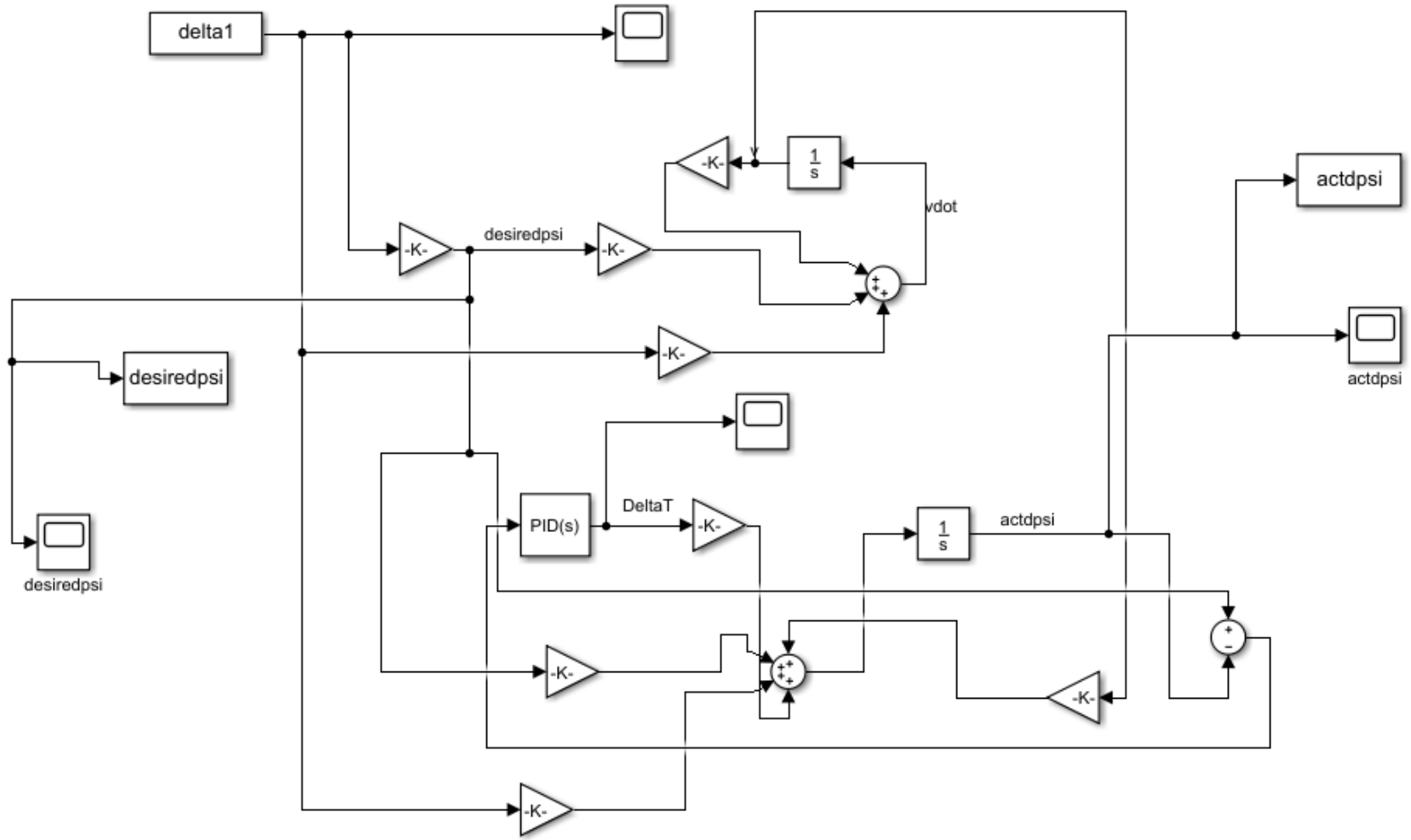
This torque signal is generated by the PI controller to tune the desired yaw rate.

Mathematical Analysis-state space equations

$$\begin{bmatrix} \dot{v_y} \\ \ddot{\psi} \end{bmatrix} = \begin{bmatrix} -\frac{C_{y,f}+C_{y,r}}{mv_{x0}} & \frac{-l_fC_{y,f}+l_rC_{y,r}}{mv_{x0}} - v_{x0} \\ \frac{-l_fC_{y,f}+l_rC_{y,r}}{I_{zz}v_{x0}} & -\frac{l_f^2C_{y,f}+l_r^2C_{y,r}}{I_{zz}v_{x0}} \end{bmatrix} \begin{bmatrix} v_y \\ \dot{\psi} \end{bmatrix} + \begin{bmatrix} \frac{C_{y,f}}{mv_{x0}} \\ \frac{l_fC_{y,f}}{I_{zz}} \end{bmatrix} \delta + \begin{bmatrix} 0 \\ \frac{1}{0.05 * I_{zz}} \end{bmatrix} \Delta T$$

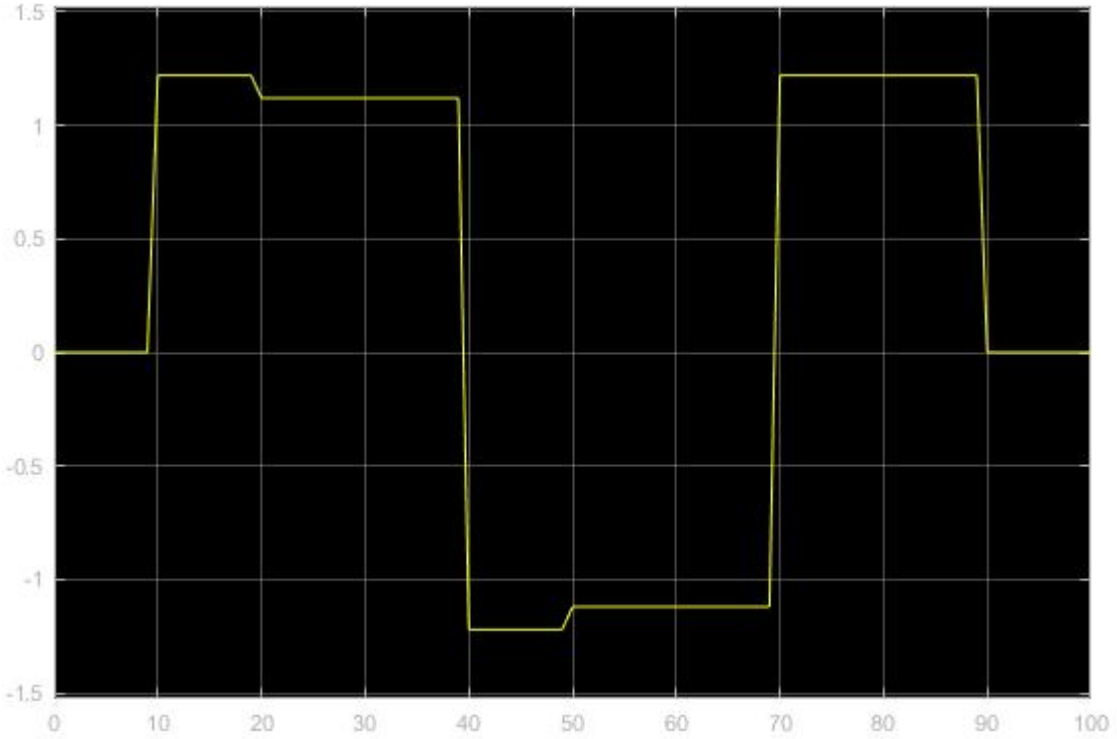
$$\dot{\psi}_{desired} = \frac{v_{CG}}{(l_r + l_f) + K_u v_{GC}^2} \delta$$

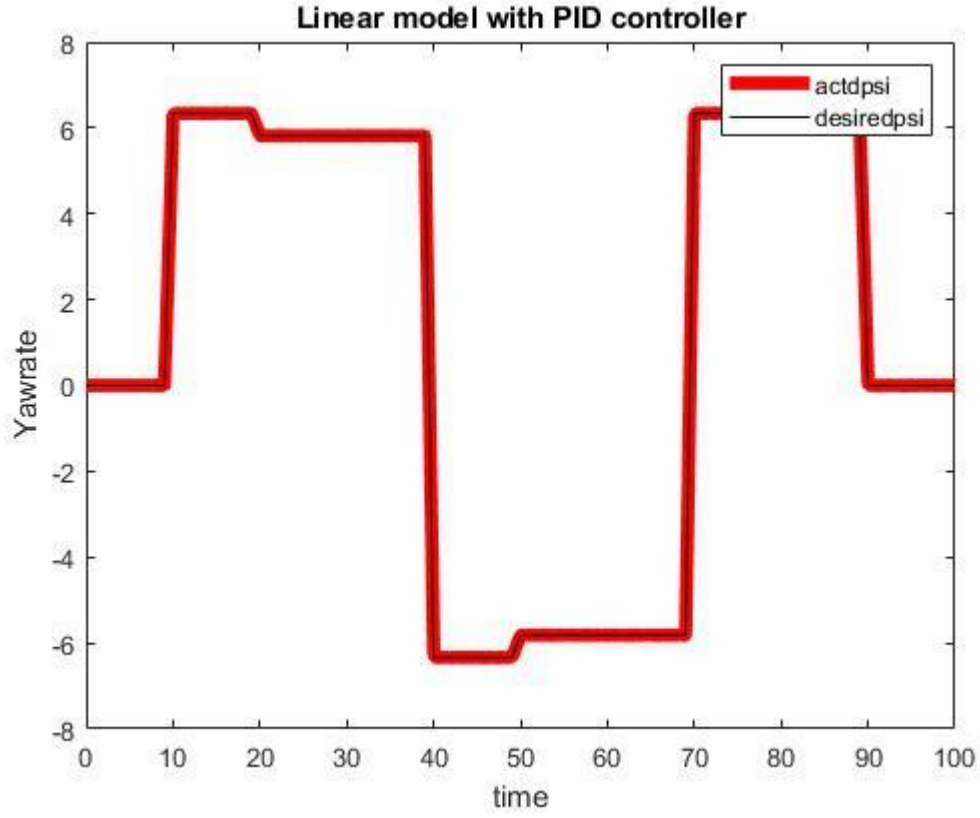
Simulink Model



Control Signal and Results

- Steering Angle control Signal





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- Direct yaw moment control actuated through electric drivetrains and friction brakes: Theoretical design and experimental assessment Leonardo De Novellis a , Aldo Sorniotti a,⇑ , Patrick Gruber a , Javier Orus b , Jose-Manuel Rodriguez Fortun b , Johan Theunissen c , Jasper De Smet.
- Driving modes for designing the cornering response of fully electric vehicles with multiple motors Leonardo De Novellis, Aldo Sorniotti n , Patrick Gruber
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