

# Model-based Development of Future Small EVs using Modelica

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To cope with demands for future low carbon society, development of new-type small electric vehicles (EVs) becomes very active. To reduce the energy consumption in various actual driving conditions, considering overall running resistance such as aerodynamic resistance, tire rolling resistance including cornering drag, mechanical and electrical losses, etc. will be necessary. On the other hand, to cope with reduced stability against external disturbances such as side wind because of the light weight, it was clarified that additional control of direct yaw moment is effective. In this paper, model-based development of a new electric vehicle using Modelica is described. Full vehicle model considering both vehicle dynamics and energy consumption was developed as shown in Figure 1 and utilized to investigate the best possible solutions for both basic design of the vehicle and design of the control system.

There are three points in this paper. First, the influence of tire rolling resistance coefficient (RRC) and tire cornering power (CP) and also the vehicle weight for overall driving resistance and energy consumption was investigated. It became clear that light vehicle weight, low RRC value and high CP value are effective to reduce the overall driving resistance and thus energy consumption as Figure 2.

Secondly, it was also proved that light vehicle weight tends to result in reduced vehicle stability against external disturbances such as side wind. To cope with this problem, a new direct yaw moment control using a torque vectoring differential gear (TVD) was proposed. Also detailed investigation about dynamic performance and energy consumption of the new TVD systems was done.

Third point is that capability of recuperating breaking energy is also essential to improve the energy consumption. To clarify the necessary specification of the electric power system, the estimation of driving and breaking powers in various driving conditions were performed. Finally estimation of proper battery capacity for breaking power regeneration for various driving conditions was done.

It was evident that Modelica was very powerful to perform this kind of multi-physics and multi-discipline investigations for the holistic vehicle systems and control design in the early phase of development planning.

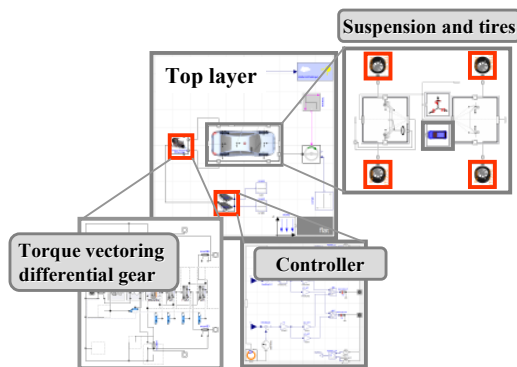


Figure 1: Total vehicle model

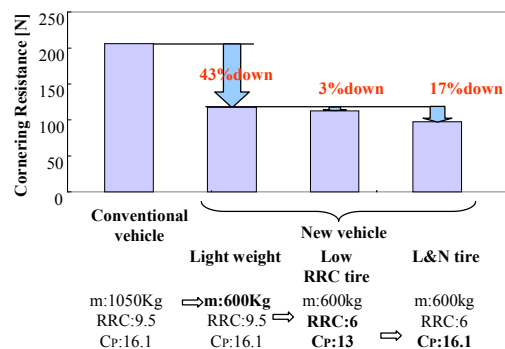


Figure 2: Comparison of cornering resistance force for various design condition