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# Engine start-stop optimization

## Reducing seat vibrations during transient engine restarts with LMS Engineering services

### Benefits

- Reduce seat vibrations during transient engine restarts
- Learn about measuring transfer functions with strain sensors for force identification in time domain
- Create an accurate multi-domain system model that includes the engine, vehicle and controls
- Optimize parameters, such as mount characteristics and suspension aspects, and the torque converter

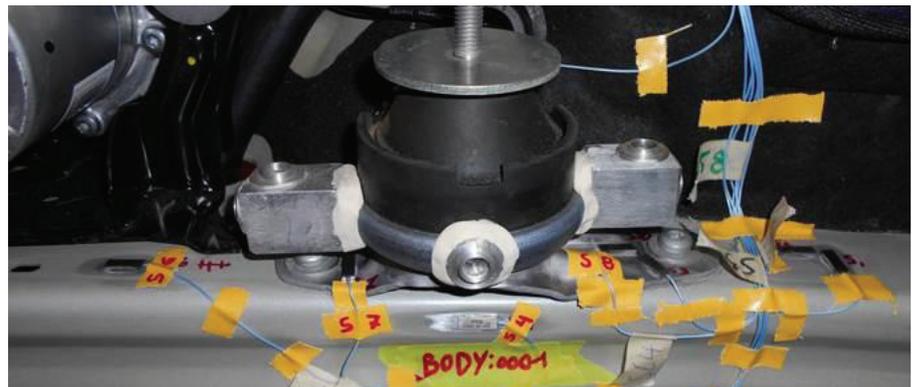
### Summary

LMS™ Engineering services help to increase comfort by reducing seat vibrations during restart after idling stops. By combining data obtained from dedicated testing with 1D system simulation, LMS Engineering experts can optimize both mechanical components and controls.

To respond to the industry mandate for eco-friendly cars, an increasing number of vehicle manufacturers are

introducing engine start-stop systems in their products. These automatically shut down and restart the internal combustion engine (ICE) to decrease the amount of idling time, thereby reducing fuel consumption and emissions. But a restart generates low-frequency transient torque oscillations in the driveline. Amplified by the powertrain, suspension and body modes, vibration can disturb seat comfort. By combining the mechanical system and engine controls, you can avoid this phenomenon.

Engine start-stop optimization requires modeling a multi-domain system, including controls. For this purpose, engineers can use LMS Imagine.Lab Amesim™ software. This 1D system simulation software contains a large set of physical libraries and features co-simulation, both for including controls and adding extra detail to mechanical components obtained with 3D simulation in LMS Virtual.Lab™ software. Dedicated testing is required to define certain model parameters, and for validation.



Identifying engine forces.

# Engine start-stop optimization

A typical engine start-stop optimization project is comprised of the following phases:

## Time-domain force identification

LMS Engineering experts use LMS testing solutions to identify the engine forces on the structure in time domain. As traditional acceleration-based methods fail to properly handle this problem due to low-frequency content and the mount nonlinearities that are typical for this transient event, LMS Engineering proposes a special matrix inversion method. It uses an over-determination of strain responses around the engine-body connection points. Strain sensors are particularly sensitive to local structural phenomena, resulting in a better numerical conditioning of the transfer function matrix. This means the calculated loads and parts are more accurate than accelerometer-derived transfer functions for this application.

## Vehicle structure modeling

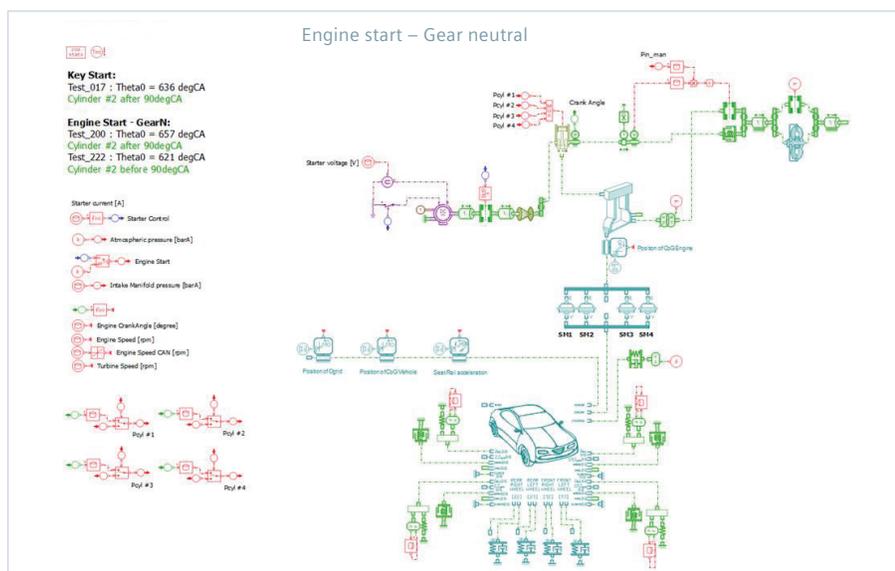
LMS Engineering experts simulate the combined driveline, engine block and chassis in a 1D system model. The chassis can be elaborated into a 3D component. Then they apply test data for the cylinder pressures to compute engine mount and suspension forces. Those are validated using the identified loads to check the quality of the model.

## Engine modeling

Using 1D system simulation, LMS Engineering experts design a detailed engine model that includes the air path, injection system, combustion model and engine control. The model is validated by comparing the cylinder pressure with test results.

## Combined mechanical and controls optimization

LMS Engineering experts combine the engine and vehicle structure into a comprehensive model that contains all multi-domain aspects of the system, including controls. They analyze how controls modifications can improve the restart behavior. They use sensitivity analyses to study parameters, such as mount characteristics and suspension aspects, and the torque converter. LMS Engineering then proposes solutions that reduce seat vibrations during restart.



Vehicle model in neutral gear.

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